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## FOREWORD

This volume, written at the conclusion of the detailed design, fabrication, and test phases of the Engineering Development contract, is an update of the Trainer Engineering Report (Preliminary), Data Item A001. This final document reflects the As-built MILES hardware design prior to delivery to OT III in Germany (Fall 1979). It has been updated in March 1981 to include Section 10 which was formerly a separate document, Data Item A00X.

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## SECTION 1

### INTRODUCTION

This volume of the Trainer Engineering Report presents the ED Hardware design on a system-by-system basis including drawings, sketches, diagrams, and calculations to support design decisions.

Section 1 defines the MILES system hardware requirements, both for ED and the long-term total MILES of the 1980s. Section 2 lists those constraints which affected the MILES system design. The results of the analyses and tradeoff studies from Volume I are summarized as added constraints to the basic system specifications and requirements. In Section 3, the electronics design is discussed including descriptions of those circuits which are basic to all MILES systems. Section 4 describes the eleven systems that comprise the MILES. Subsequent Sections treat the subjects of System Testing (Section 5), Reliability (Section 6), Maintainability (Section 7), EMI Suppression (Section 8), Worst Case Circuit Analysis (Section 9), and Design to Unit Production Cost (Section 10).

#### 1.1 1980 MILES

Engineering Development (ED) design decisions were guided by both product improvement and the ability to expand and to incorporate additional weapon systems applications. The MILES design, while more specifically oriented to ED requirement (small direct fire, and anti-armor weapons), is inherently designed to provide for the addition of other weapon systems and integrated operations in terms of:

- a. Compatibility,
- b. Configuration,
- c. Pulse Code Design,
- d. Signal Processing Circuitry,
- e. Commonality,
- f. Eye Safety.

The MILES of the 1980s is expected to provide for simulation of those weapons and weapon systems listed in table 1-1.

All design activity and decisions for the ED Program were made in terms of their impact on the overall MILES Program of the 1980s.

#### 1.2 ED MILES HARDWARE

To understand the system/assembly mix and match based upon the EDM contractual quantities of devices, two charts were prepared. The first of these charts, table 1-2, depicts the quantities of system/assemblies required for the OT II test program. (Note that this matrix is based on the Army units and type of organization which will be issued the equipment.)

LEGEND:  
 SA. SEMI-AUTOMATIC BL. BLANK  
 A. AUTOMATIC D. DUMMY  
 T. TRACER AP. ARMOR PIERCING INCENDIARY  
 B. BALL I. INCENDIARY  
 SS. SINGLE SHOT RKT MTR. ROCKET MOTOR

| WEAPON                         | TYPE OF FEED          | METHOD OF OPERATION / FIRE | MAXIMUM RANGE             | MAXIMUM EFFECTIVE RANGE<br>KILL/NEAR MISS (METERS) | MAXIMUM PRACTICAL RANGE | CYCLIC RATE OF FIRE (RPM) | SUSTAINED RATE OF FIRE SEMI/AUTO |
|--------------------------------|-----------------------|----------------------------|---------------------------|----------------------------------------------------|-------------------------|---------------------------|----------------------------------|
| <b>SMALL ARMS</b>              |                       |                            |                           |                                                    |                         |                           |                                  |
| M16A1 RIFLE                    | 30 RD MAG             | GAS/AUTO-SA                | 2650                      | 460/950                                            | 680 M                   | 700                       | 15 RPM/20 RPM                    |
| M60 MG (7.62)                  | LINK BELT             | GAS/AUTO                   | 3725                      | 800/1100                                           | 1100 M                  | 550                       | 100/MIN                          |
| <b>ANTI-TANK WEAPONS</b>       |                       |                            |                           |                                                    |                         |                           |                                  |
| BLAW                           | ONE SHOT - DISPOSABLE | ROCKET/SS                  |                           | 300/300                                            | 300                     | N/A                       | N/A                              |
| DRAGON                         | ONE SHOT - DISPOSABLE | ROCKET/SS                  | 1800 METERS               | 1000/1000                                          | 1000 METERS             | N/A                       | 2/MIN                            |
| TOW                            | MANUAL                | ROCKET/SS                  | 3000 METERS               | 3000/3000                                          | 2000 METERS             | N/A                       | 2/MIN                            |
| <b>ARMORED PERSONNEL CARR.</b> |                       |                            |                           |                                                    |                         |                           |                                  |
| M113                           |                       |                            |                           |                                                    |                         |                           |                                  |
| M2 MG (30)                     | LINK BELT             | RECOIL/AUTO                | 6800                      | 800/1600                                           | 1600 M                  | 800                       | 40 RPM                           |
| M103                           |                       |                            |                           |                                                    |                         |                           |                                  |
| BUSHMASTER 30-MM               | LINK BELT             | GAS/AUTO                   |                           | HE 2500-AP 1800                                    |                         | 225                       |                                  |
| MG (7.62)                      | LINK BELT             | GAS/AUTO                   | 2650                      | 800/1100                                           | 1100 M                  | 550                       | 100/MIN                          |
| <b>TANKS</b>                   |                       |                            |                           |                                                    |                         |                           |                                  |
| 105 GUN (M60A1)/A31            | MANUAL                | ELECTRIC/SS                | 4400                      | 3000                                               | 3000 M                  | N/A                       | N/A                              |
| MG (7.62) COAX                 | LINK BELT             | GAS RECOIL/AUTO            | 950                       | 800/1000                                           | 1100 M                  | 800                       | 100/MIN                          |
| M55 MG (30) CUPOLA             | LINK BELT             | GAS RECOIL/AUTO            | 1900                      | 800/1600                                           | 1600 M                  | 800                       | 40 RPM                           |
| 105 GUN (204-1)                | MANUAL                | ELECTRIC/SS                | 4400 M                    | 3000                                               |                         | N/A                       |                                  |
| MG COAX (7.62)                 | LINK BELT             | GAS RECOIL/AUTO            | 900 M                     | 800/1100                                           | 1100 M                  | 800                       | 100/MIN                          |
| MG CUPOLA (30) M55             | LINK BELT             | GAS RECOIL/AUTO            | 1600 M                    | 800/1600                                           | 1600 M                  | 800                       | 40 RPM                           |
| 155 GUN/MSL (M54A1)/SHERIDAN   | MANUAL                | ELECTRIC/SS                | 2800                      | 3000/2000                                          | 3000 M                  | N/A                       | N/A                              |
| SHILLELAGH M55A1               | MANUAL                | ROCKET/SS                  | 3000                      | 3000/2000                                          | 3000 M                  | N/A                       | N/A                              |
| M2 MG 1.50 TURRET              | LINK BELT             | RECOIL/AUTO                | 6800                      | 800/1600                                           | 1600 M                  | 800                       | 40 RPM                           |
| M55 MG (30) CUPOLA             | LINK BELT             | RECOIL/AUTO                | 1600                      | 800/1600                                           | 1600 M                  | 800                       | 40 RPM                           |
| MG COAX (7.62)                 | LINK BELT             | GAS/AUTO                   | 900                       | 800/1100                                           | 1100 M                  | 800                       | 100/MIN                          |
| <b>AIR DEFENSE</b>             |                       |                            |                           |                                                    |                         |                           |                                  |
| RED EYE/STINGER MISSILE        | ONE SHOT - DISPOSABLE | SHOOT - THROW AWAY         | 6000 METERS               | 4000 METERS                                        | 3000 METERS             | 1/10 SEC                  | SINGLE SHOT                      |
| VULCAN 20 MM GUN               | LINKLESS              | ELEC. GATLING/AUTO         | 3000 METERS               | 1800 METERS                                        | 1600 METERS             | 3000                      | 2000 RPM                         |
| CHAPARRAL MISSILE              | ONE SHOT              | ROCKET                     | 6000                      | 4600 METERS                                        | 4500 METERS             | 1/8 SEC                   | 1/4 SEC.                         |
| ROLAND II MISSILE              | MAGAZINE              | ROCKET                     | 6000                      | 4600 METERS                                        | 4500 METERS             | 1/4 SEC.                  | 1/4 SEC.                         |
| <b>AIRCRAFT</b>                |                       |                            |                           |                                                    |                         |                           |                                  |
| AH-1J/ADV ATK HCT              |                       |                            |                           |                                                    |                         |                           |                                  |
| MG (7.62) M134 GATLING         | LINK BELT             | ELECT. GATLING/AUTO        | 3200 M                    | 800/1100                                           |                         | 2000                      | 2000 RPM                         |
| M55 20 MM/250 MM GUN GATLING   | LINK BELT             | ELECT. GATLING/AUTO        | 3750 M                    | 1600/1600                                          |                         | 750 RPM                   | 100-200/BURST                    |
| 40 MM GR LCL MP                | LINK BELT             | ELECTRIC/AUTO              | 2000 M                    | 1200/1300                                          |                         | 400 RPM                   | 400 RPM                          |
| 2.75 ROCKET                    | POD LOADED            | ROCKET/BL/LSIVE            | 9300 M                    | 2000                                               |                         | 21-38                     | 6 PAIRS/SEC.                     |
| EXT. RANGE TOR                 | RACK LOADED           | ROCKET/SS                  | 3750 M                    | 3750/3750                                          |                         | SINGLE SHOT               | N/A                              |
| UH-1/ATTAS                     |                       |                            |                           |                                                    |                         |                           |                                  |
| MG (7.62)                      | LINK BELT             | GAS/AUTO                   | 3725 M                    | 800/1100                                           |                         | 800                       |                                  |
| OH-58/ADV SCT HOVTH            |                       |                            |                           |                                                    |                         |                           |                                  |
| MG (7.62) GATLING              | LINK BELT             | ELECT. GATLING/AUTO        | 3725 M                    | 800/1100                                           |                         | 2000                      | N/A                              |
| EXT. RANGE TOR (ASH)           | RACK LOADED           | ROCKET/SS                  | 3750 M                    | 3750/3750                                          |                         | SINGLE SHOT               | N/A                              |
| HELLFIRE (ASH)                 | RACK LOADED           | ROCKET/SS                  | 5000 DIRECT/2000 INDIRECT | 5000 DIRECT/2000 INDIRECT                          |                         | SS                        |                                  |
| ATTACK/FIGHTER (USAF)          |                       |                            |                           |                                                    |                         |                           |                                  |
| MAVERICK                       | RACK LOADED           | ROCKET/SS                  | 11 MILES ALT.             | 4000                                               |                         | N/A                       | N/A                              |
| ROCKEYE (CLUST) 2 BOMB         | RACK LOADED           | FREE FALL/MULT REL         | 6000 FT ALT               | 3000                                               |                         | N/A                       | N/A                              |
| 30 MM GUN                      | LINK BELT             | ELECT GATLING/AUTO         | 4000 M                    | 1800                                               |                         | 6000 RPM                  | 6000 RPM                         |
| 30 MM GUN                      | LINK BELT             | HYD. GATLING/AUTO          | 4000 M                    | 3000                                               |                         | 2000-4000                 |                                  |
| <b>BOMBS</b>                   |                       |                            |                           |                                                    |                         |                           |                                  |
| BOMB                           | RACK LOADED           | FREE FALL/MULT REL         | 8000 FT. ALT              | 3000                                               |                         | N/A                       | N/A                              |
| WALLEYE GBU 11                 | RACK LOADED           | GUIDE FALL/SGL REL         | 10,000 FT ALT             | 8000                                               |                         | N/A                       | N/A                              |
| LASER GUIDED BOMB              | RACK LOADED           | FREE FALL/SGL REL          |                           | 18,000                                             |                         | N/A                       |                                  |
| <b>ENEMY WEAPONS</b>           |                       |                            |                           |                                                    |                         |                           |                                  |
| SAGGER (AT08B)                 | MANUAL                | ROCKET/SS                  | 3000 METERS               | 3000                                               | 2000 METERS             | N/A                       | SINGLE SHOT                      |
| BMP (APC)                      |                       |                            |                           |                                                    |                         |                           |                                  |
| SAGGER                         | MANUAL                | ROCKET/SS                  | 3000 METERS               | 3000                                               | 3000 METERS             | N/A                       | SINGLE SHOT                      |
| 73 MM GUN                      | MANUAL                | RECOIL/SS                  | 1000 METERS               | 1000                                               | 1000 METERS             | LINK                      | LINK                             |
| ZSU-23-4                       | LINK BELT             | GAS/AUTO                   | 2000 METERS               | 2000                                               | 2500 METERS             | 2000                      | 200 RPM                          |
| <b>LASER GUIDED WEAPONS</b>    |                       |                            |                           |                                                    |                         |                           |                                  |
| GROUND L.L.D.                  | N/A                   | CONT - FLASH/AUTO          | 10TH RANKING              | 3000                                               | 3K DESIGNATE            | N/A                       | N/A                              |
| AIRBORNE L.L.D.                | N/A                   | CONT. FLASH/AUTO           | 5K DESIGNATE              | 3000                                               | 3K DESIGNATE            | N/A                       | N/A                              |
| LT WT. L.D.                    | N/A                   | CONT FLASH/AUTO            | 3K DESIGNATE              | 1000                                               | 1K DESIGNATE            | N/A                       | N/A                              |
| <b>LANDMINES</b>               |                       |                            |                           |                                                    |                         |                           |                                  |
| M16A1 ANTI-PERS (CLAYMORE)     | N/A                   | N/A/AUTO                   | 50 METERS                 | 30                                                 | 50 METERS               | N/A                       | N/A                              |
| M16 ANTI-PERS                  | N/A                   | N/A/AUTO                   | 30 METERS                 | 30                                                 | 30 METERS               | N/A                       | N/A                              |
| M21 ANTI-TANK                  | N/A                   | N/A/AUTO                   | POINT TARGET              | POINT TARGET                                       | POINT TARGET            | N/A                       | N/A                              |
| HEPT DEL A7                    |                       |                            |                           |                                                    |                         |                           |                                  |
| ARTY DEL AP                    |                       |                            |                           |                                                    |                         |                           |                                  |
| ARTY DEL A7                    |                       |                            |                           |                                                    |                         |                           |                                  |

2

| CHARACTERISTICS |                        |                      |                                    |                   |                    |                         |                              |              |                         |                                   |
|-----------------|------------------------|----------------------|------------------------------------|-------------------|--------------------|-------------------------|------------------------------|--------------|-------------------------|-----------------------------------|
|                 | RAPID RATE OF FIRE     | MAXIMUM RATE OF FIRE | MINIMUM RANGE (DESIGNED/ESSENTIAL) | AMMUNITION (TYPE) | FUSE               | BURST AREA (EFFECT)     | FIRE CONTROL SYSTEM (SIGHTS) | BASIC LOAD   | TARGET (BULL/NEAR MISS) | TECHNIQUE ENGAGEMENT (BURST RATE) |
|                 |                        |                      |                                    |                   |                    | INDIRECT/AREA FIRE      |                              |              |                         |                                   |
|                 | SA (45-80) A (150-200) | SA (15) - A (20)     | 5/25                               | B/T               |                    | N/A                     | OPEN                         | 140          | 1, 6, 7                 | 5 RDS.                            |
|                 | 200/MIN.               | 100 MIN.             | 5/25                               | B/T/AP/AP         |                    | N/A                     | OPEN                         | 600          | 1, 6, 7, 8              | 20 RDS.                           |
|                 | N/A                    | 1/10 SEC.            | 10                                 | SHAPE HEAT CHG.   | POINT DETONATING   | N/A                     | OPEN                         | 10           | 1, 3, 4, 5, 8           | SINGLE SHOT                       |
|                 | 4/MIN.                 | 2/MIN.               | 85 METERS                          | SHAPE HEAT CHG.   | POINT DETONATING   | N/A                     | OPTICAL                      | 2            | 1, 3, 4, 5, 8           | SINGLE SHOT                       |
|                 | 4/MIN.                 | 2/MIN.               | 50/200                             | SHAPE HEAT CHG.   | POINT DETONATING   | N/A                     | OPTICAL                      | 10           | 1, 3, 4, 5, 8           | SINGLE SHOT                       |
|                 |                        |                      |                                    |                   |                    |                         |                              |              |                         |                                   |
|                 | 10+ RPM                | 40 RPM               | 5/25                               | B/T/AP/AP/AP/T    | IMPACT             | N/A                     | OPEN                         | 800          | 1, 6, 7, 8              | 20 RDS.                           |
|                 |                        |                      |                                    |                   |                    |                         |                              |              |                         |                                   |
|                 | 200/MIN.               | 100/MIN.             | 5/25                               | HEIT/AP/T         |                    | N/A                     | OPEN                         | 1200         |                         | 5 RDS                             |
|                 |                        |                      |                                    | B/T/AP/AP         | IMPACT             | N/A                     | OPEN                         | 2200         | 1, 6, 7                 | 20 RDS.                           |
|                 | N/A                    | N/A                  | 50/200                             | B/T/AP            |                    | N/A                     | OPTICAL                      | 63           | 1, 3, 4, 5, 8           | SINGLE SHOT                       |
|                 | 20+ RPM                | 100 R/M              | 5/25                               | B/T/AP/AP/T       | IMPACT             | N/A                     | OPTICAL                      | 2200         | 1, 6, 7                 | 20 RDS.                           |
|                 | 60+ RPM                | 40 RPM               | 5/25                               | B/T/AP/AP/AP/BL/D | IMPACT             | N/A                     | OPEN                         | 1200         | 1, 6, 7, 8              | 20 RDS.                           |
|                 |                        |                      |                                    | SANDWICH/HEAT     |                    | N/A                     | OPTICAL                      | 63           | 1, 3, 4, 5, 8           | SINGLE SHOT                       |
|                 | 200/MIN.               | 100 RPM              | 5/25                               | AP/ B/T/BL/D      | IMPACT             | N/A                     | OPTICAL                      | 2200         | 1, 6, 7                 | 20 RDS.                           |
|                 | 40+ RPM                | 40 RPM               | 5/25                               | B/T/AP/AP/AP/BL   | IMPACT             | N/A                     | OPEN                         | 800          | 1, 6, 7, 8              | 20 RDS.                           |
|                 | N/A                    | N/A                  | 50/200                             | HE HEAT           |                    | N/A                     | OPTICAL                      | 33           | 1, 3, 4, 5, 8           | SINGLE SHOT                       |
|                 | N/A                    | N/A                  | 50/200                             | ATSM              | IMPACT             | N/A                     | OPTICAL                      | 13           | 1, 3, 4, 5, 8           | SINGLE SHOT                       |
|                 | 40+ RPM                | 40 RPM               | 5/25                               | W/T/AP/AP/AP/BL/D | IMPACT             | N/A                     | OPEN                         | 800          | 1, 6, 7, 8              | 20 RPM                            |
|                 | 80+ RPM                | 40 RPM               | 5/25                               | B/T/AP/AP/AP/BL/D | IMPACT             | N/A                     | OPEN                         | 1200         | 1, 6, 7, 8              | 20 RPM                            |
|                 |                        | 100 RPM              | 5/25                               | B/T/AP/AP/AP/BL   | IMPACT             | N/A                     | OPTICAL                      | 3080         | 1, 6, 7                 | 20 RPM                            |
|                 |                        |                      |                                    |                   |                    |                         |                              |              |                         |                                   |
|                 | N/A                    | 1 EVERY 10 SEC.      | 300/500 METERS                     |                   | IMPACT             | N/A                     | OPEN                         | 6 PER TEAM   | 6, 7                    | SINGLE SHOT                       |
|                 | 10/30/60/100 RPM       | 1000 RPM             | 200/250 METERS                     | HEIT-50           | IMPACT             | N/A                     | OPTICAL                      | 800/1800     | 1, 6, 7, 8              | 60 RDS./BURST                     |
|                 | 1/4 SEC.               | 1/4 SEC.             | 800 METERS                         | HE                | PROXIMITY          | N/A                     | OPTICAL                      | 12 PER TRACK | 6, 7                    | 1 EVERY 30 SEC.                   |
|                 | 1/4 SEC.               | 1/4 SEC.             | 800 METERS                         | SHAPE CHARGE      | PROXIMITY          | N/A                     | OPTICAL                      | 8 PER TRACK  | 6, 7                    | 1 EVERY 10 SEC.                   |
|                 |                        |                      |                                    |                   |                    |                         |                              |              |                         |                                   |
|                 | 4000 RPM               | 1000 RPM             | 0                                  | B/T               | N/A                | N/A                     | OPTICAL                      | 3000         | 1, 6, 7                 | 200 RDS.                          |
|                 | 750 RPM                | 150 RPM              | 0                                  | AP/M-1            | IMPACT             | 20x15M/20x30M           | OPTICAL                      | 980          | 2, 6, 7, 8              | 200/100                           |
|                 | N/A                    | 400 RPM              | 300 M                              | HEDP XM 430       | IMPACT             | 40 X 60 M               | OPTICAL                      | 250          | 1, 6                    | 7 RDS                             |
|                 | 6 PAIRS/SEC.           | SALVO > 6            | 300 M                              | XM 241/DM 261     | IMPACT/TIME RC.    | 10x100M                 | OPTICAL                      | 14/28/34/78  | 1, 6, 7, 8              | 2                                 |
|                 | N/A                    | N/A                  | 300 M                              | SHAPE CHARGE      | IMPACT             | N/A                     | OPTICAL WIRE                 | 1            | 1, 3, 4, 5, 8           | SINGLE SHOT                       |
|                 |                        |                      |                                    |                   |                    |                         |                              |              |                         |                                   |
|                 |                        |                      |                                    |                   |                    | N/A                     |                              | 800          | 1, 6, 7                 | 20 RDS.                           |
|                 |                        |                      |                                    |                   |                    |                         |                              | 2000         |                         | 0                                 |
|                 | N/A                    | N/A                  | 500 M                              | SHAPE CHARGE      | IMPACT             | N/A                     | OPTICAL REFLEX               | 4/6          | 1, 6, 7                 | 80 RDS.                           |
|                 | N/A                    | N/A                  | 50/200 M                           | SHAPE CHARGE      | IMPACT             | N/A                     | OPTICAL                      | 4/6          | 1, 3, 4, 5, 8           | SINGLE SHOT                       |
|                 |                        |                      |                                    |                   |                    | N/A                     | OPTICAL                      |              | 1, 3, 4, 5, 8           | SINGLE SHOT                       |
|                 | N/A                    | N/A                  | 3000 FT ALT                        | SHAPE CHARGE      | IMPACT             | N/A                     | ELECTRO-OPTICAL              | 4/6          | 1, 3, 4, 5, 8           | SINGLE SHOT                       |
|                 | N/A                    | N/A                  | 6-500 FT ALT                       | 250-600 BOMBLETS  | IMPACT             | 200 FT RADIUS           | REFLEX                       | 1/8          | 1, 3, 4, 5, 8           | 2 TO 8                            |
|                 | N/A                    | N/A                  | 0                                  | AP/M-1            | IMPACT             | REP'S MILES/REP'S MILES | REFLEX                       | 1800         | 1, 6, 7, 8              | 100                               |
|                 | N/A                    | N/A                  | 0                                  | HEDP              | IMPACT             | REP'S MILES/REP'S MILES | REFLEX                       | 1780         | 1, 6, 7, 8              | 80                                |
|                 |                        |                      |                                    |                   |                    |                         |                              |              | 1, 6, 7, 8              |                                   |
|                 | N/A                    | N/A                  | 0                                  | MBZ/BL/M          | IMPACT             | ...                     | REFLEX                       | 24/12/4      | 1, 3, 4, 5, 8           | 4/12/24                           |
|                 | N/A                    | N/A                  | 0                                  | MBZ/BL/M          | IMPACT             | ...                     | ELECTRO-OPTICAL              | 4/6          | 1, 3, 4, 5, 8           | SINGLE RELEASE                    |
|                 |                        |                      |                                    |                   |                    |                         | LASER DESIG.                 |              |                         | SINGLE RELEASE                    |
|                 | 2 RDS/MIN.             | 2 RDS/MIN.           | 500 METERS                         | SHAPE CHARGE      | IMPACT             | N/A                     | OPTICAL                      | 3 RDS.       | 1, 3, 4, 5, 8           | SINGLE SHOT                       |
|                 |                        |                      |                                    |                   |                    |                         |                              |              |                         |                                   |
|                 | 1 RDS/MIN.             | 1 RDS/MIN.           | 500 METERS                         | SHAPE CHARGE      | IMPACT             | N/A                     | OPTICAL                      | 4 RDS.       | 1, 3, 4, 5, 8           | SINGLE SHOT                       |
|                 | LINK                   | LINK                 | LINK                               | HEAT              | IMPACT             | N/A                     | OPTICAL                      | 30 RDS.      | 1, 6                    | LINK                              |
|                 | 2400 RPM               | 300 RPM              | LINK                               | AP                | IMPACT             | N/A                     | OPTICAL                      | 200          | 1, 6, 7, 8              | 20 RDS                            |
|                 |                        |                      |                                    |                   |                    |                         |                              |              | 1, 3, 4, 5, 8           |                                   |
|                 | N/A                    | N/A                  | 300 METERS                         | LASER             | N/A                | N/A                     | OPTICAL                      | N/A          |                         | N/A                               |
|                 | N/A                    | N/A                  | 300 METERS                         | LASER             | N/A                | N/A                     | OPTICAL                      | N/A          |                         | N/A                               |
|                 | N/A                    | N/A                  | 300 METERS                         | LASER             | N/A                | N/A                     | OPTICAL                      | N/A          |                         | N/A                               |
|                 |                        |                      |                                    |                   |                    |                         |                              |              |                         |                                   |
|                 | N/A                    | N/A                  | NONE                               | HE                |                    | 50 M X 2 M X 60°        | N/A                          |              | 1, 6                    |                                   |
|                 | N/A                    | N/A                  | NONE                               | HE                | 50% W/R 300 RADIUS | 30 M RADIUS             | N/A                          |              | 1, 6                    | SINGLE                            |
|                 | N/A                    | N/A                  | NONE                               | HE                |                    | N/A                     | N/A                          |              | 1, 3, 4, 5, 8           | SINGLE                            |
|                 |                        |                      |                                    |                   |                    |                         |                              |              | 1, 3, 4, 5, 8           | SINGLE                            |
|                 |                        |                      |                                    |                   |                    |                         |                              |              | 1, 6                    |                                   |



| BURST AREA<br>(EFFECT) | FIRE CONTROL<br>SYSTEM<br>(BRIGHT) | BASIC LOAD   | TARGET<br>(KILL/NEAR MISS) | TECHNIQUE OF<br>ENGAGEMENT<br>(BURST RATES) | ON EQUIP. LOAD<br>(AMMO) | REFERENCE<br>PHASE   | REMARKS | REFERENCE<br>DOCS/PH |
|------------------------|------------------------------------|--------------|----------------------------|---------------------------------------------|--------------------------|----------------------|---------|----------------------|
| INDIRECT/AREA FIRE     |                                    |              |                            |                                             |                          |                      |         |                      |
| N/A                    | OPEN                               | 148          | 1, 6, 7                    | 5 RDS.                                      |                          | FM 23-8              |         | CAT. B, 18 AUG       |
| N/A                    | OPEN                               | 600          | 1, 6, 7, 8                 | 20 RDS.                                     | 600 TO 900               | FM 23-81             |         | CAT. B, 18 AUG       |
| N/A                    | OPEN                               | 10           | 1, 3, 4, 5, 8              | SINGLE SHOT                                 | 10 RDS.                  | FM 8-1348-214-10     |         | CAT. B, 18 AUG       |
| N/A                    | OPTICAL                            | 2            | 1, 3, 4, 5, 8              | SINGLE SHOT                                 | 10 RDS.                  | TC-23-30             |         | CAT. B, 18 AUG       |
| N/A                    | OPTICAL                            | 10           | 1, 3, 4, 5, 8              | SINGLE SHOT                                 | 10 RDS.                  | TM 8-1408-478-12     |         | CAT. B, 18 AUG       |
| N/A                    | OPEN                               | 800          | 1, 6, 7, 8                 | 20 RDS.                                     |                          | FM 23-85             |         | CAT. B, 18 AUG       |
| N/A                    | OPEN                               | 1200         |                            | 5 RDS.                                      |                          | BBQ STUDY            |         |                      |
| N/A                    | OPEN                               | 2200         | 1, 6, 7                    | 20 RDS.                                     |                          | GRAY                 |         |                      |
| N/A                    | OPTICAL                            | 63           | 1, 3, 4, 5, 8              | SINGLE SHOT                                 | 63 RDS.                  | TM 8-2300-215        |         | CAT. B, 18 AUG       |
| N/A                    | OPTICAL                            | 2200         | 1, 6, 7                    | 20 RDS.                                     | 1800 RDS.                | TM 8-2300-215        |         | CAT. B, 18 AUG       |
| N/A                    | OPEN                               | 1200         | 1, 6, 7, 8                 | 20 RDS.                                     | 1200 RDS.                | TM 8-2300-215        |         | CAT. B, 18 AUG       |
| N/A                    | OPTICAL                            | 80           | 1, 3, 4, 5, 8              | SINGLE SHOT                                 |                          |                      |         |                      |
| N/A                    | OPTICAL                            | 2200         | 1, 6, 7                    | 20 RDS.                                     |                          |                      |         |                      |
| N/A                    | OPEN                               | 900          | 1, 6, 7, 8                 | 20 RDS.                                     |                          |                      |         |                      |
| N/A                    | OPTICAL                            | 23           | 1, 3, 4, 5, 8              | SINGLE SHOT                                 | 33/90 RDS.               | TM 8-2300-230-10-2-3 |         | CAT. B, 18 AUG       |
| N/A                    | OPTICAL                            | 13           | 1, 3, 4, 5, 8              | SINGLE SHOT                                 | 13/9 RDS.                | TM 8-2300-230-10-2-3 |         | CAT. B, 18 AUG       |
| N/A                    | OPEN                               | 900          | 1, 6, 7, 8                 | 20 RPM                                      | 1200 RDS.                |                      |         | CAT. B, 18 AUG       |
| N/A                    | OPEN                               | 1000         | 1, 6, 7, 8                 | 20 RPM                                      | 1200 RDS.                |                      |         | CAT. B, 18 AUG       |
| N/A                    | OPTICAL                            | 2000         | 1, 6, 7                    | 20 RPM                                      | 600 RDS.                 |                      |         | CAT. B, 18 AUG       |
| N/A                    | OPEN                               | 6 PER TEAM   | 6, 7                       | SINGLE SHOT                                 | 6 PER TEAM               | FM 23-17             |         |                      |
| N/A                    | OPTICAL                            | 800/1000     | 1, 6, 7, 8                 | 80 RDS./BURST                               | 1000/300                 |                      |         |                      |
| N/A                    | OPTICAL                            | 12 PER TRACK | 6, 7                       | 1 EVERY 10 SEC.                             | 12 PER TRACK             |                      |         |                      |
| N/A                    | OPTICAL                            | 6 PER TRACK  | 6, 7                       | 1 EVERY 10 SEC.                             | 6 PER TRACK              |                      |         |                      |
| N/A                    | OPTICAL                            | 2000         | 1, 6, 7                    | 200 RDS.                                    |                          | FM 1-40              |         |                      |
| 20x50AU/20x30M         | OPTICAL                            | 900          | 2, 6, 7, 8                 | 200/100                                     |                          | FM 1-40              |         |                      |
| 40 X 60 M              | OPTICAL                            | 200          | 1,                         | 7 RDS.                                      |                          | FM 1-40              |         |                      |
| 10x100M                | OPTICAL                            | 14/26/34/76  | 1, 6, 7, 8                 | 2                                           |                          | FM 1-40              |         |                      |
| N/A                    | OPTICAL WIRE                       | 1            | 1, 3, 4, 5, 8              | SINGLE SHOT                                 |                          | FM 1-40              |         |                      |
| N/A                    |                                    | 800          | 1, 6, 7                    | 20 RDS.                                     |                          | FM 1-40              |         |                      |
| N/A                    |                                    | 2000         |                            | 4                                           |                          | FM 1-40              |         |                      |
| N/A                    | OPTICAL REFLEX                     | 4/6          | 1, 6, 7                    | 80 RDS.                                     |                          | FM 1-40              |         |                      |
| N/A                    | OPTICAL                            | 4/6          | 1, 3, 4, 5, 8              | SINGLE SHOT                                 |                          |                      |         |                      |
| N/A                    | OPTICAL                            |              | 1, 3, 4, 5, 8              | SINGLE SHOT                                 |                          |                      |         |                      |
| N/A                    | ELECTRO-OPTICAL                    | 4/6          | 1, 3, 4, 5, 8              | SINGLE SHOT                                 |                          |                      |         |                      |
| 200 FT. RADIUS         | REFLEX                             | 1/6          | 1, 3, 4, 5, 8              | 2 TO 8                                      |                          |                      |         |                      |
| 7/23 MILES/20          | REFLEX                             | 1000         | 1, 6, 7, 8                 | 100                                         |                          |                      |         |                      |
| REP 4 MILES/5 MILES    | REFLEX                             | 1380         | 1, 6, 7, 8                 | 80                                          |                          |                      |         |                      |
| REP 5 MILES/5 MILES    |                                    |              | 1, 6, 7, 8                 |                                             |                          |                      |         |                      |
| ...                    | REFLEX                             | 24/124       | 1, 3, 4, 5, 8              | 4/12/24                                     |                          |                      |         |                      |
| ...                    | ELECTRO-OPTICAL                    | 4/6          | 1, 3, 4, 5, 8              | SINGLE RELEASE                              |                          |                      |         |                      |
|                        | LASER DESIG.                       |              |                            | SINGLE RELEASE                              |                          |                      |         |                      |
| N/A                    | OPTICAL                            | 3 RDS.       | 1, 3, 4, 5, 8              | SINGLE SHOT                                 |                          |                      |         |                      |
| N/A                    | OPTICAL                            | 4 RDS.       | 1, 3, 4, 5, 8              | SINGLE SHOT                                 |                          |                      |         |                      |
| N/A                    | OPTICAL                            | 30 RDS.      | 1, 8                       | UNK                                         |                          |                      |         |                      |
| N/A                    | OPTICAL                            | 200          | 1, 6, 7, 8                 | 20 RDS.                                     |                          |                      |         |                      |
| N/A                    | OPTICAL                            | N/A          | 1, 3, 4, 5, 8              | N/A                                         |                          |                      |         |                      |
| N/A                    | OPTICAL                            | N/A          |                            | N/A                                         |                          |                      |         |                      |
| N/A                    | OPTICAL                            | N/A          |                            | N/A                                         |                          |                      |         |                      |
| 50 M X 2 M X 60°       | N/A                                |              | 1, 8                       |                                             |                          |                      |         |                      |
| 30 M RADIUS            | N/A                                |              | 1, 8                       | SINGLE                                      |                          |                      |         |                      |
| N/A                    | N/A                                |              | 1, 3, 4, 5, 8              | SINGLE                                      |                          |                      |         |                      |
|                        |                                    |              | 1, 3, 4, 5, 8              | SINGLE                                      |                          |                      |         |                      |

|                                   |                       |                      |                                                                        |                             |              |             |                   |       |
|-----------------------------------|-----------------------|----------------------|------------------------------------------------------------------------|-----------------------------|--------------|-------------|-------------------|-------|
| M82 MG (50) CUPOLA                | LINK BELT             | GAS RECOIL/AUTO      | 1800                                                                   | 800/1000                    | 3000 M       | 800         |                   |       |
| M82 GUN (DN-1)                    | MANUAL                | ELECTRIC/SS          | 4400 M                                                                 | 3000                        |              | N/A         |                   |       |
| M8 COAX (7.62)                    | LINK BELT             | GAS RECOIL/AUTO      | 900 M                                                                  | 800/1100                    | 1100 M       | 800         | 100/RPM           | 3     |
| M8 CUPOLA (7.62) M82              | LINK BELT             | GAS RECOIL/AUTO      | 1800 M                                                                 | 800/1000                    | 3000 M       | 800         | 40 RPM            | 4     |
| 152 GUN/ASLT (M82/M27) (HERCULES) | MANUAL                | ELECTRIC/SS          | 2800                                                                   | 2000/2000                   | 2000 M       | N/A         | N/A               |       |
| SHILLELAGH MISSILE                | MANUAL                | ROCKET/SS            | 3000                                                                   | 3000/7000                   | 3000 M       | N/A         | N/A               |       |
| M8 MG (50) TURNET                 | LINK BELT             | RECOIL/AUTO          | 6000                                                                   | 800/1600                    | 1600 M       | 800         | 40 RPM            |       |
| M82 1/2 (50) CUPOLA               | LINK BELT             | RECOIL/AUTO          | 1400                                                                   | 800/1400                    | 1800 M       | 800         | 40 RPM            |       |
| M8 COAX (7.62)                    | LINK BELT             | GAS /AUTO            | 900                                                                    | 800/1100                    | 1100 M       | 800         | 100/RPM           |       |
| AIR DEFENSE                       |                       |                      |                                                                        |                             |              |             |                   |       |
| ARDEYE/STINGER MISSILE            | ONE SHOT - DISPOSABLE | SHOOT - THROW AWAY   | 6000 METERS                                                            | 4000 METERS                 | 3000 METERS  | 1/10 SEC    | SINGLE SHOT       |       |
| VULCAN 20 MM GUN                  | LINKLESS              | ELEC. GATLING/AUTO   | 3000 METERS                                                            | 1800 METERS                 | 1600 METERS  | 3000        | 2000 RPM          | 10/30 |
| CHAPARRAL MISSILE                 | ONE SHOT              | ROCKET               | 6000                                                                   | 4600 METERS                 | 4500 METERS  | 1/8 SEC     | 1/4 SEC.          |       |
| ROLAND II MISSILE                 | MAGAZINE              | ROCKET               | 6000                                                                   | 4600 METERS                 | 4800 METERS  | 1/4 SEC.    | 1/4 SEC.          |       |
| AIRCRAFT                          |                       |                      |                                                                        |                             |              |             |                   |       |
| AM-1 ADV AT/HC                    |                       |                      |                                                                        |                             |              |             |                   |       |
| M8 (7.62) M134 GATLING            | LINK BELT             | ELECT. GATLING/AUTO  | 3200 M                                                                 | 800/1100                    |              | 2000        | 2000 RPM          | 4     |
| M82 20 MM/250 MM GUN GATLING      | LINK BELT             | ELECT. GATLING/AUTO  | 3750 M                                                                 | 1800/1800                   |              | 750 RPM     | 100-200/BURST     |       |
| 40 MM GR LCHW                     | LINK BELT             | ELECTRIC/AUTO        | 2000 M                                                                 | 1200/1300                   |              | 400 RPM     | 400 RPM           |       |
| 2.75 ROCKET                       | POD LOADED            | ROCKET/REPLISIVE     | 9300 M                                                                 | 2000                        |              | 21-38       | 6 PAIRS/SEC.      | 6     |
| EXT. RANGE TOW                    | RACK LOADED           | ROCKET / SS          | 3750 M                                                                 | 3750/3750                   |              | SINGLE SHOT | N/A               |       |
| (M-1) JATTAS                      |                       |                      |                                                                        |                             |              |             |                   |       |
| M8 (7.62)                         | LINK BELT             | GAS / AUTO           | 3725 M                                                                 | 800/1100                    |              | 800         |                   |       |
| OH-6A/ADV SCT HIGHTER             |                       |                      |                                                                        |                             |              |             |                   |       |
| M3 (7.62) GATLING                 | LINK BELT             | ELECT. GATLING/AUTO  | 3725 M                                                                 | 800/1100                    |              | 2000        | N/A               |       |
| EXT. RANGE TOW (ASH)              | RACK LOADED           | ROCKET/SS            | 3750 M                                                                 | 3750/3750                   |              | SINGLE SHOT | N/A               |       |
| HELLFIRE (AAM)                    | RACK LOADED           | ROCKET/SS            | 5000 DIRECT / 7000 INDIRECT                                            | 5000 DIRECT / 7000 INDIRECT |              | SS          |                   |       |
| ATTACK/FLIGHTER (USABT)           |                       |                      |                                                                        |                             |              | N/A         |                   |       |
| MAVERICK                          | RACK LOADED           | ROCKET/SS            | 13 MILES ALT.                                                          | 4000                        |              | N/A         | 14/3              |       |
| ROCKEYE (CLUSTER BOMB)            | RACK LOADED           | FREE FALL/MULT. REL. | 6000 FT. ALT.                                                          | 3000                        |              | N/A         | N/A               |       |
| 20 MM GUN                         | LINK BELT             | ELECT. GATLING/AUTO  | 4000 M                                                                 | 1800                        |              | 8000 RPM    | 6000 RPM          |       |
| 30 MM GUN                         | LINK BELT             | HYD. GATLING/AUTO    | 4000 M                                                                 | 3000                        |              | 2000-4000   |                   |       |
| BOMBS                             | RACK LOADED           | FREE FALL/MULT. REL. | 6000 FT. ALT.                                                          | 3000                        |              | N/A         | N/A               |       |
| WALLEYE GBU-11                    | RACK LOADED           | GLIDE FALL/SGL. REL. | 10,000 FT. ALT.                                                        | 8000                        |              | N/A         | N/A               |       |
| LASER GUIDED BOMBS                | RACK LOADED           | FREE FALL/SGL. REL.  |                                                                        | 18,000                      |              | N/A         |                   |       |
| ENEMY WEAPONS                     |                       |                      |                                                                        |                             |              |             |                   |       |
| SAGGER (ATOM)                     | MANUAL                | ROCKET/SS            | 3000 METERS                                                            | 3000                        | 3000 METERS  | N/A         | SINGLE SHOT       |       |
| BMP (APC)                         |                       |                      |                                                                        |                             |              | N/A         |                   |       |
| SAGGER                            | MANUAL                | ROCKET/SS            | 3000 METERS                                                            | 3000                        | 3000 METERS  | N/A         | SINGLE SHOT       |       |
| 73 MM GUN                         | MANUAL                | RECOIL/SS            | 1000 METERS                                                            | 1000                        | 1000 METERS  | LINK        | LINK              |       |
| ZSU-23-4                          | LINK BELT             | GAS/AUTO             | 7000 METERS                                                            | 2800                        | 2500 METERS  | 2000        | 200 RPM           |       |
| LASER GUIDED WEAPONS              |                       |                      |                                                                        |                             |              |             |                   |       |
| GROUND L.L.D.                     | N/A                   | CONT. FLASH/AUTO     | 10TH RANKING                                                           | 3000                        | 3K DESIGNATE | N/A         | N/A               |       |
| AIRBORNE L.L.D.                   | N/A                   | CONT. FLASH/AUTO     | 8K DESIGNATE                                                           | 3000                        | 3K DESIGNATE | N/A         | N/A               |       |
| LT. WT. L.D.                      | N/A                   | CONT. FLASH/AUTO     | 3K DESIGNATE                                                           | 1000                        | 1K DESIGNATE | N/A         | N/A               |       |
| LANDMINES                         |                       |                      |                                                                        |                             |              |             |                   |       |
| M163 ANTI-PERS (CLAYMORE)         | N/A                   | N/A/AUTO             | 90 METERS                                                              | 30                          | 90 METERS    | N/A         | N/A               |       |
| M16 ANTI-PERS                     | N/A                   | N/A/AUTO             | 30 METERS                                                              | 30                          | 30 METERS    | N/A         | N/A               |       |
| M21 ANTI-TANK                     | N/A                   | N/A/AUTO             | POINT TARGET                                                           | POINT TARGET                | POINT TARGET | N/A         | N/A               |       |
| HCPT DEL. AT                      |                       |                      |                                                                        |                             |              |             |                   |       |
| ARTY DEL. AP                      |                       |                      |                                                                        |                             |              |             |                   |       |
| ARTY DEL. AT                      |                       |                      |                                                                        |                             |              |             |                   |       |
| VEH DEL. AT/AP                    |                       |                      |                                                                        |                             |              |             |                   |       |
| INDIRECT FIRE                     |                       |                      |                                                                        |                             |              |             |                   |       |
| COMV. ROUNDS                      |                       |                      |                                                                        |                             |              |             |                   |       |
| 81 MM MORTAR                      | MANUAL GRAVITY        | GRAVITY/SS           | 1814 1000<br>2872 1819<br>4737 3150<br>6717 5572<br>8650 6490<br>10520 | 4000                        |              |             | 30 PER MIN. FOR 1 |       |
| 4.2 INCH MORTAR                   | MANUAL GRAVITY        | GRAVITY/SS           |                                                                        | 8000                        |              |             | 18 PER MIN. FOR 1 |       |
| 105 MM HOW.                       | MANUAL                | RECOIL. MAN/SS       | 11,000 M                                                               | 11,000                      |              | N/A         | 10 PER MIN. FOR 1 |       |
| 155 MM HOW.                       | MANUAL HYDRAULIC      | RECOIL. MAN/SS       | 14,000 M                                                               | 14,000                      |              |             | 4 PER MIN. FOR 1  |       |
| 8 INCH CANNON                     | MANUAL HYDRAULIC      | MANUAL/SS            | 16,000 M                                                               | 16,000                      |              |             | 2 PER MIN. FOR 1  |       |
| CHEMICAL WEAPONS                  |                       |                      |                                                                        |                             |              |             |                   |       |
| NUCLEAR WPN EFF                   | SPK                   |                      |                                                                        |                             |              |             |                   |       |
| TARGETS                           |                       |                      |                                                                        |                             |              |             |                   |       |
| 1. INDIVIDUAL SOLDIER (UNARMED)   |                       |                      |                                                                        |                             |              |             |                   |       |
| 2. ANTITANK WEAPONS               |                       |                      |                                                                        |                             |              |             |                   |       |
| 3. ARMORED PERSONNEL CARRIERS     |                       |                      |                                                                        |                             |              |             |                   |       |
| 4. TANKS                          |                       |                      |                                                                        |                             |              |             |                   |       |
| 5. AIR DEFENSE WEAPONS            |                       |                      |                                                                        |                             |              |             |                   |       |
| 6. HELICOPTERS                    |                       |                      |                                                                        |                             |              |             |                   |       |
| 7. ATTACK/FLIGHTER AIRCRAFT       |                       |                      |                                                                        |                             |              |             |                   |       |
| 8. WHEELED VEHICLES               |                       |                      |                                                                        |                             |              |             |                   |       |

|            |                |                  |                    |                                        |                                 |               |                                     |                                  |              |
|------------|----------------|------------------|--------------------|----------------------------------------|---------------------------------|---------------|-------------------------------------|----------------------------------|--------------|
|            | 1/25           | API BT/RJD       | IMPACT             | N/A                                    | OPTICAL                         | 2200          | 1,6,7                               | 20 RDS.                          |              |
|            | 1/25           | BT/APAPUOBL      | IMPACT             | N/A                                    | OPEN                            | 800           | 1,6,7,8                             | 20 RDS.                          |              |
|            | 50/200         | HE HEAT TP       |                    | N/A                                    | OPTICAL                         | 33            | 1,3,4,5,6                           | SINGLE SHOT                      | 33/90 RDS.   |
|            | 50/200         | ATSM             | IMPACT             |                                        | OPTICAL                         | 13            | 1,3,4,5,6                           | SINGLE SHOT                      | 13/9 RDS.    |
|            | 1/25           | BT/APAPUOBL      | IMPACT             | N/A                                    | OPEN                            | 900           | 1,6,7,8                             | 20 RPM                           | 1300 RDS.    |
|            | 1/25           | BT/APAPUOBL      | IMPACT             | N/A                                    | OPEN                            | 1080          | 1,6,7,8                             | 30 RPM                           | 1300 RDS.    |
|            | 1/25           | BT/APAPUOBL      | IMPACT             | N/A                                    | OPTICAL                         | 3080          | 1,6,7                               | 20 RPM                           | 600 RDS.     |
|            |                |                  |                    |                                        |                                 |               |                                     |                                  |              |
| SEC.       | 300/500 METERS |                  | IMPACT             | N/A                                    | OPEN                            | 6 PER TEAM    | 6,7                                 | SINGLE SHOT                      | 6 PER TEAM   |
|            | 300/250 METERS | HEIT-SD          | IMPACT             | N/A                                    | OPTICAL                         | 900/1800      | 1,6,7,8                             | 60 RDS./BURST                    | 1000/200     |
|            | 800 METERS     | HE               | PROXIMITY          | N/A                                    | OPTICAL                         | 12 PER TRACK  | 6,7                                 | 1 EVERY 10 SEC.                  | 12 PER TRACK |
|            | 800 METERS     | SHAPE CHANGE     | PROXIMITY          | N/A                                    | OPTICAL                         | 6 PER Y TRACK | 6,7                                 | 1 EVERY 10 SEC.                  | 3 PER TRACK  |
|            |                |                  |                    |                                        |                                 |               |                                     |                                  |              |
|            | 0              | BT               | N/A                | N/A                                    | OPTICAL                         | 3000          | 1,6,7                               | 200 RDS.                         |              |
|            | 0              | AP/NEI           | IMPACT             | 20x50M/20x30M                          | OPTICAL                         | 900           | 2,6,7,8                             | 300/100                          |              |
|            | 300 M          | HEDP XM 430      | IMPACT             | 40 X 60 M                              | OPTICAL                         | 288           | 1,                                  | 7 RDS                            |              |
|            | 300 M          | XM 241/XM 261    | IMPACT/TIME RE.    | 10x100M                                | OPTICAL                         | 14/28/34/76   | 1,6,7,8                             | 2                                |              |
|            | 300 M          | SHAPE CHANGE     | IMPACT             | N/A                                    | OPTICAL WIRE                    | 1             | 1,3,4,5,6                           | SINGLE SHOT                      |              |
|            |                |                  |                    | N/A                                    |                                 | 800           | 1,6,7                               | 20 RDS.                          |              |
|            |                |                  |                    |                                        |                                 | 2000          |                                     | 0                                |              |
|            | 300 M          | SHAPE CHANGE     | IMPACT             | N/A                                    | OPTICAL REFLEX                  | 4/8           | 1,6,7                               | 80 RDS.                          |              |
|            | 50/200 M       | SHAPE CHANGE     | IMPACT             | N/A                                    | OPTICAL                         | 4/8           | 1,3,4,5,6                           | SINGLE SHOT                      |              |
|            |                |                  |                    | N/A                                    | OPTICAL                         |               | 1,3,4,5,6                           | SINGLE SHOT                      |              |
|            | 3000 FT. ALT.  | SHAPE CHANGE     | IMPACT             | N/A                                    | ELECTROOPTICAL                  | 4/8           | 1,3,4,5,6                           | SINGLE SHOT                      |              |
|            | 4-500 FT. ALT. | 250-600 BOMBLETS | IMPACT             | 200 FT. RADIUS                         | REFLEX                          | 1/8           | 1,3,4,5,6                           | 2 TO 8                           |              |
|            | 0              | AP/NEI           | IMPACT             | REP'S MILLS/RED                        | REFLEX                          | 1000          | 1,6,7,8                             | 100                              |              |
|            | 0              | HEDP             | IMPACT             | REP'S MILLS/2 MILLS<br>REP'S MILLS/RED | REFLEX                          | 1380          | 1,6,7,8                             | 80                               |              |
|            |                |                  |                    |                                        |                                 |               | 1,6,7,8                             |                                  |              |
|            | 0              | MK82/EJ/M        | IMPACT             | ...                                    | REFLEX                          | 24/12/4       | 1,3,4,5,6                           | 4/12/24                          |              |
|            | 0              | MK82/BM          | IMPACT             | ...                                    | ELECTRO-OPTICAL<br>LASER DESIG. | 4/8           | 1,3,4,5,6                           | SINGLE RELEASE<br>SINGLE RELEASE |              |
| BMM        | 900 METERS     | SHAPE CHANGE     | IMPACT             | N/A                                    | OPTICAL                         | 3 RDS.        | 1,3,4,5,6                           | SINGLE SHOT                      |              |
| BMM        | 900 METERS     | SHAPE CHANGE     | IMPACT             | N/A                                    | OPTICAL                         | 4 RDS.        | 1,3,4,5,6                           | SINGLE SHOT                      |              |
| UNL        | UNL            | HEAT             | IMPACT             | N/A                                    | OPTICAL                         | 30 RDS.       | 1,8                                 | UNL                              |              |
| UNL        | UNL            | API              | IMPACT             | N/A                                    | OPTICAL                         | 3000          | 1,6,7,8                             | 20 RDS                           |              |
|            |                |                  |                    |                                        |                                 |               | 1,3,4,5,6                           |                                  |              |
| 300 METERS | LASER          | N/A              | N/A                | N/A                                    | OPTICAL                         | N/A           |                                     | N/A                              |              |
| 300 METERS | LASER          | N/A              | N/A                | N/A                                    | OPTICAL                         | N/A           |                                     | N/A                              |              |
| 300 METERS | LASER          | N/A              | N/A                | N/A                                    | OPTICAL                         | N/A           |                                     | N/A                              |              |
|            | NONE           | HE               |                    | 50 M X 2 M X 60P                       | N/A                             |               | 1,8                                 |                                  |              |
|            | NONE           | HE               | 50% W/R 304 RADIUS | 30 M RADIUS                            | N/A                             |               | 1,8                                 | SINGLE                           |              |
|            | NONE           | HE               |                    | N/A                                    | N/A                             |               | 1,3,4,5,6                           | SINGLE                           |              |
|            |                |                  |                    |                                        |                                 |               | 1,3,4,5,6                           | 81R/L                            |              |
|            |                |                  |                    |                                        |                                 |               | 1,8                                 |                                  |              |
|            |                |                  |                    |                                        |                                 |               | 1,3,4,5,6                           |                                  |              |
|            |                |                  |                    |                                        |                                 |               | 5,5,4,5,6                           |                                  |              |
|            |                |                  |                    |                                        |                                 |               | 1,3,5,6                             |                                  |              |
|            |                |                  |                    |                                        |                                 |               | 1,3,5,6                             |                                  |              |
|            | 40 37%         | HE ILLUM         | 20 M DIA           |                                        |                                 |               | 1,3,5,6                             |                                  |              |
|            | 75 50          | HP ILLUM         | 34 1100            |                                        |                                 |               | 1,3,5,6                             |                                  |              |
|            | 75 100         | HP ILLUM         | 34 1100            | 34 M DIA.                              | N/A                             | 80/1161       | 1,3,5,6                             | 35/20 RPM                        |              |
|            | 75 87          | HE ILLUM         | 40 x 20 (H-E)      | 30 X 40 M                              | N/A                             | 90/1801       | 1,3,5,6                             | 10/0 RPM                         |              |
|            | 370 600        | WE ILLUM         | 1300 DIA (I)       | 30 X 30 M                              | N/A                             | 72            | 1,3,5,6                             | 10/3 RPM                         |              |
|            | 1000 M         | HE/CM            | IMPACT             | 30 X 50 M                              | N/A                             | 20            | 1,3,5,6                             | 4/1 RPM                          |              |
|            | 2000 M         | HE/CM            | IMPACT             | 30 X 50 M                              | N/A                             | 2             | 1,3,4,5,6                           | 1 RPM                            |              |
|            | 3000 M         | HE/CM            | IMPACT             | 30 X 80 M                              | N/A                             |               | 1,                                  |                                  |              |
|            |                |                  |                    | ICM                                    |                                 |               | 1                                   |                                  |              |
|            |                |                  |                    | 150-150 M DIA                          |                                 |               |                                     |                                  |              |
|            |                |                  |                    | 155-120 M DIA                          |                                 |               |                                     |                                  |              |
|            |                |                  |                    | 8"-130 M DIA                           |                                 |               |                                     |                                  |              |
|            |                |                  |                    |                                        |                                 |               | ...                                 |                                  |              |
|            |                |                  |                    |                                        |                                 |               | MAE P <sup>2</sup> P <sup>2</sup> S |                                  |              |
|            |                |                  |                    |                                        |                                 |               | S                                   | P                                | T            |
|            |                |                  |                    |                                        |                                 |               | 5                                   | 9                                | 7            |
|            |                |                  |                    |                                        |                                 |               | MK82                                | 30,000                           | 15,000       |
|            |                |                  |                    |                                        |                                 |               | MK81                                | 50,000                           | 24,000       |
|            |                |                  |                    |                                        |                                 |               | MK81                                |                                  | 2500         |
|            |                |                  |                    |                                        |                                 |               |                                     |                                  | 5000         |
|            |                |                  |                    |                                        |                                 |               |                                     |                                  | K2.3/        |
|            |                |                  |                    |                                        |                                 |               |                                     |                                  | K3.6/        |



**TABLE 1-2**

GT II TEST PLAN  
ORGANIZATION/HARDWARE[illegible]

| 50 Cal                                                                           |                                                               |   |          |   |          |   |          |   |          | 1 Platoon |  |           |         |          |     |                           |  |  |  |  |  |
|----------------------------------------------------------------------------------|---------------------------------------------------------------|---|----------|---|----------|---|----------|---|----------|-----------|--|-----------|---------|----------|-----|---------------------------|--|--|--|--|--|
| DRAGON (A17C5)<br>(Have M16D but do not have<br>M16A1 Rifles)                    | 1                                                             | 1 | 1        | 1 | 1        | 1 | 1        | 1 | 1        | 1 Platoon |  | 10        | (17A54) | 10 (2)   | 12  | M16<br>Adapter Kit<br>120 |  |  |  |  |  |
|                                                                                  | 1 Platoon                                                     |   |          |   |          |   |          |   |          |           |  |           |         | 20 (3)   | 23  |                           |  |  |  |  |  |
| VIPER (A17C7)<br>(Riflemen with M16A1 Rifles<br>and M16Ds)                       | 2                                                             | 2 | 2        | 2 | 2        | 2 | 2        | 2 | 2        | 2 Platoon |  | 20        | (17A56) |          |     |                           |  |  |  |  |  |
| M16A1 Rifles (5.56 mm)<br>(Part of A17A60)                                       | 8 Rifles                                                      |   | 8 Rifles |   | 8 Rifles |   | 8 Rifles |   | 8 Rifles |           |  |           |         |          |     |                           |  |  |  |  |  |
| Squad Leader (1)<br>Team Leader (2)<br>Individual<br>Rifleman (5)                | 8                                                             | 8 | 8        | 8 | 8        | 8 | 8        | 8 | 8        |           |  |           |         |          |     |                           |  |  |  |  |  |
| None for APC Driver<br>None for DRAGON Gunner<br>None for 2 Man Machine Gun Team | 1<br>(Platoon<br>Leader)                                      |   | 1        |   | 1        |   | 1        |   | 1        |           |  |           |         |          |     |                           |  |  |  |  |  |
|                                                                                  | 11 Platoon (Platoon Sgts., RTDs,<br>Comm. Section Personnel)  |   |          |   |          |   |          |   |          |           |  |           |         |          |     |                           |  |  |  |  |  |
| M60 Machine Gun (7.62 mm)<br>(A17A61)                                            | 1                                                             | 1 | 1        | 1 | 1        | 1 | 1        | 1 | 1        | 1 Platoon |  |           |         | 10 (2)   | 12  |                           |  |  |  |  |  |
| M16D<br>(Part of A17A60)*                                                        | Tank<br>Crew                                                  |   |          |   |          |   |          |   |          |           |  | 10        |         |          |     |                           |  |  |  |  |  |
|                                                                                  |                                                               |   |          |   |          |   |          |   |          |           |  | 2 Platoon |         |          |     |                           |  |  |  |  |  |
| M60 MG                                                                           | 1                                                             | 1 | 1        | 1 | 1        | 1 | 1        | 1 | 1        | 2 Platoon |  | 10        |         | 190 (10) | 200 |                           |  |  |  |  |  |
| TOW<br>Crews                                                                     | 8                                                             |   | 8        |   | 8        |   | 8        |   | 8        |           |  |           |         |          |     |                           |  |  |  |  |  |
| DRAGON<br>Crews                                                                  | 1                                                             | 1 | 1        | 1 | 1        | 1 | 1        | 1 | 1        | 1 Platoon |  |           |         |          |     |                           |  |  |  |  |  |
| Leaders and Riflemen                                                             | 3                                                             | 3 | 3        | 3 | 3        | 3 | 3        | 3 | 3        |           |  |           |         |          |     |                           |  |  |  |  |  |
|                                                                                  | 1<br>Platoon<br>Leader                                        |   |          |   |          |   |          |   |          |           |  |           |         |          |     |                           |  |  |  |  |  |
| Squad Leader (1)<br>Team Leader (2)<br>Riflemen (5)                              | 26 Platoon (Platoon Sgts., RTDs,<br>Comm. Sect., Maintenance) |   |          |   |          |   |          |   |          |           |  |           |         |          |     |                           |  |  |  |  |  |

2

The total ED contractually required hardware was derived from table 1-2 and is shown in matrix form in table 1-3. The organization of this chart is by system and by assemblies within the systems. This matrix shows the mix of assemblies and the type of adapters required. The field tester shown in table 1-3 was eliminated as a requirement after OT II and prior to OT III testing.

The ED MILES systems are shown conceptually in figures 1-1 through 1-3. The major assemblies that are used throughout the various MILES systems are depicted in figure 1-4.

Table 1-4, Nomenclature, is included as an aid to the reader. The MILES official nomenclature is compared to the common names which are used throughout the text.

Table 1-3. ED Hardware Matrix

[illegible]

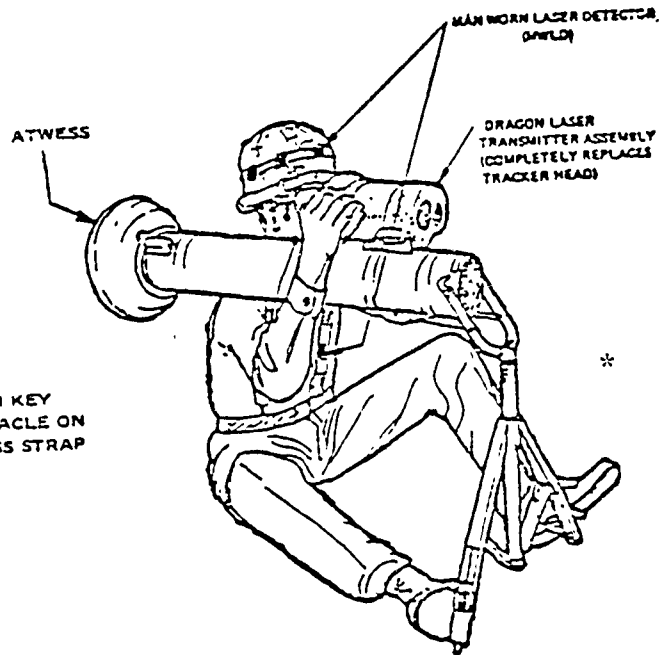
**Notes:** 1. The M60A2 system is designed but no hardware fabrication (or I.D.).

2. One M60A1 system to be assigned as one National Reconnaissance Company.
2. 32 MidAL Rifle systems are in JOM APC subsystem
2. One assembly, chamber mounted, includes all weapon simulators thus above.

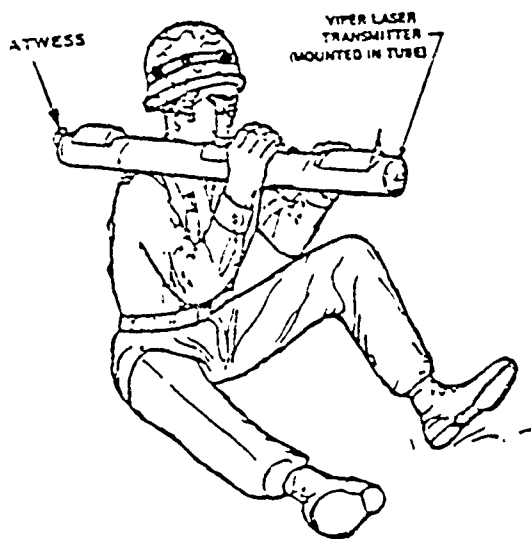




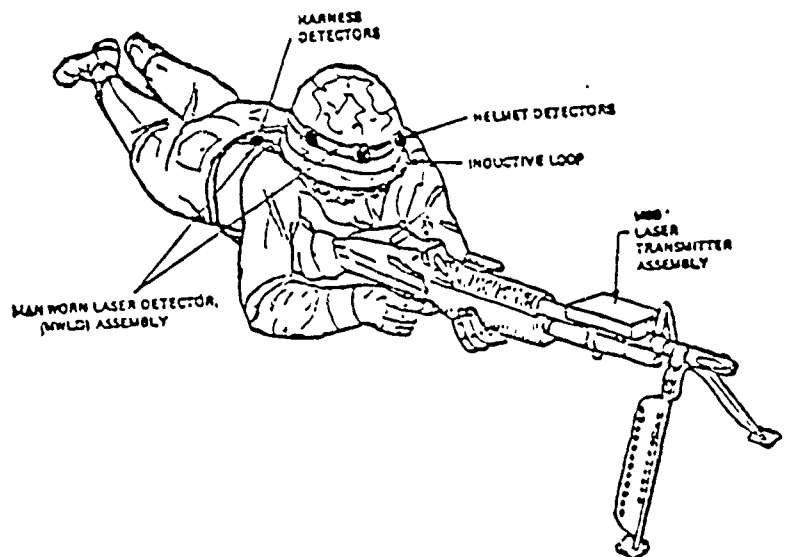
M16A1 RIFLE SYSTEM (A17A60)



DRAGON MISSILE SYSTEM (A17C5)

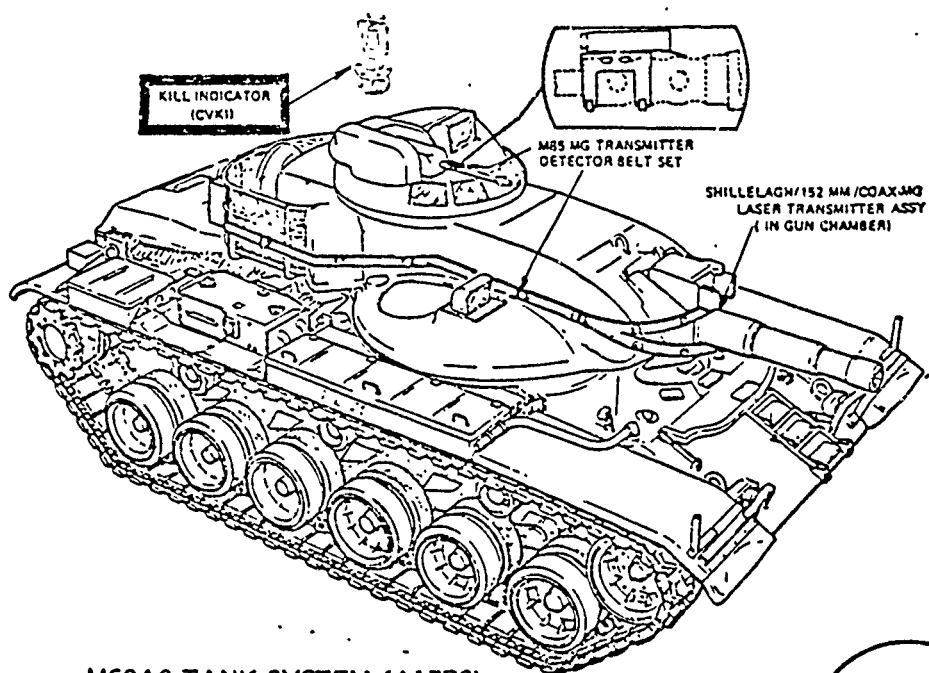


VIPER SYSTEM (A17C7)

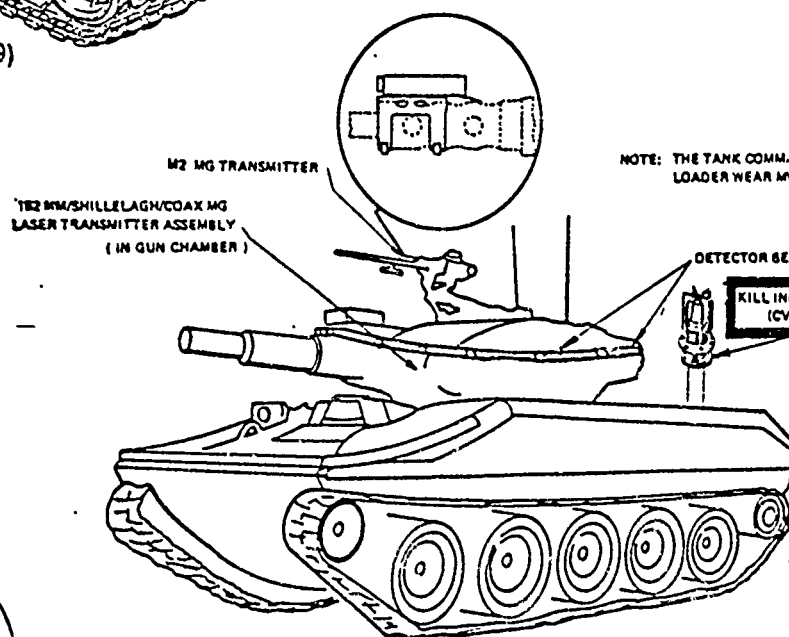


M60 MACHINE GUN SYSTEM (A17A61)

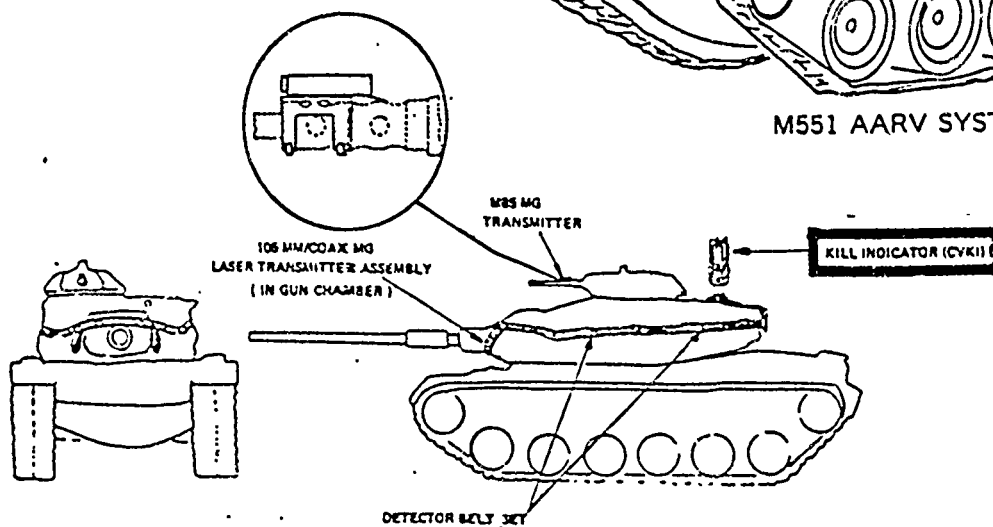
Figure 1-1. MILES Man-Carried Systems



M60A2 TANK SYSTEM (A17B9)

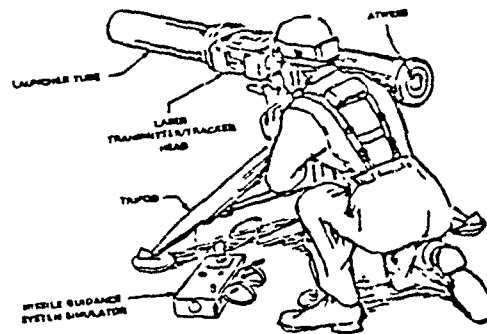


M551 AARV SYSTEM (A17B10)

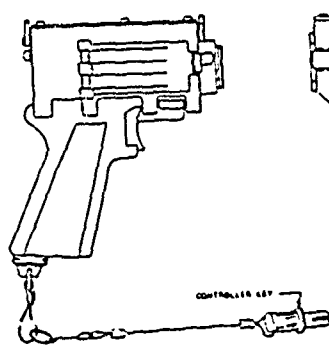


M60A1/A3 TANK SYSTEM (A17B8)

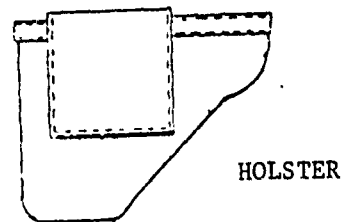
Figure 1-2. MILES Tank Systems



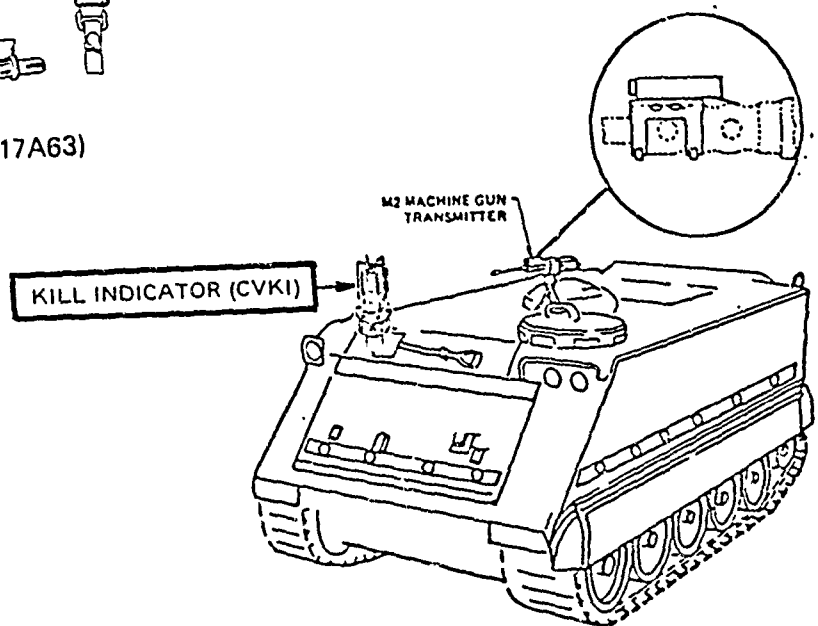
TOW SYSTEM



CONTROLLER GUN (A17A63)



HOLSTER \*



M113 APC/M2 SYSTEM (A17A62)

Figure 1-3. MILES Controller Gun, M113 Vehicle, and TOW Systems

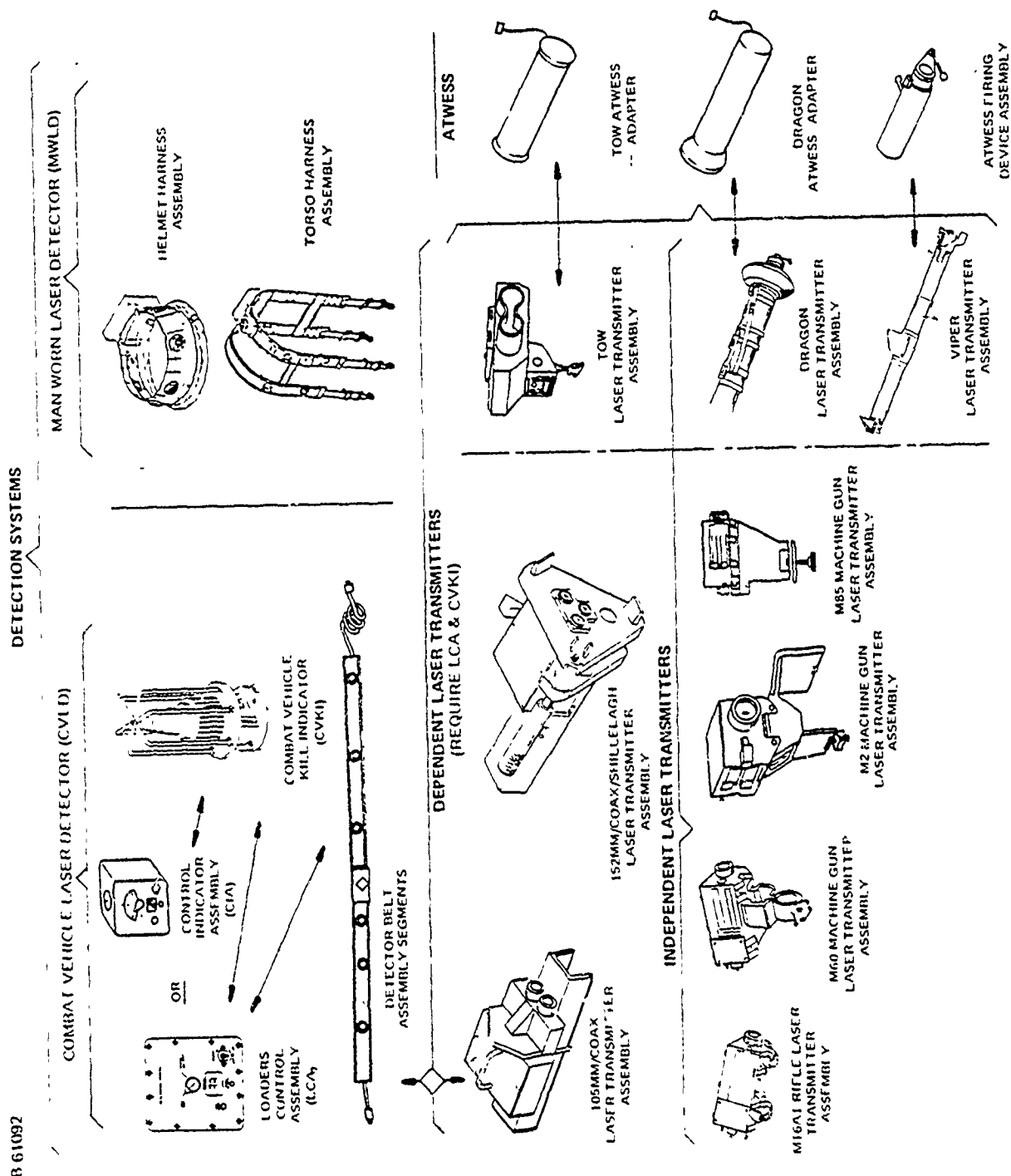


Figure 1-4. MILES Major Assemblies

Table 1-4. Nomenclature

| MILES<br>OFFICIAL NOMENCLATURE                                 | MILES<br>COMMON NAME(S)                                      |
|----------------------------------------------------------------|--------------------------------------------------------------|
| Simulator System, Firing, Laser: XM60 for M16A1 Rifle          | M16A1 Rifle Transmitter System<br>M16 Rifle System           |
| Simulator System, Firing, Laser: XM61 for M60 Machine Gun      | M60 Machine Gun Transmitter System<br>M60 Machine Gun System |
| Simulator System, Firing, Laser: XM63 for M113 APC             | M113 APC Simulator System<br>M113 APC System                 |
| Simulator System, Firing, Laser: XM65 for M60A1/A3 Tank        | M60A1/A3 Tank Simulator System<br>M60A1 Tank System          |
| Simulator System, Firing, Laser: XM66 for M60A2 Tank           | M60A2 Tank Simulator System<br>M60A2 Tank System             |
| Simulator System, Firing, Laser: XM67 for M551 Vehicle         | M551 Vehicle Simulator System<br>M551 Vehicle System         |
| Simulator System, Firing, Laser: XM62 for DRAGON Missile       | DRAGON Simulator System<br>DRAGON System                     |
| Simulator System, Firing, Laser, XM64 for TOW                  | TOW Simulator System<br>Independent TOW *                    |
| Simulator System, Firing, Laser: XM68 for LAW/VIPER Rocket     | VIPER Simulator System<br>VIPER System                       |
| Controllers Gun, Simulator System, Laser                       | Controller Gun                                               |
| Transmitter Assy, Simulator System, Laser: for M16A1 Rifle     | M16A1 Laser Transmitter<br>M16 Transmitter                   |
| Detector Assy, Simulator System, Laser: Man Worn               | Man Worn Laser Detector (MWLD)                               |
| Transmitter Assy, Simulator System, Laser: For M60 Machine Gun | M60 Machine Gun Laser Transmitter<br>M60 Transmitter         |
| Transmitter Assy, Simulator System, Laser: For M2 Machine Gun  | M2 Machine Gun Laser Transmitter<br>M2 Transmitter           |
| Console, Simulator System, Laser: For M113 APC                 | Control Indicator Assembly (CIA)<br>Control Indicator        |

Table 1-4. Nomenclature (Cont.)

| MILES<br>OFFICIAL NOMENCLATURE                                           | MILES<br>COMMON NAME(S)                                                                          |
|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| Indicator, Simulator System, Laser:<br>Combat Vehicle Kill/Hit/Miss      | Combat Vehicle Kill Indicator<br>(CVKI)                                                          |
| Transmitter Assy, Simulator System, Laser:<br>For M85 Machine Gun        | M85 Machine Gun Laser Transmitter<br>M85 Transmitter                                             |
| Transmitter Assy, Simulator System, Laser:<br>105MM/Coax                 | 105MM/Coax Laser Transmitter Assy<br>105MM/Coax Transmitter Assy                                 |
| Console, Simulator System, Laser: For<br>M113 TOW/M60 Tanks/MS51 Vehicle | Control Console<br>Loaders Control Assy (LCA)                                                    |
| Transmitter Assy, Simulator System, Laser:<br>For 152MM/Shillelagh/Coax  | 152MM/Coax/Shillelagh Laser<br>Transmitter Assembly<br>152MM/Coax/Shillelagh Transmitter<br>Assy |
| Transmitter Assy, Simulator System, Laser:<br>For DRAGON Missile         | DRAGON Laser Transmitter Assy<br>DRAGON Transmitter                                              |
| Transmitter Assy, Simulator System, Laser:<br>For TOW Missile            | TOW Laser Transmitter Assy<br>TOW Transmitter                                                    |

## SECTION 2

### DESIGN CONSTRAINTS

#### 2.1 INTRODUCTION

In the MILES system there were a number of constraints which impacted the design. These and other criteria are defined in the system specification NTEC No. 2234-122 and documents referenced in that specification. Among the more important design constraints were:

- a. False alarm rate
- b. Weapon characteristics to be simulated
- c. Eye safety limitations on transmitter power
- d. Design-to-unit-production costs (DTUPC)
- e. Temperature environment
- f. Power considerations

#### 2.2 FALSE ALARM RATE (FAR)

The NTEC Specification requires not more than one false hit per target system in 100 hours of field operation. This requirement is analyzed in Volume I and FAR rates established for the MILES systems. FAR and other important parameters derived from the system analysis are repeated in table 2-1. These criteria primarily affect the design of the detection system which is the heart of MILES.

#### 2.3 WEAPON CHARACTERISTICS

A major constraint on system design was that the weapon characteristics be accurately simulated. Range, rate of fire, ammunition loads, hit/kill effects, and audio-visual cues are some of the more critical characteristics essential to realistic simulation.

Table 2-2 lists the weapons simulated and their characteristics. The laser transmitter design parameters of power, beam size and coding were selected to accomplish the simulation.

The restraints imposed by weapon characteristics simulation directly affect laser transmitter commonality and, in turn, DTUPC. For example, the multiplicity of range requirements forced noncommonality of the laser transmitters from the standpoint of laser power and beam spread. This is an area where extensive tradeoffs were performed comparing cost in terms of performance.

#### 2.4 EYE SAFETY

Eye safety is governed by TB MED 279 criteria and was an overriding constraint on the laser output power and on the laser optics design. Table 2-3 shows the TB MED 279 eye safety limit criteria, eye safety information based on Letterman Army Institute of Research (LAIR) testing, and the XEOS laser parameters based on eye safety analysis.

TABLE 1-2  
CRITICAL PARAMETER SUMMARY

| Parameter                                                      | Condition                                                                                                  | Minimum                                | Nominal                              | Maximum                                                            |   |
|----------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|----------------------------------------|--------------------------------------|--------------------------------------------------------------------|---|
| Noise Equivalent Radiant Exposure                              | Sunlight and signal on 5 of 6 detectors                                                                    |                                        |                                      | 0.49 $\mu\text{ergs}/\text{cm}^2$                                  | * |
| Threshold/Noise Ratio                                          | Full sun                                                                                                   | 4.5 (TES)                              | 5.5                                  | 6.0                                                                |   |
| Signal-to-Noise Ratio                                          | ( $P_k = 90\%$ )                                                                                           | 7                                      | 7                                    | 11:1                                                               |   |
| False Alarm Rate FAR                                           | MWLD-full sun<br>CVLD-full sun                                                                             |                                        |                                      | $3.33 \times 10^{-5}/\text{hr}$<br>$2.50 \times 10^{-5}/\text{hr}$ |   |
| Irradiance (minimum required)                                  |                                                                                                            | 1.3 $\mu\text{W}/\text{cm}^2$          |                                      |                                                                    |   |
| Peak Emission Wavelengths                                      | -25°C to +62°C                                                                                             | 8650Å                                  | 9100Å                                | 9311Å                                                              | * |
| Detector Area                                                  |                                                                                                            | 1 $\text{cm}^2$<br>(1 detector)        |                                      | 8 $\text{cm}^2$<br>(8 detectors)                                   |   |
| Shot Noise Bandwidth                                           |                                                                                                            | 100 kHz                                |                                      |                                                                    |   |
| Amplifier/Detector Bandwidth for Signal                        |                                                                                                            |                                        |                                      |                                                                    | * |
| Johnson Noise Bandwidth                                        |                                                                                                            | 500 kHz                                |                                      |                                                                    |   |
| Transmitter Power Output (with sun loading and barrel heating) | 450M at 65°C<br>800M at 65°C<br>1000M at 65°C<br>2000M at 65°C<br>3000M at 65°C                            | 0.3W<br>0.8W<br>0.9W<br>1.26W<br>1.55W | 0.4W<br>0.9W<br>1.0W<br>1.5W<br>2.0W | 0.5W<br>1.0W<br>1.2W<br>2.0W<br>2.5W                               |   |
| Scintillation Signal Reduction                                 | $\geq 1000\text{M}$<br>5 detectors                                                                         | 20%                                    | 35%                                  | 45%                                                                |   |
| Optical Filter Sun Current Reduction                           | RG 830                                                                                                     | 70%                                    | 75%                                  | 80%                                                                |   |
| Protective Cover Sun Current Reduction (Incremental Effect)    | Optical filter already in place                                                                            | 17%                                    | 20%                                  | 23%                                                                | * |
| Optical Filter Laser Signal Reduction                          | RG 830 at 9040Å                                                                                            | 10%                                    | 11%                                  |                                                                    |   |
| EMI Filter Signal Reduction                                    |                                                                                                            | 14%                                    | 16%                                  |                                                                    |   |
| Protective Cover Signal Reduction                              |                                                                                                            | 9%                                     | 12%                                  | 14%                                                                | * |
| Code Weight                                                    |                                                                                                            | 6                                      | 6                                    | 6                                                                  |   |
| Number of Word Repeats                                         | Kill TES<br>VES<br>Near Miss TES<br>VLS                                                                    |                                        | 4<br>8<br>24<br>128                  |                                                                    |   |
| Cosine and Off Axis Losses                                     | 45° off axis                                                                                               | 30%                                    | 40%                                  | 50%                                                                |   |
| Laser Transmitter                                              | Present TB MEN 279 Maximum Output Energy per Pulse = 0.32 erg                                              |                                        |                                      | $7.5 \times 10^{-8}$ joules/ $\text{cm}^2$                         |   |
|                                                                | *Tentative LAIR eye safety conference ruling for MILES allows 5 ergs/pulse or 3.33 watts peak power output |                                        |                                      | *2.36 ergs/pulse<br>*1.57 watts peak power                         |   |
|                                                                | ED Baseline                                                                                                |                                        |                                      | 4.5 ergs/pulse maximum                                             |   |



TABLE 2-2

## WEAPON CHARACTERISTICS

| Weapons Simulated           | Used by                 | Store Basic Load (rounds) | Firing Rate (RPM) | Burst Limit (rounds) | Range of Simulator (Meters) |           |
|-----------------------------|-------------------------|---------------------------|-------------------|----------------------|-----------------------------|-----------|
|                             |                         |                           |                   |                      | Kill                        | Near Miss |
| <u>Short Range</u>          |                         |                           |                   |                      |                             |           |
| M161A1 Rifle                | Infantry                | 210                       | 650               | 30                   | 5/25 to 460                 | 460       |
| M60 Machine Gun             | Infantry                | 600/1800                  | 650               | 200                  | 5/25 to 800                 | 1100      |
| Coax Machine Gun            | Tanks                   | 1800                      | 650               | 200                  | 5/25 to 800                 | 1100      |
| M2/M85 Machine Gun          | Tanks                   | 1200                      | 650               | 200                  | 5/25 to 800                 | 1600      |
| <u>Anti-Armor</u>           |                         |                           |                   |                      |                             |           |
| Guns (Anti-tank)*:          |                         |                           |                   |                      |                             |           |
| 105 mm Gun                  | M60A1/A3 Tank           | 63                        | 12                |                      | 50/200 to 3000              | 3000      |
| 152 mm Gun                  | M60A2 and M551 AARV     | 33 and 20                 | 6                 |                      | 50/200 to 2000              | 2000      |
| <u>Missiles (Anti-tank)</u> |                         |                           |                   |                      |                             |           |
| Viper                       | Infantry                | 4                         | 6                 |                      | 10 to 300                   | 300       |
| Dragon                      | Infantry                | 10                        | 4                 |                      | 50/200 to 1000              | 1000      |
| TOW                         | Infantry and Helicopter | 10                        | 4                 |                      | 50/200 to 3000              | 3000      |
| Shillelagh                  | M60A2 and M551 AARV     | 13 and 9                  | 4                 |                      | 800 to 3000                 | 3000      |

\*:Defined to include "tank versus tank."

An eye safety analysis is included as Appendix A in Volume I. The analysis includes a report on the laser tests conducted by LAIR. Extensive analysis and design efforts were directed toward reducing the laser power required for the MILES systems.

TABLE 2-3  
EYE SAFETY CRITERIA

|                                | <u>TB MED<br/>Criteria</u> | <u>LAIR Tests<br/>Eye Safe</u> | <u>XEOS Design<br/>Baseline Values</u> |
|--------------------------------|----------------------------|--------------------------------|----------------------------------------|
| Short Range Laser Output Power | 1.57W                      | 3.33W                          | 0.8W                                   |
| Long Range Laser Output Power  | 1.57W                      | 3.33W                          | 3.0W                                   |
| Pulsewidth                     |                            |                                | 150 nsec.                              |
| Pulse Rate                     |                            |                                | 3.0 KHz                                |

## 2.5 DESIGN-TO-UNIT-PRODUCTION COST (DTUPC)

From the beginning of the first MILES Advanced Development (AD) program, DTUPC has been a major design constraint. The AD DTUPC goals expressed in June 1973 constant dollars are shown in table 2-4.

System cost as represented by DTUPC was a major design constraint throughout the program. No design decision was made without consideration of its impact upon the production unit costs. Cost tradeoffs were continually made to insure that DTUPC was minimized while at the same time the system performance criteria were met.

Since DTUPC was one of the first priority constraints on system design, tradeoffs were made whenever DTUPC goals were threatened. For example, the parts standardization program had a negative effect on DTUPC. The most cost effective approach was to use commercial components with the provision that the components and system satisfy the performance criteria of the specifications. Non-standard parts submittals were made for Government approval wherever DTUPC was a major factor in the decision. Table 2-5 is a December 1976 cost comparison of commercial components versus a MIL-SPEC equivalent. As can be noted from this abbreviated tradeoff chart, the MIL-SPEC standard components are three to five times the cost of the equivalent commercial component. DTUPC goals for the ED program and DTUPC estimates are included in Section 9.

TABLE 2-4  
DTUPC GOALS

| <u>Devices</u> | <u>Production<br/>Quantity</u> | <u>DTUPC Goal<br/>June 1973</u> |
|----------------|--------------------------------|---------------------------------|
| TES 17A30      | 20,000                         | \$520                           |
| MGL 17A33      | 4,000                          | \$525                           |
| VES 17A29      | 5,000                          | \$810                           |

TABLE 2-5  
COST COMPARISONS  
COMMERCIAL VERSUS MIL-SPEC COMPONENTS

| Commercial<br>Part No. | Unit Cost<br>Commercial<br>Part | Unit Cost<br>MIL-SPEC 883<br>B Screening<br>Equivalent Part |
|------------------------|---------------------------------|-------------------------------------------------------------|
| 14006 CP               | \$ .80                          | \$ 4.00                                                     |
| 14007 CP               | .20                             | 1.06                                                        |
| 14013 CP               | .35                             | 2.00                                                        |
| 14015 CP               | .70                             | 4.00                                                        |
| 14024 CP               | .60                             | 3.00                                                        |
| 14040 CP               | .60                             | 3.00                                                        |
| 14510 CP               | .70                             | 3.00                                                        |
| 14528 CP               | .80                             | 4.00                                                        |

Notes:

1. Parts are discrete electronic components used on ADM MJLES.
2. Vendor quotation was from Motorola, Inc.
3. Prices quoted were budgetary and based on production quantities of 10,000 units per lot.
4. Prices are from August 1976 time period.

## 2.6 TEMPERATURE ENVIRONMENT

Temperature constraints were imposed by the ambient environment defined in the system specification and AR 70-38; "Research, Development, Test, and Evaluation of Material for Extreme Climate Conditions," 1 July 1969. The applicable environments are summarized in table 2-6.

Added to the ambient air temperature are the effects of both solar heating and weapon heating due to the firing of blanks. These added effects were analyzed and verified in blank firing thermal tests and the results are included as Appendix B.

Calculated simulator temperatures for a hypothetical firing sequence (see figure 2-1) show an increase of 45 degrees F in a period of 16 minutes with an expenditure of 100 rounds of blank ammunition. Figure 2-2 is a revised chart showing actual laser diode temperature with respect to time using three different firing rates for the weapon.

As the detail design progressed, the computer model developed for temperature determinations was refined and used to analytically verify the thermal design of the final configuration.

56171

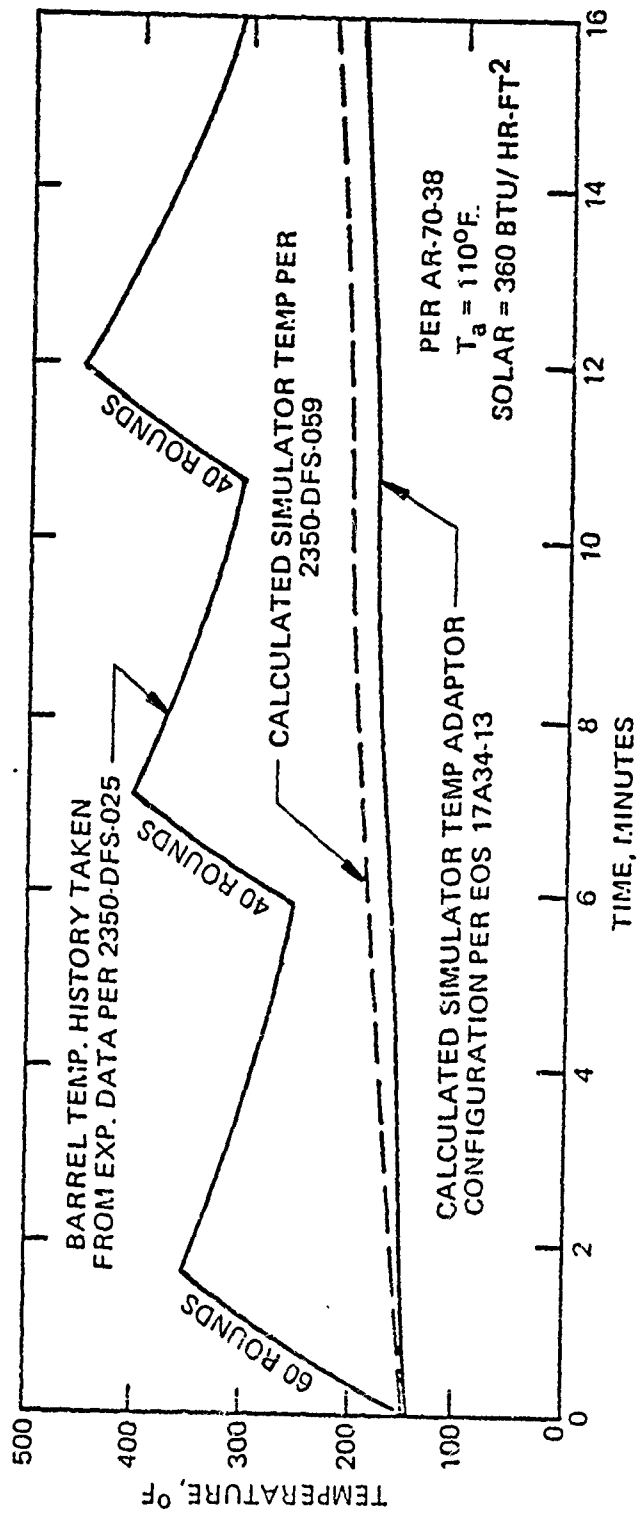


Figure 2-1. M16A1 Simulator Temperature History

60032

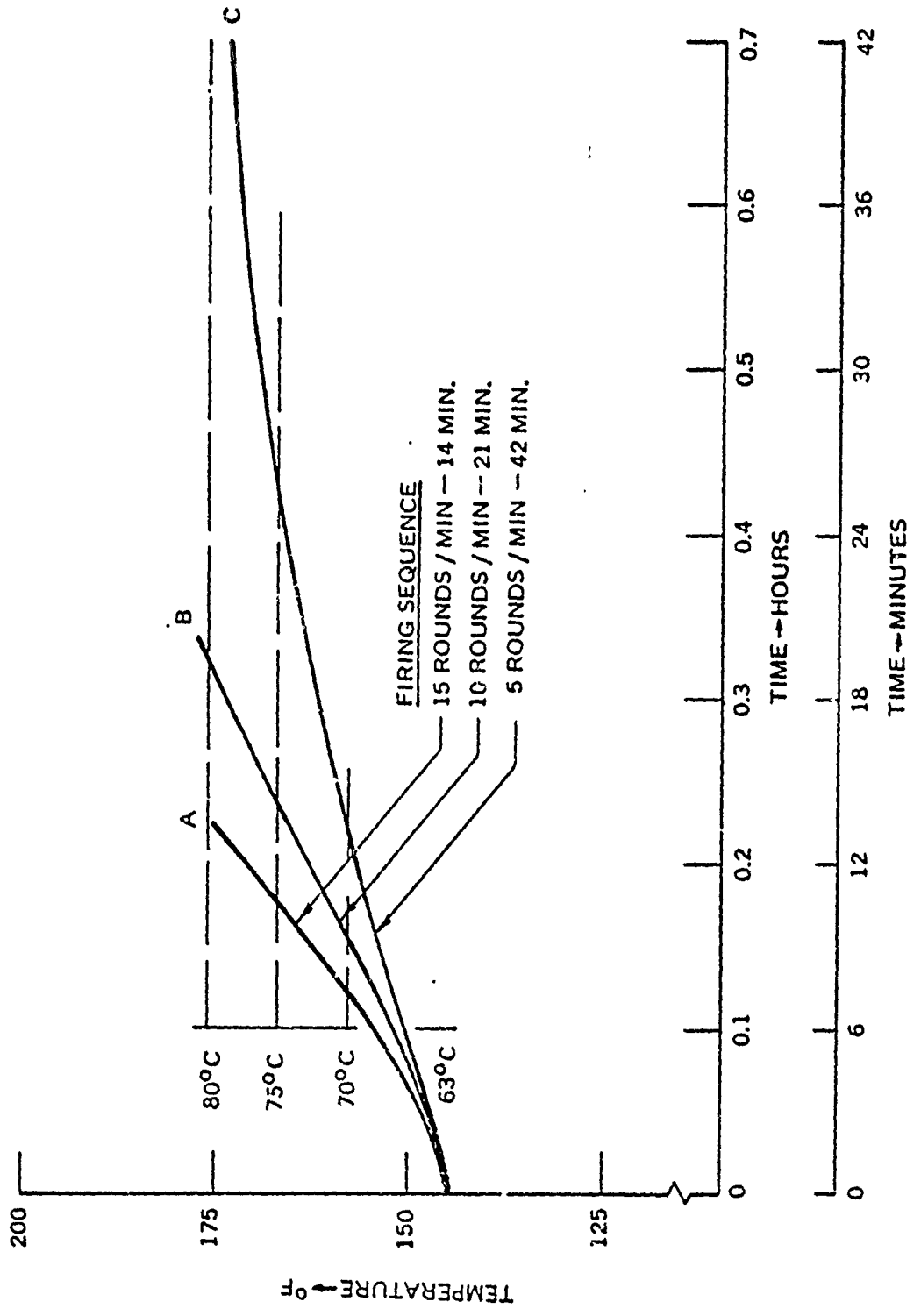


Figure 2-2. M16 Rifle Laser Diode Temperature While Firing 210 Rounds of Blank Ammunition Revised Computer Model (Per Actual Firing Data)

TABLE 2-6

## MILES TEMPERATURE ENVIRONMENT SEQUENCE

| Climatic                  | Operational Conditions  |                              |                              | Storage and Transient Conditions |                              |
|---------------------------|-------------------------|------------------------------|------------------------------|----------------------------------|------------------------------|
|                           | Ambient Air Temp.<br>°F | Solar Radiation<br>BTU/Hr-Ft | Ambient Rel. Hum.<br>Percent | Induced Air Temp.<br>°F          | Induced Rel. Hum.<br>Percent |
| 5<br>Intermediate Hot-Dry | 70 to 110               | 0 to 360                     | 20 to 85                     | 70 to 145                        | 5 to 50                      |
| 6<br>Intermediate Cold    | -5 to -25               | -                            | Tending Toward Saturation    | -10 to -30                       | Tending Toward Saturation    |

2.7 POWER CONSIDERATIONS

The size, weight, and required battery lifetime of 100 hours for the M16A1 Rifle System limited the available power sources. Investigation and study resulted in the following battery choices:

Environment

For Ambient Temperatures  
Above 26°F

For Ambient Temperature  
Below 26°F

Battery Selection

Alkaline Battery  
Mallory P/N MN1604  
(MIL-B-18D, P/N BA3090/U)

Lithium Organic Battery  
Mallory PCI (400-9)  
(MIL-B-18D, P/N BA5090/U)

The two batteries are physically interchangeable, the only differences between them being a greater lifetime at low temperature for the lithium organic battery (see figure 2-3). The physical configuration is shown in figure 2-4. Cost for the lithium organic battery is about three times that of the alkaline.

The Mallory MN1604 9V battery is rated for a service capacity of 500 milliamp hours (at 70°F temperature to 4.8 volts). Discharge curves for this battery are shown on figure 2-5.

Similarly, batteries for the vehicles were investigated resulting in the following selection for use in the CVKI:

Environment

For Ambient Temperatures  
Above 26°F

For Ambient Temperatures  
Below 26°F

Battery Selection

Carbon Zinc Battery  
BA200

Alkaline Battery  
BA3200

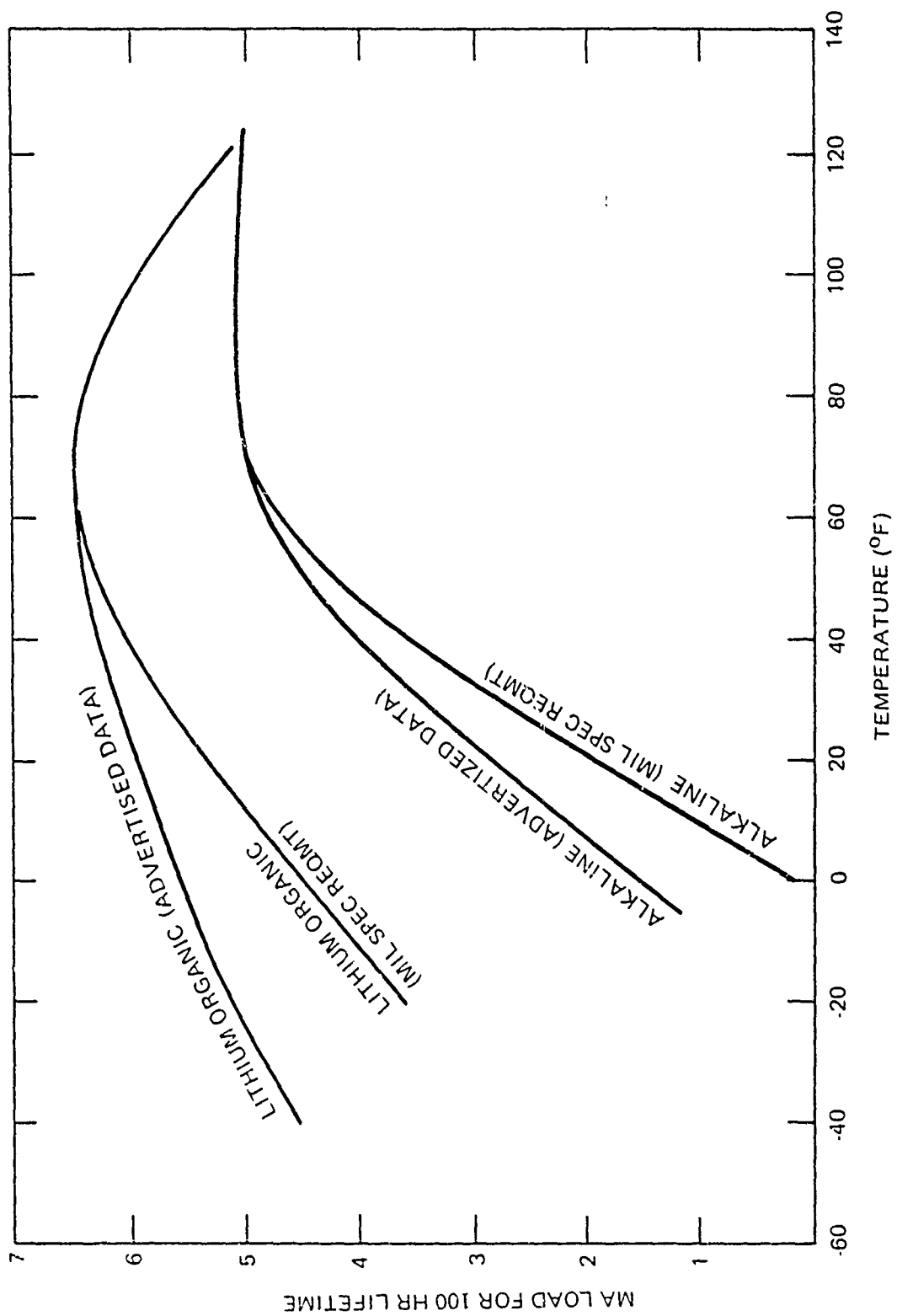


Figure 2-3. Battery Lifetime in Terms of Temperature

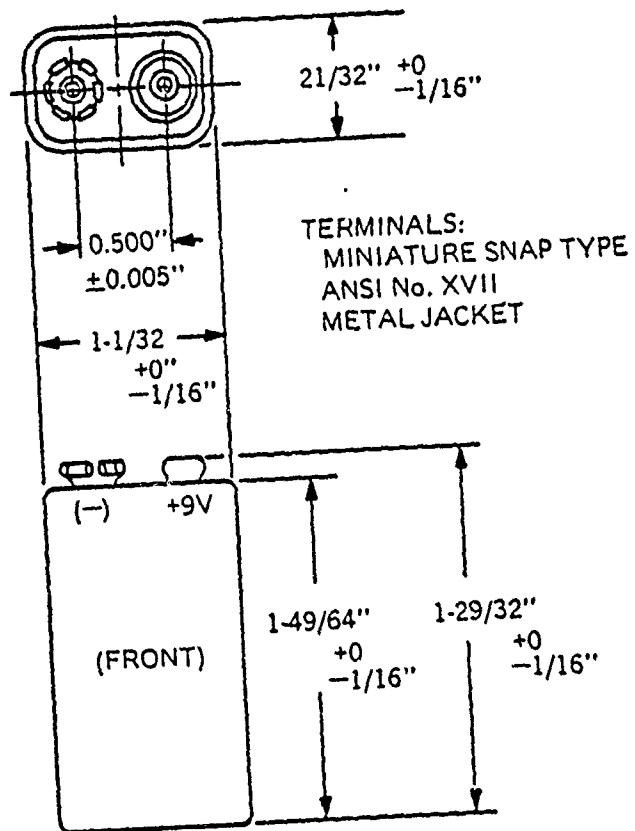


Figure 2-4. MILES 9-Volt Battery Configuration

54498



56229

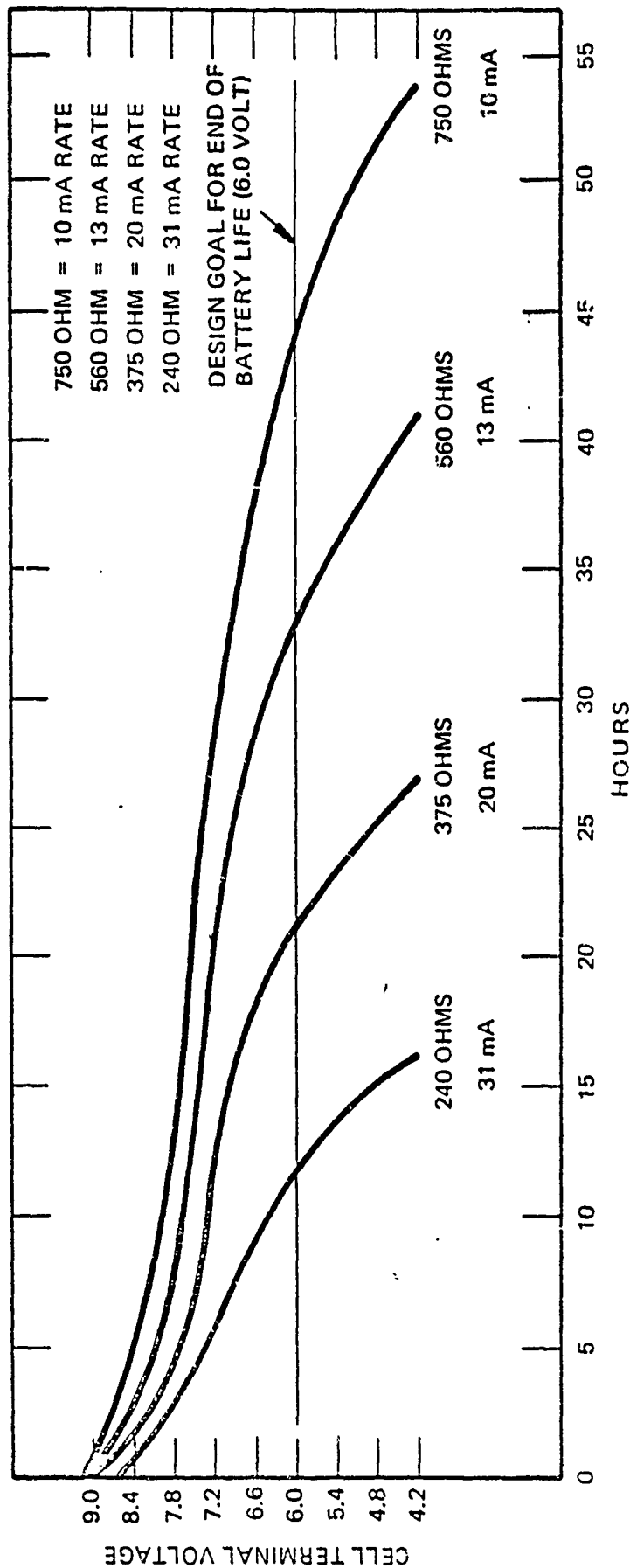


Figure 2-5. Resistance Values and Equivalent Current Drains at 7.5 Volts

A maximum current drain of 2.5 ma per 9-volt battery in the system was established as a goal and was met. Typical current drain for MILES transmitters is 2.1 ma with surge currents to 20 ma. This load assures 100 hours life from alkaline batteries at all temperatures above 26 degrees F. All MILES electronic circuits are designed to operate at supply voltages of between 7.5 and 9 volts dc. Thus, battery life is defined as ending when battery voltage drops below 7.5 volts. Tables 2-7 and 2-8 show the current drain per battery for the MILES systems. It is obvious from the chart that the laser transmitters are within the design goal.

The CVKI exceeds the design goal and requires the use of vehicle power. Vehicle power is used only to power the vehicle hit/kill/miss strobe light.

Vehicle power, used only for the CVKI, is assumed to be defined by MIL-STD-1275 (AT, 14 July 1966, "Military Standard Electrical Circuit 28 Volt DC Transient Characteristics for Military Vehicles"). This specification indicates a nominal operating range from 26 to 30 volts with voltage swings from 15 to 40 volts. Ripple and spike specifications are also stated.

The addition of ATWESS to the MILES for use on TOW, DRAGON, and VIPER adds some drain to the MILES batteries. Surge current for firing the ATWESS is about 56 ma. Basic ammunition loads for the missiles are low. So, although ATWESS will reduce battery lifetime, it should not seriously degrade the total battery life under normal tactical training exercises.

TABLE 2-7

TES LASER TRANSMITTER CURRENT REQUIREMENTS

|                                    |                                             |                      |
|------------------------------------|---------------------------------------------|----------------------|
| Encoder ROM                        | 1.5 mA at 1% $\eta$<br>0.1 mA at 99% $\eta$ | 0.114 mA (idle mode) |
| Encoder Microprocessor             | 1.6 mA at 1% $\eta$<br>0.8 mA at 99% $\eta$ | 0.808 mA             |
| Laser Driver                       |                                             | 0.355 mA             |
| Laser Driver Interface             |                                             | 0.275 mA             |
| Total (Includes blank fire enable) |                                             | 1.552 mA             |
| Design Goal                        |                                             | 2.5 mA               |

TABLE 2-8  
BATTERY CURRENT DRAIN  
(NOT INCLUDING ATWESS)

| SYSTEM                      | ESTIMATED<br>CURRENT<br>DRAIN | ACTUAL<br>PTM<br>MEASUREMENT |
|-----------------------------|-------------------------------|------------------------------|
| MWLD                        |                               |                              |
| Harness                     | 1.81 mA                       | 1.529 mA                     |
| Helmet                      | 1.0 mA                        | 0.954 mA                     |
| Laser Transmitter           |                               |                              |
| M16A1                       | 1.55 mA                       | 1.82 mA                      |
| M60 MG                      | 1.55 mA                       |                              |
| M2 MG                       | 1.55 mA                       |                              |
| M85 MG                      | 1.55 mA                       |                              |
| DRAGON                      | 1.55 mA                       | 1.50 mA                      |
| VIPER                       | 1.55 mA                       |                              |
| M60A1/A3                    |                               |                              |
| Laser Transmitter - 105mm   |                               |                              |
| Laser Transmitter COAX.MG   | 18.79 mA                      |                              |
| CVLD                        |                               |                              |
| CVKI                        |                               |                              |
| M60A2/M551                  |                               |                              |
| Laser Transmitter - 152 mm  |                               |                              |
| Laser Transmitter - COAX MG | 18.75 mA                      |                              |
| CVLD                        |                               |                              |
| CVKI                        |                               |                              |
| APC - M2 MG                 |                               |                              |
| Laser Transmitter - M2 MG   | 1.55 mA                       |                              |
| CVLD                        |                               |                              |
| CVKI                        | 17.25 mA                      |                              |
| INDEPENDENT TOW             |                               |                              |
| Laser Transmitter           | 1.55 mA                       |                              |
| Reveiver                    | 1.81 mA                       |                              |

\*

## SECTION 3

### ELECTRONICS

The MILES electronic design represents a careful compromise between cost, performance, and reliability. Unit production cost was the driving consideration as outlined in subsection 3.1. The technologies chosen were as new as possible to avoid obsolescence in the MILES lifetime, but not so new as to run a risk of being proven inadequate and dropped from the marketplace during the MILES lifetime.

The electronics general design specifications were:

Temperature range: -35 C to +65°C (no blank fire heating)  
-35 C to +85°C (blank fire heating)  
Battery voltage: 6.8V to 9V (9V transistor battery)  
8V to 12V (12V lantern battery)

System performance, as tied to electronics design, is discussed in Volume I.

#### 3.1 DTUPC

The following decisions were made based upon DTUPC considerations:

- a. Automatic insertion of components in all high volume units dictated an inefficient board layout with component locations aligned. Thus, size was sacrificed in favor of cost.
- b. Microprocessor implementation was chosen over a custom digital LSI circuit for all encoder applications. The cost advantage here lies in the high manufacturing volume inherent in the microprocessor product line. A microprocessor chip set is less expensive than a single very complex custom LSI. It is also much more flexible, a quality required due to the significant differences between weapon characteristics. A

single circuit board type performs all encoding functions for M16, M60, M85, and M2. Another single circuit board performs all encoding functions for the Viper and Dragon.

It should be noted that the MILES volume (about 30,000 units) is not high enough to justify most custom IC designs unless competing technologies are very expensive. The only case where a completely custom LSI was chosen was in the receiver decoder. In this case, microprocessors were unsuitable for the specialized task, and the task was well defined. The device could be used throughout the MILES system, and no commercial MSI circuits were available to do the task efficiently.

- c. Semicustom LSI (Monochips by Interdesign) were chosen over custom linear ICs or standard operational amplifiers. Again, 90 percent of the Monochip fabrication process is identical for all Interdesign customers. Chip manufacturing overhead is geared to a high volume, thus yielding a lower unit cost than with a special MILES linear design. Standard operational amplifiers, on the other hand, do not simultaneously meet power, band-width, and noise requirements.
- d. In many cases MIL-SPEC parts were too expensive and exceeded reliability requirements. Instead, non-MIL parts were procured with source control drawings (SCDs) which tailored reliability and testing requirements to the MILES system MTBF. Cost was thus significantly reduced and the system was designed to a specific failure rate.

The MILES system is represented by numerous electrical diagrams. The major ones are listed in table 3-1 and as needed referenced throughout this section in describing various circuit functions.

TABLE 3-1

## MILES ELECTRICAL DIAGRAMS

| Title                                         | Drawing Number |
|-----------------------------------------------|----------------|
| Connection Diagram, Small Arms (M16)          | 11748949       |
| Schematic Diagram                             |                |
| Encoder - Small Arms                          | 11749203-1     |
| Laser Driver Interface Monochip               | 11748909       |
| Laser Driver Monochip I                       | 11748892       |
| Modulator Dual Power                          | 11749204-1     |
| Laser                                         | 11749205-1     |
| Connection Diagram, Small Arms (M85)          | 11748949       |
| Schematic Diagram                             |                |
| Encoder - Small Arms                          | 11749203-4     |
| Laser Driver Monochip I                       | 11748892       |
| Laser Driver Interface Monochip               | 11748909       |
| Modulator Dual Power                          | 11749204-2     |
| Laser                                         | 11749205-2     |
| Connection Diagram, Detector Belt, Seg. No. 2 | 11749242       |
| Schematic Diagram                             |                |
| Postamp/Signal Monochip Threshold Detector    | 11748921       |
| Preamplifier Monochip                         | 11748922       |
| Detector Amplifier                            | 11749314       |
| Connection Diagram, Detector Belt, Seg. No. 3 | 11749303       |
| Schematic Diagram                             |                |
| Postamp/Signal Monochip Threshold Detector    | 11748921       |
| Preamplifier Monochip                         | 11748922       |
| Detector Amplifier                            | 11749314       |
| Connection Diagram, Detector Belt, Seg. No. 4 | 11749299       |
| Schematic Diagram                             |                |
| Postamp/Signal Monochip Threshold Detector    | 11748921       |
| Preamplifier Monochip                         | 11748922       |
| Detector Amplifier                            | 11749314       |
| Connection Diagram, Detector Belt, Seg. No. 5 | 11749295       |
| Schematic Diagram                             |                |
| Postamp/Signal Monochip Threshold Detector    | 11748921       |
| Preamplifier Monochip                         | 11748922       |
| Detector Amplifier                            | 11749314       |

TABLE 3-1 (Cont)  
MILES ELECTRICAL DIAGRAMS

| Title                                         | Drawing Number |
|-----------------------------------------------|----------------|
| Connection Diagram, 152 mm (SHILLELAGH) XMTR  | 11748885       |
| Schematic Diagrams                            |                |
| Laser                                         | 11749205-3     |
| Laser                                         | 11749205-2     |
| Laser                                         | 11749368       |
| Laser Driver Monochip I                       | 11748892       |
| SCR Driver Monochip I                         | 11748968       |
| Laser Driver Monochip I                       | 11748892       |
| 105 mm, 152 mm, Coax Transmitter              | 11749308       |
| 152 mm WFS Transmitter                        | 11749309       |
| Connection Diagram, Controller Gun            | 11748967       |
| Schematic Diagrams                            |                |
| Laser                                         | 11749205-2     |
| Modulator - Single Power                      | 11749370       |
| Controller Gun                                | 11749327       |
| Laser Driver Monochip I                       | 11748892       |
| Laser Driver Interface Monochip               | 11748909       |
| Connection Diagram, TOW Simulator System      | 11835614       |
| Schematic Diagrams                            |                |
| Encoder TOW                                   | 11835587       |
| Modulator                                     | 11749370       |
| Laser Tube                                    | 11749205-5     |
| Decoder - TOW                                 | 11835590       |
| Amplifier                                     | 11749314       |
| Reticle Control                               | 11835812       |
| MCS                                           | 11835595       |
| Tube Assembly                                 | 11749619       |
| ATWESS                                        | 11749687       |
| Connection Diagrams, Tracker Assembly         | 11748952       |
| Schematic Diagram                             |                |
| Laser                                         | 11749205-3     |
| Laser Driver Interface Monochip               | 11748909       |
| Laser Driver Monochip I                       | 11748892       |
| Modulator - Single Power                      | 11749370       |
| Encoder - Dragon                              | 11749311       |
| Connection Diagram, Detector Belt, Seg. No. 1 | 11749241       |
| Schematic Diagram                             |                |
| Postamp/Signal Monochip Threshold Detector    | 11748921       |
| Detector Amplifier                            | 11749314       |
| Preamplifier Monochip                         | 11748922       |

TABLE 3-1 (Cont)

## MILES ELECTRICAL DIAGRAMS

| Title                               | Drawing Number |
|-------------------------------------|----------------|
| Connection Diagram for CVKI         | 11748993       |
| Schematic Diagrams                  |                |
| CVKI Electronics Board              | 11749376       |
| CIA Console                         | (11749448)     |
| Schematic Diagrams                  |                |
| CVKI Interface                      | 11749386       |
| Microprocessor                      | 11749345       |
| Logic Diagrams                      |                |
| Multi-Digit Display, 7 Segment      | 11749497       |
| Weapon ID                           | 11749427       |
| Decoder                             | 11749343       |
| LCA Console                         | (11749396)     |
| Schematic Diagrams                  |                |
| CVKI Interface                      | 11749386       |
| Microprocessor                      | 11749345       |
| Trigger Interface                   | 11749341       |
| Logic Diagrams                      |                |
| Multi-Digit Display, 7 Segment      | 11749497       |
| Weapon ID and Display               | 11749344       |
| Decoder                             | 11749343       |
| Transmitter Interface               | 11749342       |
| Connection Diagram, Small Arms (M2) | 11748949       |
| Schematic Diagrams                  |                |
| Encoder - Small Arms                | 11749203-3     |
| Laser Driver Monochip I             | 11748892       |
| Laser Driver Interface Monochip     | 11748909       |
| Modulator Dual Power                | 11749204-2     |
| Laser                               | 11749205-2     |



TABLE 3-1 (Cont)

## MILES ELECTRICAL DIAGRAMS

| Title                                      | Drawing Number |
|--------------------------------------------|----------------|
| Connection Diagram, VIPER Assembly         | 11748951       |
| Schematic Diagram                          |                |
| Encoder - VIPER                            | 11749312       |
| Laser Driver Monochip I                    | 11748892       |
| Laser Driver Interface Monochip            | 11748909       |
| Modulator Dual Power                       | 11749204-2     |
| Laser                                      | 11749205-2     |
| Connection Diagram, 105 mm/COAX XMTR       | 11748884       |
| Schematic Diagram                          |                |
| Laser                                      | 11749205-2     |
| 105 mm, 152 mm, COAX Transmitter           | 11749308       |
| Connection Diagram, Small Arms (M60)       | 11748949       |
| Schematic Diagram                          |                |
| Encoder - Small Arms                       | 11749203-2     |
| Modulator Dual Power                       | 11749204-2     |
| Laser                                      | 11749205-2     |
| Laser Driver Monochip I                    | 11748892       |
| Laser Driver Interface Monochip            | 11748909       |
| Connection Diagram, Helmet                 | 11748891       |
| Connection Diagram, MWLD Harness           | 11748857       |
| Schematic Diagram                          |                |
| Detector Amplifier                         | 11749314       |
| Preamplifier Monochip                      | 11748922       |
| Postamp/Signal Monochip Threshold Detecotr | 11748921       |
| MWLD Harness                               | 11749315       |
| Helmet MWLD                                | 11749313       |

### 3.2 PROGRAMMING THE UNITS WITH JUMPER STRAPS

#### 3.2.1 LCA WEAPONS

##### 3.2.1.1 LCA Loaders Box Weapon Selection

- a. The LCA loaders box has the capability of controlling zero to three weapons, dependent upon the type of vehicle.
- b. The LCA loaders box has the capability of accommodating three different types of weapons (total amount equals 31).
  - (1) Missile weapons (4) (refer to table 3-2)
  - (2) Heavy slow rate weapons (15) (refer to table 3-3)
  - (3) Automatic rapid fire weapons (12) (refer to table 3-4)
- c. Four possible combinations can be accommodated in a three-weapon vehicle setup:
  - (1) Automatic, heavy, missile (example: M551 tank)
  - (2) Automatic, heavy, automatic
  - (3) Automatic, automatic, missile
  - (4) Automatic, automatic, automatic
- d. Four possible combinations can be accommodated in a two-weapon vehicle setup:
  - (1) Automatic, heavy (example: M60A1 tank)
  - (2) Automatic, missile
  - (3) Automatic, automatic
  - (4) Heavy, missile
- e. For a one-weapon setup:
  - (1) Automatic
  - (2) Heavy
  - (3) Missile

\*

##### 3.2.1.2 LCA Loaders Box Weapon Setup

- a. Weapon 1 - automatic rapid fire weapon with or without blank fire. The rate of fire is dependent upon the number of hit and miss words per round.

TABLE 3-2

MILES WEAPON SIMULATION MISSILES

| <u>Weapon</u> | <u>Basic Load<br/>(Actual)</u> | <u>Basic Load<br/>MILES</u> | <u>Firing Rate<br/>(Actual)</u> | <u>Firing Rate<br/>MILES</u> | <u>Code<br/>Hit/NM</u> | <u>Source</u>   |
|---------------|--------------------------------|-----------------------------|---------------------------------|------------------------------|------------------------|-----------------|
| Hellfire      | 16                             | 16                          | 4                               | 4                            | 2                      | Estimate        |
| TOU*          | 12                             | 12                          | 4                               | 4                            | 7                      | Specification * |
| Shillelagh    | 9                              | 9                           | 4                               | 4                            | 7                      | Specification   |
| Sagger        | 4                              | 4                           | 4                               | 4                            | 3                      | Estimate        |
| Dragon*       | 4                              | 4                           | 4                               | 4                            | 8                      | Specification   |

\*Independent weapon transmitter

TABLE 3-3

## MILES WEAPON SIMULATION SLOW FIRE WEAPONS

| <u>Weapon</u>                | <u>Basic Load<br/>(Actual)</u> | <u>Basic Load<br/>MILES</u> | <u>Firing Rate<br/>(Actual)</u> | <u>Firing Rate<br/>MILES</u> | <u>Code<br/>Hit/NM</u> | <u>Source</u>       |
|------------------------------|--------------------------------|-----------------------------|---------------------------------|------------------------------|------------------------|---------------------|
| 60 mm                        | 75                             | 75                          | 30                              | 30                           | 4/28                   | Estimate            |
| 81 mm                        | 114                            | 99                          | 12                              | 12                           | 4/28                   | Estimate            |
| 4.2 inch                     | 88                             | 88                          | 10                              | 10                           | 4/28                   | Estimate            |
| 2.75 inch Rocket<br>(4 pods) | 76                             | 76                          |                                 | 116                          | 14/28                  | Army Ref. Guide     |
| 105 mm (XMI)                 | 60                             | 60                          | 12                              | 12                           | 12/28                  | Estimate            |
| 105 mm                       | 63                             | 63                          | 12                              | 12                           | 12/28                  | Specification       |
| 90 mm M48                    | 60                             | 60                          |                                 | 12                           | 17/28                  | Jane's Page 356     |
| 120 mm English               | 53                             | 53                          |                                 | 12                           | 16/28                  | Jane's Page 346     |
| 120 mm (XMI)                 | 50                             | 50                          |                                 | 12                           | 16/28                  | Estimate            |
| 152 mm (M551)                | 20                             | 20                          | 6                               | 6                            | 13/28                  | Specification       |
| 8" Howitzer                  |                                | 99                          | 0.5                             | 2                            | 13/28                  | Jane's Page 412     |
| 105 mm Howitzer              |                                | 99                          | 3                               | 3                            | 13/28                  | Jane's Page 419     |
| Maverick                     |                                | 4                           |                                 | 2                            | 1/28                   | Estimate            |
| Chaparral                    | 12                             | 12                          | 6                               | 4                            | 25/28                  | MILES Task III Rep. |
| 40 mm Grenade Launcher       | 300                            | 99                          | 400                             | 100                          | 19/29                  | Army Ref. Guide     |
| Viper*                       | 4                              | 4                           | 6                               | 6                            | 15/28                  | Specification       |

TABLE 3-4

## MILES WEAPON SIMULATION RAPID FIRE WEAPONS

| Weapon                         | Basic Load |       | Firing Rate |       | Code<br>Hit/NM | Source          |
|--------------------------------|------------|-------|-------------|-------|----------------|-----------------|
|                                | (Actual)   | MILES | (Actual)    | MILES |                |                 |
| Coax (7.62 mm)                 | 1800       | 1800  | 650         | 682   | 27/29          | Specification   |
| Coax (7.62 mm)                 | 4900       | 4900  | 650         | 682   |                | Estimate        |
| Coax (7.62 mm)                 |            | 9900  |             | 750   |                | Estimate        |
| Minigun, 7.62 mm<br>M27E1 Helo | 2000       | 2000  | 2000        | 2045  | 27/29          | Army Ref. Guide |
| Bushmaster (25 mm)             | 900        | 900   | 750         | 744   | 25/29          | Army Ref. Guide |
| Vulcan 20 mm                   | 1100       | 1100  | 1000        | 1023  | 23/29          | Jane's Page 100 |
| Vulcan 20 mm                   | 1100       | 1100  | 3000        | 3273  | 23/29          | Jane's Page 100 |
| Vulcan 20 mm (Airborne)        | 1200       | 1200  | 6000        | 5455  | 23/29          | Jane's Page 519 |
| ZU23-4                         |            | 1800  | 4000        | 4090  | 22/29          | Jane's Page 101 |
| GAU-8 30 mm                    | 1350       | 1400  | 2000        | 2045  | 21/28          | Jane's Page 518 |
| GAU-8 30 mm                    | 1350       | 1400  | 4000        | 4090  | 21/28          | Jane's Page 518 |
| XM-188 (AH) 50 mm              | 600        | 600   | 2000        | 2045  | 21/28          | Jane's Page 521 |
| M16A1*                         | 210        | 210   | 650         | 682   | 27/29          | Specification   |
| M2 Machine Gun*                | 600        | 600   | 650         | 682   | 24/29          | Specification   |
| M85 Machine Gun*               | 1200       | 1200  | 650         | 682   | 24/29          | Specification   |
| M60 Machine Gun*               | 1200       | 1200  | 650         | 682   | 27/29          | Specification   |

\*Independent weapon transmitter

Six variables and two fixed constants are required for Weapon 1.

Variables

- (1) Number of belts (selection - 0 through 99)
- (2) Rounds per belt (selection - 0 through 255)
- (3) Hit code (110 \_ \_ \_ \_ \_ \_ \_ \_ )
- (4) Hit words per round (selection - 0 through 255)
- (5) Miss code (110 \_ \_ \_ \_ \_ \_ \_ \_ )
- (6) Miss words per round (selection - 0 through 255)

Fixed Constants

- (1) Hit load/fire encode (to select the proper load capacitor and laser)
- (2) Miss load/fire encode (to select the proper load capacitor and laser)

Example for Weapon 1: coax 7.62 mm machine gun

- b. Weapon 2 - heavy slow rate weapon with 128 man hit words inserted between the heavy weapon hit and miss word messages OR automatic rapid fire weapon without blank fire (variables and fixed constants same as Weapon 1).

Six variables and five fixed constants are required for Weapon 2.

Variables

- (1) Number of heavy weapon rounds (selection - 0 through 99)
- (2) Rate of fire (selection - 2 through 120 rpm)
- (3) Heavy weapon hit code (110 \_ \_ \_ \_ \_ \_ \_ \_ )
- (4) Hit words per round (selection - 0 through 255)
- (5) Heavy weapon miss code (110 \_ \_ \_ \_ \_ \_ \_ \_ )
- (6) Miss words per round (selection - 0 through 255)

Fixed Constants

- (1) Heavy weapon hit load/fire encode (to select the proper load capacitor and laser)
- (2) Man hit words per round (128)
- (3) Man hit code (11001000111, code number 27)
- (4) Man hit load/fire encode (to select the proper load capacitor and laser)
- (5) Heavy weapon miss load/fire encode (to select the proper load capacitor and laser)

Example for Weapon 2 (heavy weapon): 152 mm main gun

- c. Weapon 3 - missile weapon with 128 man hit words following after the fixed 10.24 second missile track sequence period OR automatic rapid fire weapon without blank fire (variables and fixed constants same as Weapon 1). Two variables and six fixed constants are required for Weapon 3 as a missile weapon.

Variables

- (1) Number of missile rounds (selection - 0 through 99)
- (2) Missile hit code (110 \_ \_ \_ \_ \_ \_ \_ \_)

Fixed Constants

- (1) Number of missile words per message (8)
- (2) Number of missile messages per round (32):
  - 2 per second for first 8 seconds
  - 8 per second for last 2 seconds
- (3) Missile hit load/fire encode (to select the proper load capacitor and laser)
- (4) Man hit words per round (128)
- (5) Man hit code (11001000111, code number #27)
- (6) Man hit load/fire encode (to select the proper load capacitor and laser)

Example for Weapon 3 (missile weapon): Shillelagh

The selection of the weapons is accomplished by programming jumpers in the cable mating with connector J3 of the LCA unit (refer to table 3-5).

### 3.2.2 LCA LOADERS BOX VEHICLE SETUP

- a. The LCA loaders box can be configured into 4 different vehicle configurations.
  - (1) Tank (example: M60A1 tank)
  - (2) APC (example: M13 APC)
  - (3) Aircraft/helicopter for future MILES
  - (4) Truck/jeep for future MILES
- b. Each vehicle configuration has separate kill probabilities for weapon hit reception.

TABLE 3-5. VEHICLE - WEAPON SELECTION

| WEAPON                         | WEAPON 1 <sup>1</sup><br>CONNECTOR J3 <sup>2,7</sup> |   |   |   |   |   |   | WEAPON 2<br>CONNECTOR J3 <sup>2,7</sup> |   |   |   |   |   |   | WEAPON 3<br>CONNECTOR J3 <sup>2,7</sup> |   |   |  |  |  |  |
|--------------------------------|------------------------------------------------------|---|---|---|---|---|---|-----------------------------------------|---|---|---|---|---|---|-----------------------------------------|---|---|--|--|--|--|
|                                | Pins                                                 |   |   |   |   |   |   | Pins                                    |   |   |   |   |   |   | Pins                                    |   |   |  |  |  |  |
|                                | a                                                    | F | b | G | c | H | J | K                                       | d | L | r | M | f | N | P                                       | g | R |  |  |  |  |
| Hellfire <sup>3</sup>          | -                                                    | - | - | - | - | - | - | -                                       | - | - | - | 0 | 0 | 0 | 0                                       | 0 | 0 |  |  |  |  |
| TOW <sup>3</sup>               | -                                                    | - | - | - | - | - | - | -                                       | - | - | - | 0 | 0 | 0 | 0                                       | 0 | 1 |  |  |  |  |
| Shillelagh <sup>3</sup>        | -                                                    | - | - | - | - | - | - | -                                       | - | - | - | 0 | 0 | 0 | 0                                       | 1 | 0 |  |  |  |  |
| Sagger <sup>3</sup>            | -                                                    | - | - | - | - | - | - | -                                       | - | - | - | 0 | 0 | 0 | 0                                       | 1 | 1 |  |  |  |  |
| 60mm <sup>4</sup>              | -                                                    | - | - | - | - | 0 | 0 | 0                                       | 1 | 0 | 0 | - | - | - | -                                       | - | - |  |  |  |  |
| 81mm <sup>4</sup>              | -                                                    | - | - | - | - | 0 | 0 | 0                                       | 1 | 0 | 1 | - | - | - | -                                       | - | - |  |  |  |  |
| 4.2 inch <sup>4</sup>          | -                                                    | - | - | - | - | 0 | 0 | 0                                       | 1 | 1 | 0 | - | - | - | -                                       | - | - |  |  |  |  |
| 2.75" Rocket <sup>4</sup>      | -                                                    | - | - | - | - | 0 | 0 | 0                                       | 1 | 1 | 1 | - | - | - | -                                       | - | - |  |  |  |  |
| 105mm<br>(XM1) <sup>4</sup>    | -                                                    | - | - | - | - | 0 | 0 | 1                                       | 0 | 0 | 0 | - | - | - | -                                       | - | - |  |  |  |  |
| 90mm <sup>4</sup>              | -                                                    | - | - | - | - | 0 | 0 | 1                                       | 0 | 0 | 1 | - | - | - | -                                       | - | - |  |  |  |  |
| 105mm <sup>4</sup>             | -                                                    | - | - | - | - | 0 | 0 | 1                                       | 0 | 1 | 0 | - | - | - | -                                       | - | - |  |  |  |  |
| 120mm<br>English <sup>4</sup>  | -                                                    | - | - | - | - | 0 | 0 | 1                                       | 0 | 1 | 1 | - | - | - | -                                       | - | - |  |  |  |  |
| 152mm <sup>4</sup>             | -                                                    | - | - | - | - | 0 | 0 | 1                                       | 1 | 0 | 0 | - | - | - | -                                       | - | - |  |  |  |  |
| 120mm<br>(XM1) <sup>4</sup>    | -                                                    | - | - | - | - | 0 | 0 | 1                                       | 1 | 0 | 1 | - | - | - | -                                       | - | - |  |  |  |  |
| 8 inch <sup>4</sup>            | -                                                    | - | - | - | - | 0 | 0 | 1                                       | 1 | 1 | 0 | - | - | - | -                                       | - | - |  |  |  |  |
| 105mm<br>Howitzer <sup>4</sup> | -                                                    | - | - | - | - | 0 | 0 | 1                                       | 1 | 1 | 1 | - | - | - | -                                       | - | - |  |  |  |  |
| Maverick <sup>4</sup>          | -                                                    | - | - | - | - | 0 | 1 | 0                                       | 0 | 0 | 0 | - | - | - | -                                       | - | - |  |  |  |  |
| Chapparral <sup>4</sup>        | -                                                    | - | - | - | - | 0 | 1 | 0                                       | 0 | 0 | 1 | - | - | - | -                                       | - | - |  |  |  |  |
| Grenade<br>(40mm) <sup>4</sup> | -                                                    | - | - | - | - | 0 | 1 | 0                                       | 0 | 1 | 0 | - | - | - | -                                       | - | - |  |  |  |  |



TABLE 3-5. VEHICLE - WEAPON SELECTION (Cont.)

| WEAPON                                      | WEAPON 1 <sup>1</sup><br>CONNECTOR J3 <sup>2,7</sup> |   |   |   |   |   | WEAPON 2<br>CONNECTOR J3 <sup>2,7</sup> |   |   |   |   |   | WEAPON 3<br>CONNECTOR J3 <sup>2,7</sup> |   |   |   |   |  |
|---------------------------------------------|------------------------------------------------------|---|---|---|---|---|-----------------------------------------|---|---|---|---|---|-----------------------------------------|---|---|---|---|--|
|                                             | Pins                                                 |   |   |   |   |   | Pins                                    |   |   |   |   |   | Pins                                    |   |   |   |   |  |
|                                             | a                                                    | F | b | G | c | H | J                                       | K | d | L | r | M | f                                       | N | P | g | R |  |
| Coax (1800 Rnds)<br>(7.62mm) <sup>5</sup>   | 1                                                    | 0 | 0 | 1 | 1 | 1 | 1                                       | 0 | 0 | 1 | 1 | 1 | 1                                       | 0 | 0 | 1 | 1 |  |
| 7.62mm<br>(4900 Rnds) <sup>5</sup>          | 1                                                    | 0 | 1 | 0 | 0 | 1 | 1                                       | 0 | 1 | 0 | 0 | 1 | 1                                       | 0 | 1 | 0 | 0 |  |
| 7.62mm<br>(9900 Rnds) <sup>5</sup>          | 1                                                    | 0 | 1 | 0 | 1 | 1 | 1                                       | 0 | 1 | 0 | 1 | 1 | 1                                       | 0 | 1 | 0 | 1 |  |
| 7.62mm mini-<br>gun (2000 rpm) <sup>5</sup> | 1                                                    | 0 | 1 | 1 | 0 | 1 | 1                                       | 0 | 1 | 1 | 0 | 1 | 1                                       | 0 | 1 | 1 | 0 |  |
| Bushmaster                                  | 1                                                    | 0 | 1 | 1 | 1 | 1 | 1                                       | 0 | 1 | 1 | 1 | 1 | 1                                       | 0 | 1 | 1 | 1 |  |
| 20mm Vulcan<br>(1000 rpm) <sup>5</sup>      | 1                                                    | 1 | 0 | 0 | 0 | 1 | 1                                       | 1 | 0 | 0 | 0 | 1 | 1                                       | 1 | 0 | 0 | 0 |  |
| 20mm Vulcan<br>(3100 rpm) <sup>5</sup>      | 1                                                    | 1 | 0 | 0 | 1 | 1 | 1                                       | 1 | 0 | 0 | 1 | 1 | 1                                       | 1 | 0 | 0 | 1 |  |
| 20mm Vulcan<br>(5400 rpm) <sup>5</sup>      | 1                                                    | 1 | 0 | 1 | 0 | 1 | 1                                       | 1 | 0 | 1 | 0 | 1 | 1                                       | 1 | 0 | 1 | 0 |  |
| 23mm, Zu23-4 <sup>5</sup>                   | 1                                                    | 1 | 0 | 1 | 1 | 1 | 1                                       | 1 | 0 | 1 | 1 | 1 | 1                                       | 1 | 0 | 1 | 1 |  |
| 30mm GAU-8<br>(2000 rpm) <sup>5</sup>       | 1                                                    | 1 | 1 | 0 | 0 | 1 | 1                                       | 1 | 1 | 0 | 0 | 1 | 1                                       | 1 | 1 | 0 | 0 |  |
| 30mm GAU-8<br>(4000 rpm) <sup>5</sup>       | 1                                                    | 1 | 1 | 0 | 1 | 1 | 1                                       | 1 | 1 | 0 | 1 | 1 | 1                                       | 1 | 1 | 0 | 1 |  |
| 30mm(AH)<br>XM-188 <sup>5</sup>             | 1                                                    | 1 | 1 | 1 | 0 | 1 | 1                                       | 1 | 1 | 1 | 0 | 1 | 1                                       | 1 | 1 | 1 | 0 |  |
| Dummy <sup>6</sup>                          | 1                                                    | 1 | 1 | 1 | 1 | 1 | 1                                       | 1 | 1 | 1 | 1 | 1 | 1                                       | 1 | 1 | 1 | 1 |  |

NOTES:

- <sup>1</sup> Blank fire or dry fire selected at connector J1.
- <sup>2</sup> 0 = Ground = Logic Level 0  
1 = V<sub>dd</sub> = Logic Level 1
- <sup>3</sup> Missiles can be simulated only in Weapon 3 position
- <sup>4</sup> Slow firing weapons can be simulated only in Weapon 2 position
- <sup>5</sup> Rapid fire weapons can be simulated in all Weapon positions
- <sup>6</sup> No Weapon Selected
- <sup>7</sup> Reference - Connector J3, 11749505

The selection of the vehicle type is accomplished by cable programming on connector J3 of the LCA unit. Refer to table 3-6.

TABLE 3-6

LCA VEHICLE TYPE :

| <u>Vehicle Type</u> | <u>Connector J3</u>                 |                                     |
|---------------------|-------------------------------------|-------------------------------------|
|                     | <u>Vehicle ID 2</u><br><u>Pin D</u> | <u>Vehicle ID 1</u><br><u>Pin E</u> |
| Tank                | 1                                   | 1                                   |
| APC                 | 1                                   | 0                                   |
| AC/Helo             | 0                                   | 1                                   |
| Jeep/Truck          | 0                                   | 0                                   |

Note: 0 = Ground = Logic Level 0

1 = VDD = Logic Level 1

### 3.2.3 LCA COAX BLANK FIRE

Automatic rapid fire weapons used as Weapon 1, listed in table 3-2 have the option of operating in either the dry fire mode where the trigger activation initiates the fire sequence or the blank fire enable mode where the audio from the blank fire ammunition initiates the fire sequence. The selection of either dry fire or blank fire enable mode is accomplished by using either the dry fire adapter or blank fire adapter.

### 3.2.4 CIA VEHICLE TYPE

The CIA has the capability of simulating the vulnerability of four different vehicle types, but does not simulate weapons. The four different types of vehicles are:

- a. Tank
- b. APC (example: M113)
- c. Aircraft/Helicopter
- d. Jeep/Truck

The selection of the vehicle type is accomplished by cable programming on J1 of the CIA unit. Refer to table 3-7.

TABLE 3-7  
CIA VEHICLE TYPE

| <u>Vehicle Type</u> | <u>Vehicle ID 2<br/>Pin D</u> | <u>Vehicle ID 1<br/>Pin E</u> |
|---------------------|-------------------------------|-------------------------------|
| Tank                | 1                             | 1                             |
| APC                 | 1                             | 0                             |
| Aircraft/Helo       | 0                             | 1                             |
| Jeep/Truck          | 0                             | 0                             |

---

Note: 0 = Ground = Logic Level 0  
1 = VDD = Logic Level 1

### 3.2.5 SMALL ARMS TRANSMITTER

The small arms transmitter (TES Encoder) is designed such that the encoder electronics printed circuit board and TES Encoder Software in the ROM can be used in the following weapons:

- a. M16 Rifle
- b. M60 Machine Gun
- c. M2 Machine Gun
- d. M85 Machine Gun

The selection of one of the four weapons is accomplished by jumper wires on the encoder electronics printed circuit board. Refer to figure 3-1, Note 4.

#### 3.2.6 VIPER/DRAGON/TOW ENCODER BOARDS

The Viper/Dragon/TOW Software (in a ROM) is designed to be utilized for the Viper, Dragon, and TOW weapons. The Viper, Dragon, and TOW encoder electronics are very similar, the exceptions being (1) the Viper transmits two levels of laser power whereas the Dragon and TOW transmit only one level of laser power, (2) the Dragon requires a weapon key signal whereas the Viper and TOW do not. These differences are incorporated in the different encoder printed circuit boards for the three weapons. The selection of the three weapons is accomplished by two weapon ID bits which are monitored by the 1802 microprocessor on two of its external flag inputs (EF3\* and EF4\*).

Viper encoder printed circuit board (refer to figure 3-2)

Dragon encoder printed circuit board (refer to figure 3-3)

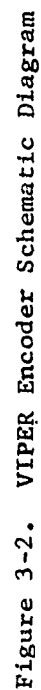
TOW encoder printed circuit board (refer to figure 3-4)

No jumpers are required to perform the selection, because the circuit boards are different for the three weapons.

#### 3.3 POWER-ON-RESET (POR)

The MILES devices use both random and programmable logic in a variety of ways. In most cases, it is necessary to ensure that the logic circuitry be reset to a specific state at the time power is connected so that subsequent processing of signals may proceed in the expected way. This feature is provided by the POR circuitry. The basic requirements of a POR circuit are as follows:







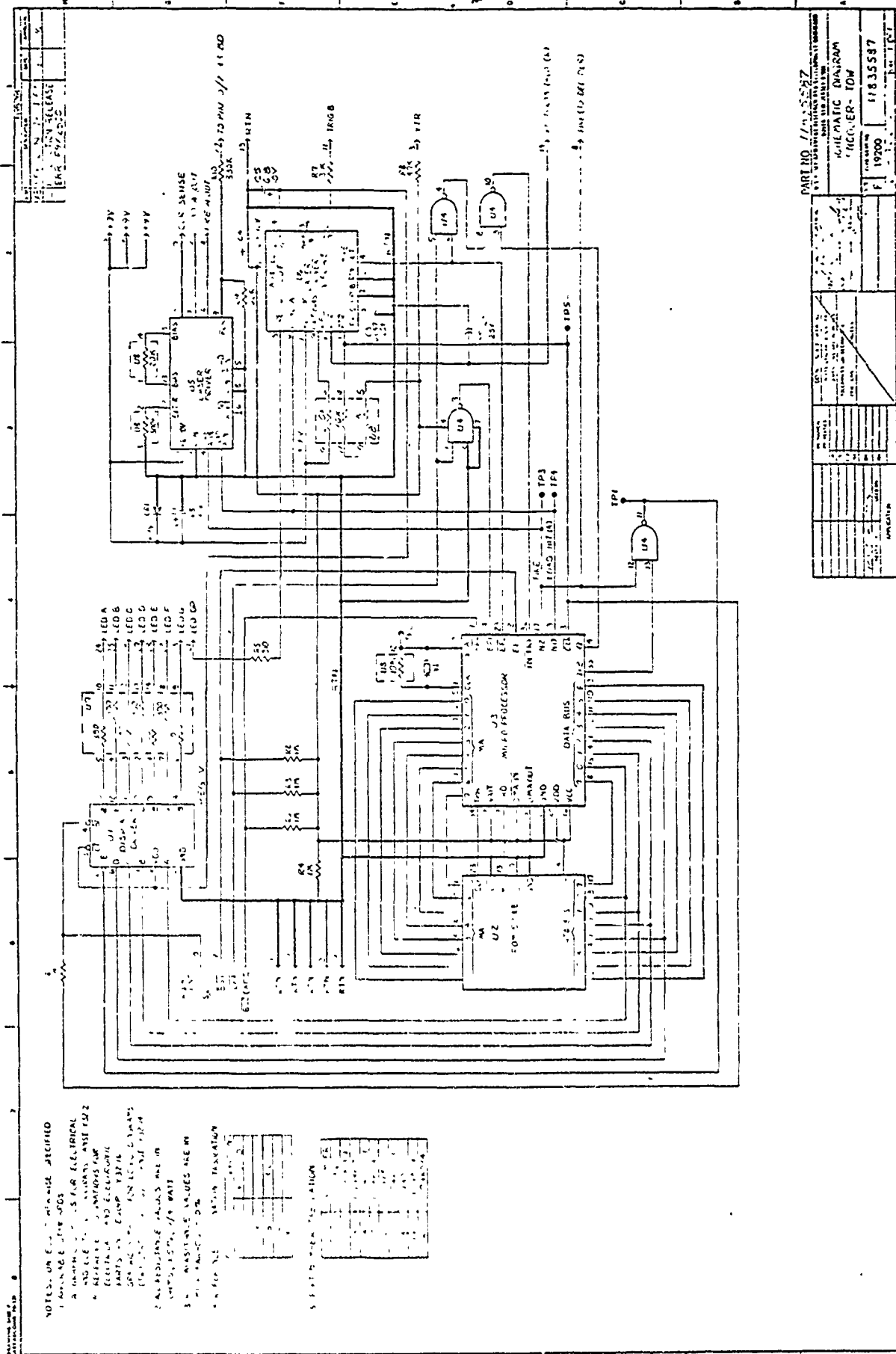


Figure 3-4. TOW Code Schematic Diagram



- a. It must provide a reset signal of the desired polarity.
- b. The signal must persist long enough after power is applied to permit other functions such as the crystal clock oscillator to start properly.
- c. The rise or fall time at the end of the POR signal must be fast enough to avoid logic problems.
- d. The reset time of the POR circuit itself must be reasonably short. Thus, if power is first applied and then for some reason is removed and re-applied, the waiting period before the second application of power to guarantee a successful POR must not be inconveniently long.

In the MILES system, the active portion of the POR circuitry is part of a specialized large scale integrated circuit (LSI). This circuit, together with some external components, generates the logic pulse required by the microprocessor and associated logic. The pulse produced for this purpose must remain low after power application for about 15 milliseconds after which there must be a fast transition in about 500 nsec to a high logic level. Because the required POR pulse is low during the reset interval, it is properly called  $\overline{\text{POR}}$ .

The positive POR signal is also used in the independent MILES transmitters such as the M16A1 rifle, the machine guns and the Viper, Dragon, and TOW. In these cases a brief positive pulse is required by the Laser Driver circuitry to ensure that an erroneous "load" command for the laser does not occur at power turn-on but awaits the appropriate signal from the microprocessor. Careful pulse shaping is not required in this case.

A typical POR application in MILES occurs in the Encoder - Small Arms, figure 3-1. Here U6 is the specialized LSI, part of which is used to generate  $\overline{\text{POR}}$ . This reset signal is fed to the microprocessor "clear" input to perform the necessary reset function at power turn-on. POR is fed to U5, the laser driver circuit, to insure re-setting the load flip flops so that load signals for the laser will only be generated in accordance with the proper commands from the microprocessor.

To understand the function of the POR generating circuit, reference is made to figure 3-5 where the pertinent section of figure 3-1 is reproduced together with the significant portion of U6.

It will be seen that when the battery is first connected, C2 is initially discharged. Current to charge C2 must flow through the series 10K resistor, U8-R5, and through the parallel combination of R1 and CR3 and the base of Q1 within U6. As a result Q1 is turned on, which turns Q29 and Q30 off and Q31 on. This causes the collector of Q31 to saturate, producing a low-voltage at pin 11 ( $\overline{\text{POR}}$ ). This low voltage persists until the charging current for C2 gradually diminishes at which point Q1 begins to turn off. As the collector voltage of Q1 begins to rise, Q29 and Q30 begin to turn on. Q29 shunts current from the base of Q1, greatly accelerating the rate at which Q1 turns off. The end result is that Q31 turns off quite rapidly producing a fast, well-defined trailing edge to the  $\overline{\text{POR}}$  pulse.

The voltage appearing at pin 10 of U6 is somewhat greater than one base emitter drop at the moment the battery is connected. This signal, called POR, is fed to the bases of a pair of transistors within U5 which serve to re-set the two "load" flip-flops thereby avoiding false load signals.

Thus, we have described the generation of the two pulses, POR and  $\overline{\text{POR}}$ . There remains a description of the situation when power is removed. At this time, C2 is charged to battery voltage. With the battery removed, C2 discharges through the series combination of U8-R5 and R1 and the remainder of the encoder circuitry which completes the discharge circuit. At the beginning of the discharge period, the encoder circuitry looks like about 5000  $\Omega$  but this equivalent resistance gradually rises as the voltage drops until it eventually reaches

62051

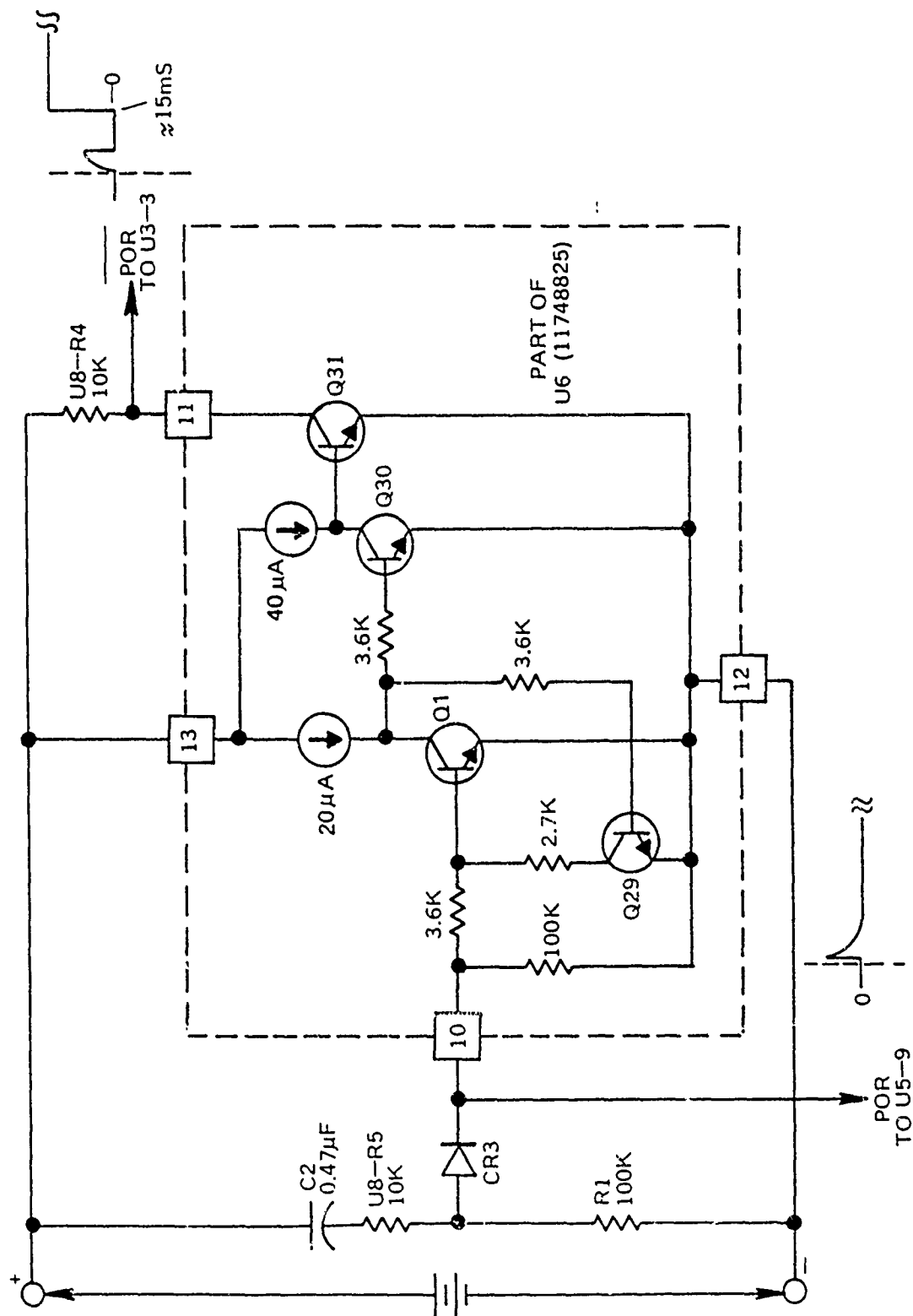


Figure 3-5. POR Circuitry

perhaps 200 Kohms. Even using the maximum value of discharge resistance and allowing five time constants to discharge C2, the circuit should be ready for re-application of battery voltage in less than one second. This is true only if removal of the battery would result in complete loss of power. There is a 68  $\mu$ F filter capacitor connected to the power source (C1 of figure 3-1) and it is this capacitor which determines the rate at which the supply voltage falls when the battery is removed. Thus, a much longer time constant is involved than that of the POR circuit alone, and several seconds must transpire before the circuit will again generate a valid POR signal.

### 3.4 TRIGGERING

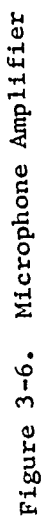
#### 3.4.1 MICROPHONE

The noise generated by firing a blank is detected by means of a miniature dynamic microphone mounted within the transmitter housing. The microphone signal is amplified and used to signal the microprocessor that a round has been fired and that the MILES circuitry must simulate the round by generating the appropriate set of coded signals.

The microphone is mechanically loaded by a mass and cushioned to make it relatively insensitive to mechanical shocks to the weapon. Its aperture is protected by a cellular plastic material which is transparent to the acoustical transient produced by firing the blank.

#### 3.4.2 MICROPHONE AMPLIFIER

The microphone signal is amplified and limited by circuitry which is part of a large scale integrated circuit (LSI) U6 (see figure 3-1). The applicable portion is reproduced in figure 3-6.



As will be seen from the latter figure, the microphone, loaded by the 0.68  $\mu$ F capacitor, is capacitively coupled to the amplifier input. Q2 and emitter follower Q3 form an inverting feedback amplifier. A negative pulse from the microphone causes Q4 to begin to conduct if the signal level is large enough to overcome the combined drop of the emitter-base voltage of Q4 and the diode in series with its emitter. This threshold prevents adjacent weapons and mechanical shocks from generating an output pulse. When Q4 conducts, Q102 and Q7 are turned on, producing a brief negative pulse at pin 4 of U6. This pulse is then used as a trigger signal by the microprocessor.

The input at pin 2 of U6 is employed in Dragon, Viper, and TOW to invert the positive trigger signal developed in these units and thereby produce the negative trigger required by the remaining associated circuitry. The positive trigger signal is employed in Dragon, Viper, and TOW to interface properly with the requirements of the associated ATWESS device. For more details, refer to subsection

#### 3.4.3 SENSITIVITY ADJUSTMENT

No sensitivity control is provided in the form of amplifier gain adjustment. It is possible to vary the size of the 0.68  $\mu$ F capacitor presently shunting the microphone. Reducing this capacitor increases the microphone output for a given audio input. At present, all applications of the microphone are able to employ the same 0.68  $\mu$ F capacitor size.

#### 3.4.4 VEHICLE LCA WEAPON TRIGGER CIRCUITRY

The laser codes transmitted by the LCA vehicle weapon simulators are initiated by actual vehicle triggers. An electrical signal is picked off the vehicle trigger circuit and interfaced to the LCA

by cable. In the LCA, optically coupled isolators are used to interface the electrical trigger signals to the LCA electronics (refer to figure 3-7). The conditioned trigger signals are continuously monitored by the 1802 microprocessor on the external flag input lines as input parameters. An exception to this is the coax machine gun in the blank fire mode. A microphone is physically located in the close proximity of the coax blank fire adapter. The microphone pickup signal (interfaced by cable to the LCA) is amplified in the LCA and used in place of the coax machine gun weapon trigger (refer to subsection 3.2.3).

### 3.5 ENCODERS

#### 3.5.1 SMALL ARMS

The small arms TES encoder is designed as a microprocessor based unit (refer to figure 3-1). The main components of the encoder are the 1802 microprocessor (U3), 1831 ROM (U2) in which the software program is stored, Laser Driver Circuit (U5), and Laser Driver interface circuit (U6). The TES encoder is utilized with one of four different weapons determined by two weapon ID straps (jumper wires).

- a. M16 rifle
- b. M60 machine gun
- c. M2/M85 machine gun

The basic clock rate for the 1802 microprocessor is 1.536MHz which is generated by a clock oscillator incorporated in the microprocessor in conjunction with a 1.536MHz crystal. The complete TES encoder operation is controlled by the microprocessor software program. Various

4. APPLICABLE STANDARDS:

- GRAPHIC SYMBOLS FOR ELECTRICAL AND ELECTRONICS DIAGRAMS.....ANSI Y32.1
- REFERENCE DESIGNATIONS FOR ELECTRICAL AND ELECTRONICS PARTS AND EQUIPMENTS ANSI Y32.6
- GRAPHIC SYMBOLS FOR LOGIC DIAGRAMS (TWO-STATE DEVICES).....ANSI Y32.14

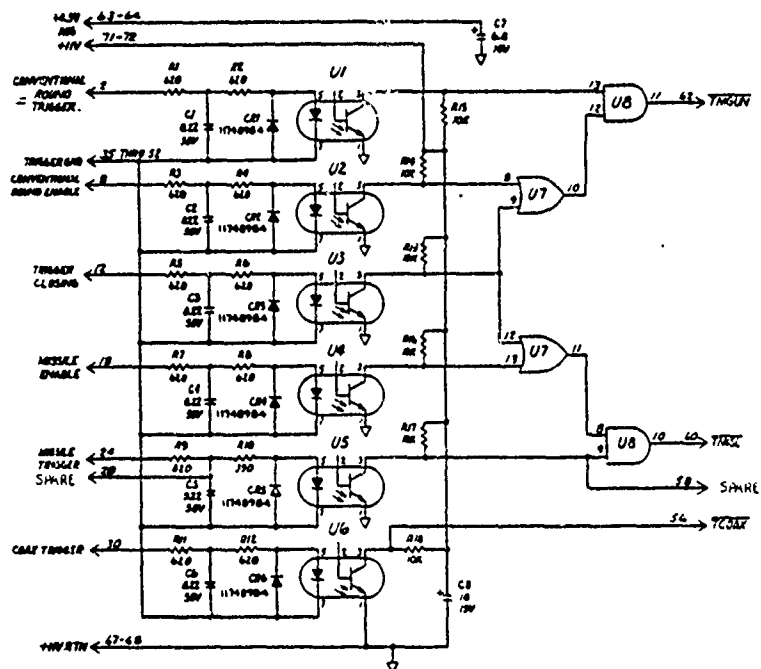
3. ALL CAPACITANCE VALUES ARE MICROFARADS UNLESS

4. ALL ANSWERS ARE 1706284

## 2. POWER DISTRIBUTION

| REF DES | PART NO    | PM ASSIGNMENTS |   |    |
|---------|------------|----------------|---|----|
|         |            | AND            | S | NC |
| UR2336  | 11748850   | -              | - | 6  |
| U7      | 1174886-1  | 7              | M | -  |
| 00      | 11748897-1 | 7              | M | -  |

| REF DESIGNATIONS |          |
|------------------|----------|
| LAST USED        | NOT USED |
| CA               |          |
| CB               |          |
| CA18             |          |
| 48               |          |



3-29



input parameters are monitored by the microprocessor and dependent upon these parameters; outputs are generated to perform the required output functions. The TES encoder has three modes of operation: dry (silent) fire, blank fire enable, and boresight mode. The 1802 microprocessor is programmed to enter the IDLE mode between all encoder operations to conserve battery power. Input parameters are monitored by the microprocessor on four external flag inputs or the interrupt input port. Trigger activation (signal TRIG\*), control key engagement, and audio from the blank fire microphone are gated into the interrupt input port.

Eight input parameters, two weapon ID bits, control key, weapon key, dry fire signal, boresight mode signal, semiautomatic signal, and trigger activation are monitored on the four external flag inputs. The eight input parameters are multiplexed into the four flag inputs by a quad 2 to 1 multiplexer (U1) controlled by the 1802 microprocessor Q output. For the different modes of operation, the microprocessor generates the load and fire pulses for the required weapon code words at the 3 KHz bit rate. These pulses are output to the Laser Driver circuit where the signals are conditioned to drive the laser electronics. The Laser Driver Interface circuit provides a regulated voltage for the microprocessor components from the 9-volt battery source supply, provides a power on reset signal at power turn-on, amplifies and interfaces the audio pickup from the microphone, and provides a signal to illuminate the firing indicator LED when fire pulses are generated to indicate firing.

### 3.5.2 VIPER/DRAGON/TOW

The Viper/Dragon/TOW encoder is designed as a microprocessor based unit (refer to figures 3-2, 3-3 and 3-4). The main components are the 1802 microprocessor (U3), 1831 ROM (U2) in which the software

program is stored, rounds-remaining display network (U1 and U9), Laser Driver circuit (U5), and Laser Driver Interface circuit (U6).

The complete encoder operation for the three weapon encoders, Viper, a single shot weapon, Dragon, and TOW tracking missile weapons, are controlled by the microprocessor software program contained in the one ROM. Selection of the weapon is accomplished by ID bits, refer to Section 3.2.6. The basic clock rate for the 1802 microprocessor is 1.53 MHz which is generated by a clock oscillator incorporated in the microprocessor in conjunction with a 1.536 MHz crystal. Input parameters are monitored by the microprocessor and, depending upon these parameters, outputs are generated to perform the required output functions. Input parameters are monitored by the microprocessor on four external flag inputs or the interrupt input port. The trigger activation signal is input to both the interrupt input port and one of the flag inputs. Input parameters, weapon ID bits control key, and weapon key (Dragon only) are monitored on the flag inputs.

For the encoder operations, the 1802 microprocessor generates the load and fire pulses for the required weapon code words at the 3 kHz bit rate. For the rounds remaining display network function refer to Section 3.11.1. The load and fire pulses are output to the Laser Driver circuit where the signals are conditioned to drive the laser electronics. The Laser Driver Interface circuit provides a regulated voltage for the microprocessor components from the 9 volt battery power supply, provides a power-on reset signal at power turn-on, and provides a signal to illuminate the displays decimal point when fire pulses are generated to indicate firing.

### 3.5.3 CONTROLLER GUN

The Controller Gun encoder is designed as a microprocessor based unit (refer to figure 3-8). The main components of the encoder are the 1802 microprocessor (U3), 1831 ROM (U2) in which the software program is stored, Laser Driver circuit (U5), and Laser Driver Interface circuit (U6). The complete encoder operation for the controller gun is controlled by the microprocessor software program. The basic clock rate for the 1802 microprocessor is 1.536 MHz which is generated by a clock oscillator incorporated in the microprocessor in conjunction with a 1.536 MHz crystal. Three input parameters are monitored by the microprocessor, the trigger activation signal on the interrupt input port, and two switch input signals on two of the external flag inputs. The outputs of the two switches along with the trigger activation causes the controller gun to transmit the near miss codes, near hit code, or the universal hit code. Upon trigger activation, the microprocessor generates the load and fire pulses for the required miss codes or either of the two hit codes at the 3 kHz bit rate. The load and fire pulses are output to the laser driver circuit where the signals are conditioned to drive the laser electronics. The laser driver interface circuit provides a regulated voltage for the microprocessor components from the 9-volt battery power supply, provides a power-on reset signal at power turn-on, and provides a signal to illuminate the first indicator LED when fire pulses are generated to indicate firing.

### 3.5.4 ENCODING FOR DEPENDENT TRANSMITTERS

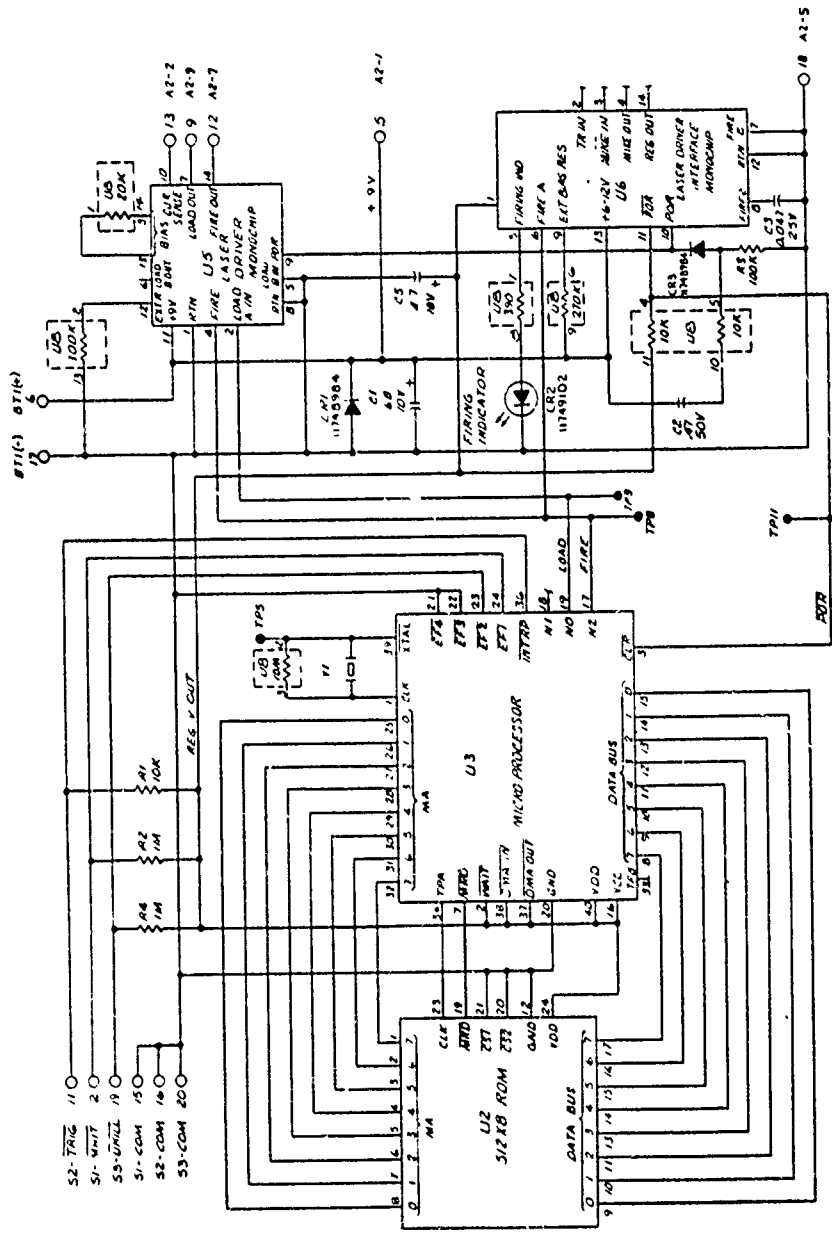
On vehicles, laser transmitters and their associated analog electronics are physically located in the breach or in the close proximity of the weapon. Signals that control the laser electronics are generated in

NOTES: UNLESS OTHERWISE SPECIFIED:  
1. APPROXIMATE VALUES OR ELECTRICAL  
AND MECHANICAL DIMENSIONS  
2. REFERENCE DESIGNATION, FOR  
ELECTRICAL AND MECHANICAL  
PARTS AND DIMENSIONS  
3. DIMENSIONS FOR LONG  
DIMENSIONS  
4. ALL DIMENSIONAL VALUES ARE IN  
MILLIMETERS, UNLESS  
OTHERWISE SPECIFIED

- 1. APPROXIMATE VALUES OR ELECTRICAL AND MECHANICAL DIMENSIONS
- 2. REFERENCE DESIGNATION, FOR ELECTRICAL AND MECHANICAL PARTS AND DIMENSIONS
- 3. DIMENSIONS FOR LONG DIMENSIONS
- 4. ALL DIMENSIONAL VALUES ARE IN MILLIMETERS, UNLESS OTHERWISE SPECIFIED

| REF. DES. | QTY. | UNIT | VAL.  |
|-----------|------|------|-------|
| U1        | 1    | IC   | 74181 |
| U2        | 1    | IC   | 74182 |
| U3        | 1    | IC   | 74183 |
| U4        | 1    | IC   | 74184 |
| U5        | 1    | IC   | 74185 |
| U6        | 1    | IC   | 74186 |
| U7        | 1    | IC   | 74187 |
| U8        | 1    | IC   | 74188 |
| U9        | 1    | IC   | 74189 |
| U10       | 1    | IC   | 74190 |
| U11       | 1    | IC   | 74191 |
| U12       | 1    | IC   | 74192 |
| U13       | 1    | IC   | 74193 |
| U14       | 1    | IC   | 74194 |
| U15       | 1    | IC   | 74195 |
| U16       | 1    | IC   | 74196 |
| U17       | 1    | IC   | 74197 |
| U18       | 1    | IC   | 74198 |
| U19       | 1    | IC   | 74199 |
| U20       | 1    | IC   | 74200 |
| U21       | 1    | IC   | 74201 |
| U22       | 1    | IC   | 74202 |
| U23       | 1    | IC   | 74203 |
| U24       | 1    | IC   | 74204 |
| U25       | 1    | IC   | 74205 |
| U26       | 1    | IC   | 74206 |
| U27       | 1    | IC   | 74207 |
| U28       | 1    | IC   | 74208 |
| U29       | 1    | IC   | 74209 |
| U30       | 1    | IC   | 74210 |
| U31       | 1    | IC   | 74211 |
| U32       | 1    | IC   | 74212 |
| U33       | 1    | IC   | 74213 |
| U34       | 1    | IC   | 74214 |
| U35       | 1    | IC   | 74215 |
| U36       | 1    | IC   | 74216 |
| U37       | 1    | IC   | 74217 |
| U38       | 1    | IC   | 74218 |
| U39       | 1    | IC   | 74219 |
| U40       | 1    | IC   | 74220 |
| U41       | 1    | IC   | 74221 |
| U42       | 1    | IC   | 74222 |
| U43       | 1    | IC   | 74223 |
| U44       | 1    | IC   | 74224 |
| U45       | 1    | IC   | 74225 |
| U46       | 1    | IC   | 74226 |
| U47       | 1    | IC   | 74227 |
| U48       | 1    | IC   | 74228 |
| U49       | 1    | IC   | 74229 |
| U50       | 1    | IC   | 74230 |
| U51       | 1    | IC   | 74231 |
| U52       | 1    | IC   | 74232 |
| U53       | 1    | IC   | 74233 |
| U54       | 1    | IC   | 74234 |
| U55       | 1    | IC   | 74235 |
| U56       | 1    | IC   | 74236 |
| U57       | 1    | IC   | 74237 |
| U58       | 1    | IC   | 74238 |
| U59       | 1    | IC   | 74239 |
| U60       | 1    | IC   | 74240 |
| U61       | 1    | IC   | 74241 |
| U62       | 1    | IC   | 74242 |
| U63       | 1    | IC   | 74243 |
| U64       | 1    | IC   | 74244 |
| U65       | 1    | IC   | 74245 |
| U66       | 1    | IC   | 74246 |
| U67       | 1    | IC   | 74247 |
| U68       | 1    | IC   | 74248 |
| U69       | 1    | IC   | 74249 |
| U70       | 1    | IC   | 74250 |
| U71       | 1    | IC   | 74251 |
| U72       | 1    | IC   | 74252 |
| U73       | 1    | IC   | 74253 |
| U74       | 1    | IC   | 74254 |
| U75       | 1    | IC   | 74255 |
| U76       | 1    | IC   | 74256 |
| U77       | 1    | IC   | 74257 |
| U78       | 1    | IC   | 74258 |
| U79       | 1    | IC   | 74259 |
| U80       | 1    | IC   | 74260 |
| U81       | 1    | IC   | 74261 |
| U82       | 1    | IC   | 74262 |
| U83       | 1    | IC   | 74263 |
| U84       | 1    | IC   | 74264 |
| U85       | 1    | IC   | 74265 |
| U86       | 1    | IC   | 74266 |
| U87       | 1    | IC   | 74267 |
| U88       | 1    | IC   | 74268 |
| U89       | 1    | IC   | 74269 |
| U90       | 1    | IC   | 74270 |
| U91       | 1    | IC   | 74271 |
| U92       | 1    | IC   | 74272 |
| U93       | 1    | IC   | 74273 |
| U94       | 1    | IC   | 74274 |
| U95       | 1    | IC   | 74275 |
| U96       | 1    | IC   | 74276 |
| U97       | 1    | IC   | 74277 |
| U98       | 1    | IC   | 74278 |
| U99       | 1    | IC   | 74279 |
| U100      | 1    | IC   | 74280 |

| REFERENCE DESIGNATION | VALUE |
|-----------------------|-------|
| U1                    | 74181 |
| U2                    | 74182 |
| U3                    | 74183 |
| U4                    | 74184 |
| U5                    | 74185 |
| U6                    | 74186 |
| U7                    | 74187 |
| U8                    | 74188 |
| U9                    | 74189 |
| U10                   | 74190 |
| U11                   | 74191 |
| U12                   | 74192 |
| U13                   | 74193 |
| U14                   | 74194 |
| U15                   | 74195 |
| U16                   | 74196 |
| U17                   | 74197 |
| U18                   | 74198 |
| U19                   | 74199 |
| U20                   | 74200 |
| U21                   | 74201 |
| U22                   | 74202 |
| U23                   | 74203 |
| U24                   | 74204 |
| U25                   | 74205 |
| U26                   | 74206 |
| U27                   | 74207 |
| U28                   | 74208 |
| U29                   | 74209 |
| U30                   | 74210 |
| U31                   | 74211 |
| U32                   | 74212 |
| U33                   | 74213 |
| U34                   | 74214 |
| U35                   | 74215 |
| U36                   | 74216 |
| U37                   | 74217 |
| U38                   | 74218 |
| U39                   | 74219 |
| U40                   | 74220 |
| U41                   | 74221 |
| U42                   | 74222 |
| U43                   | 74223 |
| U44                   | 74224 |
| U45                   | 74225 |
| U46                   | 74226 |
| U47                   | 74227 |
| U48                   | 74228 |
| U49                   | 74229 |
| U50                   | 74230 |
| U51                   | 74231 |
| U52                   | 74232 |
| U53                   | 74233 |
| U54                   | 74234 |
| U55                   | 74235 |
| U56                   | 74236 |
| U57                   | 74237 |
| U58                   | 74238 |
| U59                   | 74239 |
| U60                   | 74240 |
| U61                   | 74241 |
| U62                   | 74242 |
| U63                   | 74243 |
| U64                   | 74244 |
| U65                   | 74245 |
| U66                   | 74246 |
| U67                   | 74247 |
| U68                   | 74248 |
| U69                   | 74249 |
| U70                   | 74250 |
| U71                   | 74251 |
| U72                   | 74252 |
| U73                   | 74253 |
| U74                   | 74254 |
| U75                   | 74255 |
| U76                   | 74256 |
| U77                   | 74257 |
| U78                   | 74258 |
| U79                   | 74259 |
| U80                   | 74260 |
| U81                   | 74261 |
| U82                   | 74262 |
| U83                   | 74263 |
| U84                   | 74264 |
| U85                   | 74265 |
| U86                   | 74266 |
| U87                   | 74267 |
| U88                   | 74268 |
| U89                   | 74269 |
| U90                   | 74270 |
| U91                   | 74271 |
| U92                   | 74272 |
| U93                   | 74273 |
| U94                   | 74274 |
| U95                   | 74275 |
| U96                   | 74276 |
| U97                   | 74277 |
| U98                   | 74278 |
| U99                   | 74279 |
| U100                  | 74280 |



PART NO 11714327

|         |          |
|---------|----------|
| DATE    | 11/22/77 |
| BY      | 11714327 |
| CHKD    | 11714327 |
| APP'D   | 11714327 |
| REV     | 11714327 |
| QTY     | 11714327 |
| UNIT    | 11714327 |
| PRICE   | 11714327 |
| TOTAL   | 11714327 |
| REMARKS | 11714327 |
| 1       | 11714327 |
| 2       | 11714327 |
| 3       | 11714327 |
| 4       | 11714327 |
| 5       | 11714327 |
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| 7       | 11714327 |
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| 20      | 11714327 |
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| 22      | 11714327 |
| 23      | 11714327 |
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| 50      | 11714327 |
| 51      | 11714327 |
| 52      | 11714327 |
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| 54      | 11714327 |
| 55      | 11714327 |
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| 57      | 11714327 |
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| 59      | 11714327 |
| 60      | 11714327 |
| 61      | 11714327 |
| 62      | 11714327 |
| 63      | 11714327 |
| 64      | 11714327 |
| 65      | 11714327 |
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| 67      | 11714327 |
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| 69      | 11714327 |
| 70      | 11714327 |
| 71      | 11714327 |
| 72      | 11714327 |
| 73      | 11714327 |
| 74      | 11714327 |
| 75      | 11714327 |
| 76      | 11714327 |
| 77      | 11714327 |
| 78      | 11714327 |
| 79      | 11714327 |
| 80      | 11714327 |
| 81      | 11714327 |
| 82      | 11714327 |
| 83      | 11714327 |
| 84      | 11714327 |
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| 87      | 11714327 |
| 88      | 11714327 |
| 89      | 11714327 |
| 90      | 11714327 |
| 91      | 11714327 |
| 92      | 11714327 |
| 93      | 11714327 |
| 94      | 11714327 |
| 95      | 11714327 |
| 96      | 11714327 |
| 97      | 11714327 |
| 98      | 11714327 |
| 99      | 11714327 |
| 100     | 11714327 |

SCHEMATIC DIAGRAM  
CONTROLLER GUN

11714327

the LCA transmitter encoder electronics and are interfaced by cable. The LCA is designed with the 1802 microprocessor as the central element. The basic clock rate for the 1802 microprocessor is 1.536 MHz which is generated by a clock oscillator incorporated in the microprocessor in conjunction with a 1.536 MHz crystal. The 1.536 MHz clock is also divided down into other required clock rates in a counter divide network and distributed to logic circuits that support the microprocessor within the LCA. The complete LCA operation is controlled by the microprocessor software program. The LCA transmitter encoder receives transmission parameters from the data bus lines and gated timing and control signals to clock the parameters into working registers from the microprocessor (refer to figure 3-9). The first transmission parameter is the number of copies per code word to be transmitted which is clocked into countdown counters (U12 and U13). The second transmission parameter is the transmission encode data which is clocked into a 4-bit storage register (U10). The encoder data provides the correct laser load and fire pulses for the selected weapons. The last transmission parameter is the actual code bit pattern to be transmitted which is clocked into a circular parallel-to-serial shift register (U2). The clock signal for the code bit pattern also acts as a start signal for the LCA transmitter encoder.

### 3.6 MODULATORS

In this discussion we shall refer to "modulators" as those circuits which accept a "load" pulse from encoding logic and, as a result, ladle a precise amount of energy into an energy storage capacitor (figure 3-10). The circuit which discharges the capacitor into the laser diode upon receipt of a "fire" pulse is also included.

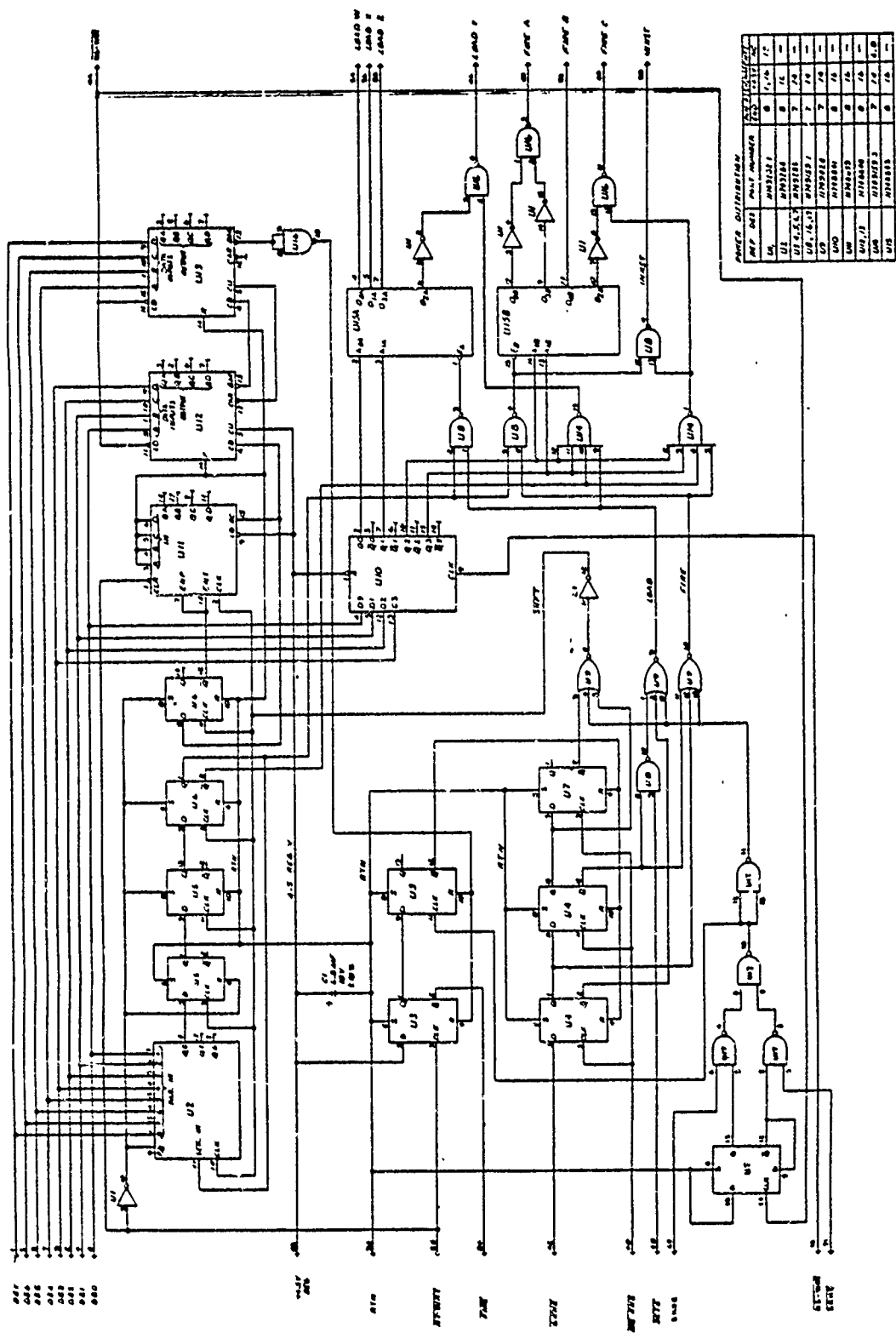


Figure 3-9. Transmitter Interface Logic Diagram



### 3.6.1 ENERGY LADLING

Figure 3-10 shows the modulator circuit. The circuit works by building a magnetic field in the primary of transformer T1 when Q1 or Q2 turns on. When that magnetic field contains a precise amount of energy,  $I^2 L_p / 2$  (as measured in its current), transistor Q1 or Q2 turns off and the energy is transferred to voltage appearing on the energy storage capacitor C. Diode CR1 prevents discharge of the capacitor back through the transformer secondary. The capacitor now contains a precise energy controlled by the current at which Q1 or Q2 was turned off. We say that the energy from the primary has been "ladled" to the capacitor.

The precision element in the energy ladle is the pair of current sensing resistors R6 and R7. When the voltage across these resistors reaches a set threshold, as determined in the Laser Driver integrated circuit, U1, the transistor Q1 or Q2 is turned off. The circuit is configured such that the trigger point for energy transfer is independent of power supply voltage. There is a temperature dependence in the trigger point inside U1, but this is compensated in the TC network discussed in 3.6.2.

### 3.6.2 TEMPERATURE COMPENSATION

A amount of current through the laser diode must vary with temperature in order to compensate for the laser diode's inherent variations. Those variations tend to lower laser output energy as the temperature increases.

The mechanism for causing a programmed current variation is the pair of thermistors YT1 and YT2. Table 3-8 below shows thermistor variation



with temperature at high, low, and room temperatures. Component specifications may be consulted for more detailed data.

TABLE 3-8  
THERMISTOR RESISTANCE VS. TEMPERATURE

| <u>Temperature</u> | <u>YT1 (ohms)</u> | <u>YT2 (ohms)</u> |
|--------------------|-------------------|-------------------|
| -35°C              | 14.17K            | 649.3K            |
| +25°C              | 1K                | 30K               |
| +85°C              | 152.4             | 3.272K            |

The thermistor network forms one leg of a voltage divider between the current sense resistors and the comparator in U1. As the temperature increases, the amount of divider attenuation increases, causing the transformer primary current to reach a higher value before the energy transfer takes place. This obviously increases the charge on storage capacitor C of figure 3-10, and increases the drive to the laser diode. The opposite effect is observed at low temperatures.

#### 3.6.2.1 Analysis of Temperature Compensation (TC) Circuit

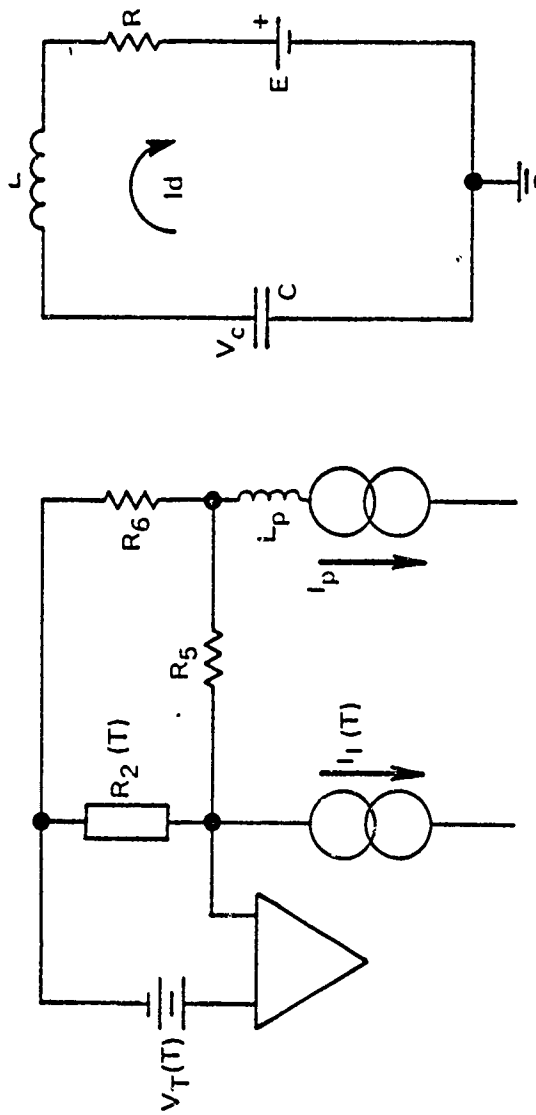
Figures 3-10 and 3-11 show a simplified schematic of the MILES laser transmitter and an equivalent circuit. Figure 3-11 also shows equations governing the circuit. The artificial resistor  $R_2$  in figure 3-11 represents the total resistance of  $T_1$ ,  $R_3$ ,  $R_1$ ,  $Y_{T2}$ ,  $R_4$  and  $R_2$  in figure 3-10. The quantities  $R$ ,  $L$ , and  $E$  in the laser discharge loop represent parasitic resistance, inductance, and forward voltage drops in the laser diode and SCR. As the note states, the resistance in that loop is negligible and the output circuit is not damped appreciably. The quantity  $E$  is approximately 2 volts.

62050

# ED MILES

## PARAMETER VALUES

$L = 75 \times 10^{-9} \text{ H}$   
 $R = 2 \text{ OHMS}$   
 $R_6 = 2 \text{ TO } 10 \text{ OHMS}$   
 $R_5 = 11 \text{ K}$   
 $R_2 = 3 \text{ K TO } 28 \text{ K}$   
 $V_T (25^\circ\text{C}) = 1.1 \text{ V}$   
 $I_1 (25^\circ\text{C}) = 100 \mu \text{ A}$   
 $E = 2 \text{ V}$   
 $L_p = 1.25 \times 10^{-3} \text{ H}$



$$(1) I_p = \frac{1}{R_6} [V_T (1 + R_5/R_2) - I R_5] \quad \text{AT TURN-OFF}$$

$$(2) V_c = I_p \sqrt{L_p/C}$$

$$(3) I_d = \frac{(V_c - E) (1 - R^2 C/4L) \exp \left[ \frac{-RA/2L \omega}{\omega L} \right]}{\omega L}$$

WHERE

$$\omega = \sqrt{1/LC - R^2/4L^2}$$

$$A = \tan^{-1} \sqrt{(4L/R^2C) - 1}$$

NOTE: IN PRACTICE, R IS NEGLIGIBLY SMALL AND EQUATION 3 REDUCES TO:  
 (3a)  $I_d \approx (V_c - E) \sqrt{C/L}$

Figure 3-11. Equivalent Circuit - MILES Transmitter

Bias current  $I(T)$  and threshold voltage  $V_t(T)$  are derived in the laser driver IC. As the notation suggests, these vary with temperature and the thermistor network must also compensate for these variations. Any thermal testing of the modulator must, therefore, include subjecting the laser driver IC to the thermal environment.

#### 3.6.2.2 Development of a Production Technique

A convenient point to measure TC network performance is the voltage,  $V_c$ , across the capacitor. Vagaries of the laser diodes and the high frequency discharge network are eliminated and the network may be tested and calibrated over temperature. Implementation of temperature compensation is governed by data obtained on circuit elements as follows:

- a. The TC network must be characterized such that we know how to adjust network resistors to achieve any desired  $V_c$  profile against temperature.
- b. Diode statistics must be measured so that we are able to make decisions on whether to customize each diode's TC network or use a common one. Results show that multi-heterostructure diodes may use a single TC network for each weapon type. Single heterostructure diodes require a customized network derived from screening data on each diode.

#### Characterization of TC Network

Measurements of the TC network have been made in a convection oven in order to characterize the circuit. Figure 3-12 shows a schematic of

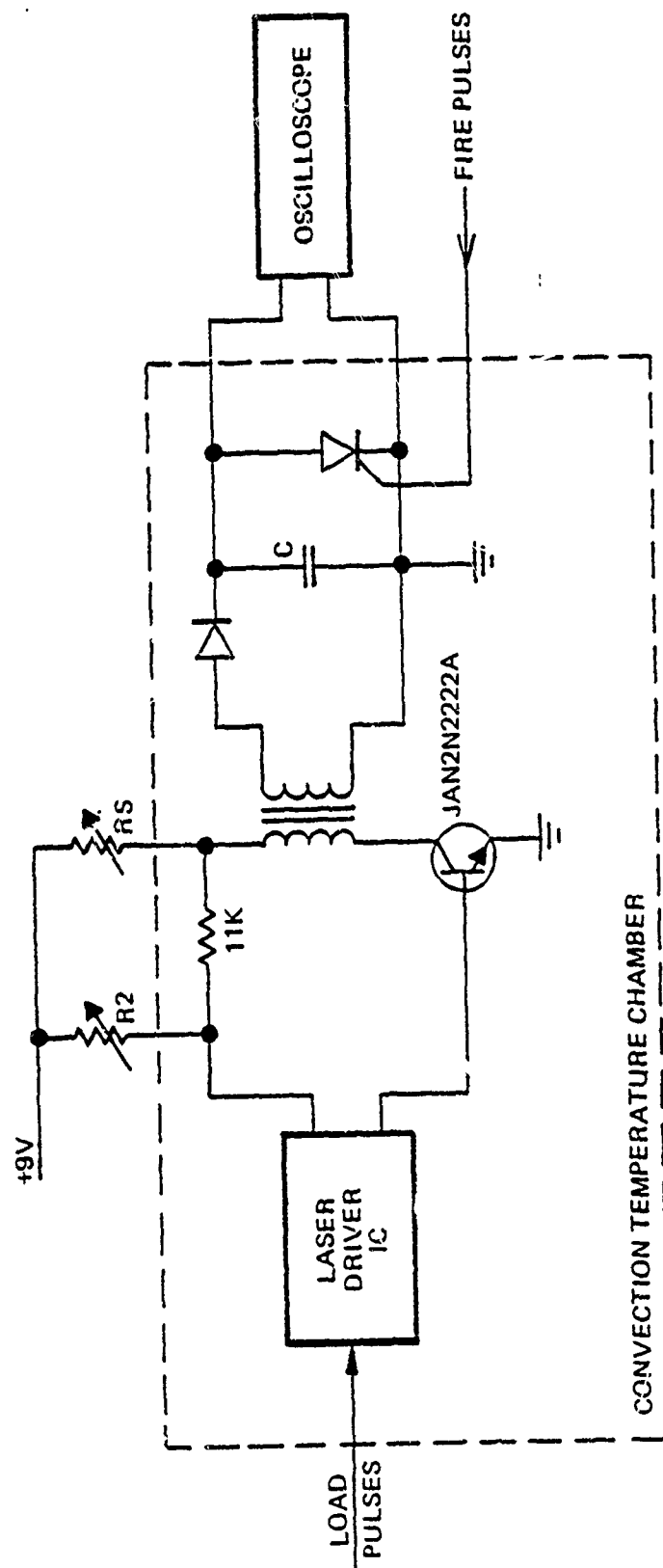


Figure 3-12. Schematic, Temperature Compensation Characterization

the set-up. Decade resistances  $R_2$  and  $R_s$  represent the TC network and the sense resistor respectively. Voltage across the storage capacitor is measured as temperature,  $R_2$ ,  $R_s$ , and capacitor values are changed. Figures 3-13 through 3-19 show the results of tests on an ED MILES circuit.

#### Diode Screening in the Dry Box

During the MILES ED program, it was necessary to screen a large number of laser diodes to obtain statistical data on temperature characteristics. A test fixture, called the "dry box" was devised which allowed quick repeatable measurement of diode output power, capacitor voltage, and diode current while diode temperature was varied. Figure 3-20 shows the scheme.

The diodes are mounted on a copper plate to which two copper tubes are brazed. For cooling, liquid nitrogen is run from a dewar through a coil to vaporize it and through one of the tubes on the copper plate. For heating, dry air is run through a heating coil wrapped around an electric heater and then through the other tube on the copper plate.

The entire fixture is enclosed in a plastic box which is purged and maintained at a positive pressure with dry nitrogen. This is to eliminate any water condensation on the diode or the radiometric optics. An EG & G model 460 radiometer is used to measure output energy per pulse into an  $f/2.5$  cone. A fixture maintains aperture and distance from the diode to insure  $f/2.5$ .

Using this technique, it is possible to reliably and repeatably run through a  $+25^{\circ}\text{C}$ ,  $-35^{\circ}\text{C}$ ,  $+85^{\circ}\text{C}$ ,  $+25^{\circ}\text{C}$  temperature cycle in about 30 minutes.

$R_2 = 11K$   
 $T = 25^\circ C$

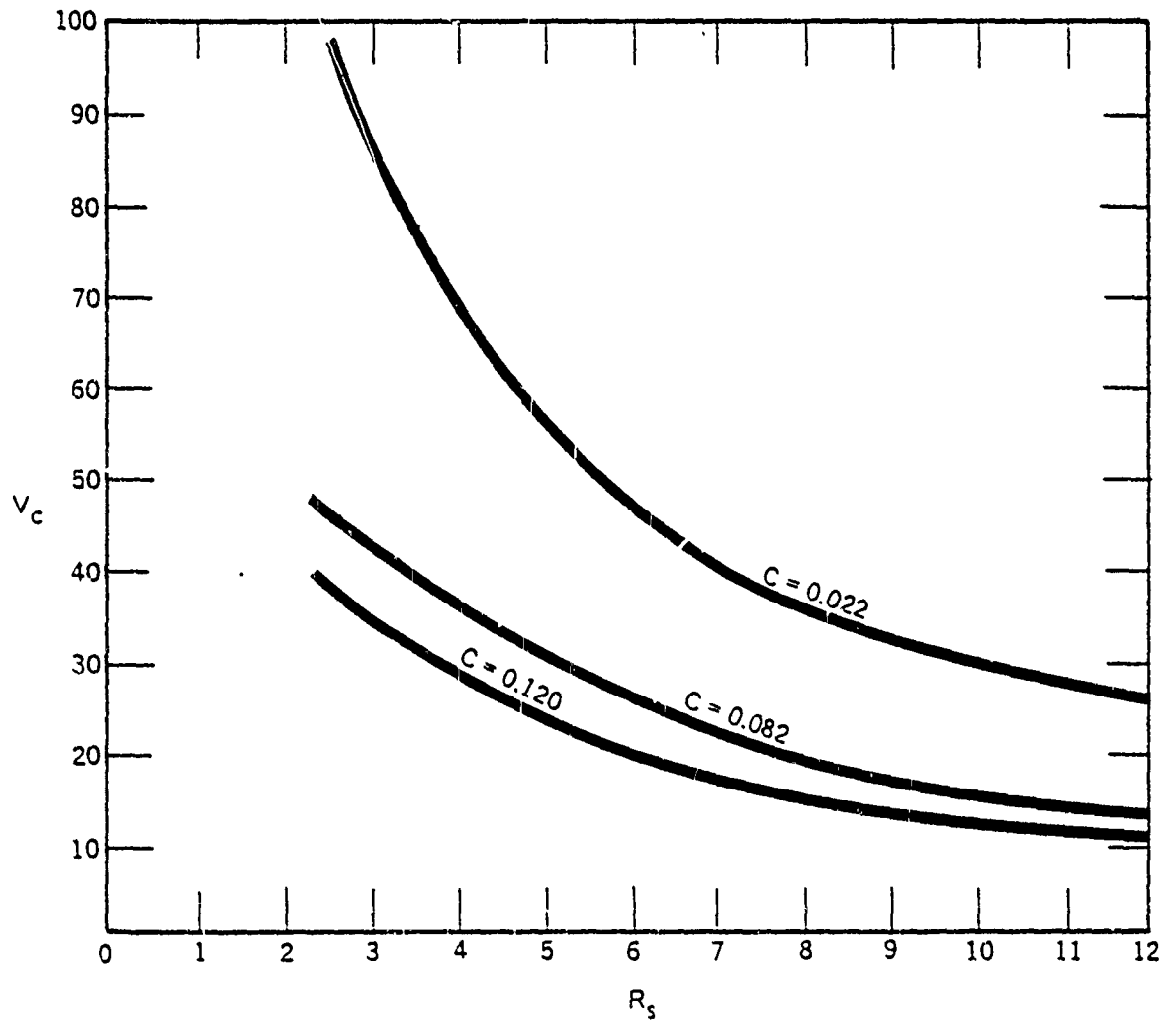


Figure 3-13. MILES Transmitter - Capacitor Voltage versus  $R_s$

$C = 0.022 \mu f$   
 $T = -35^{\circ}C$

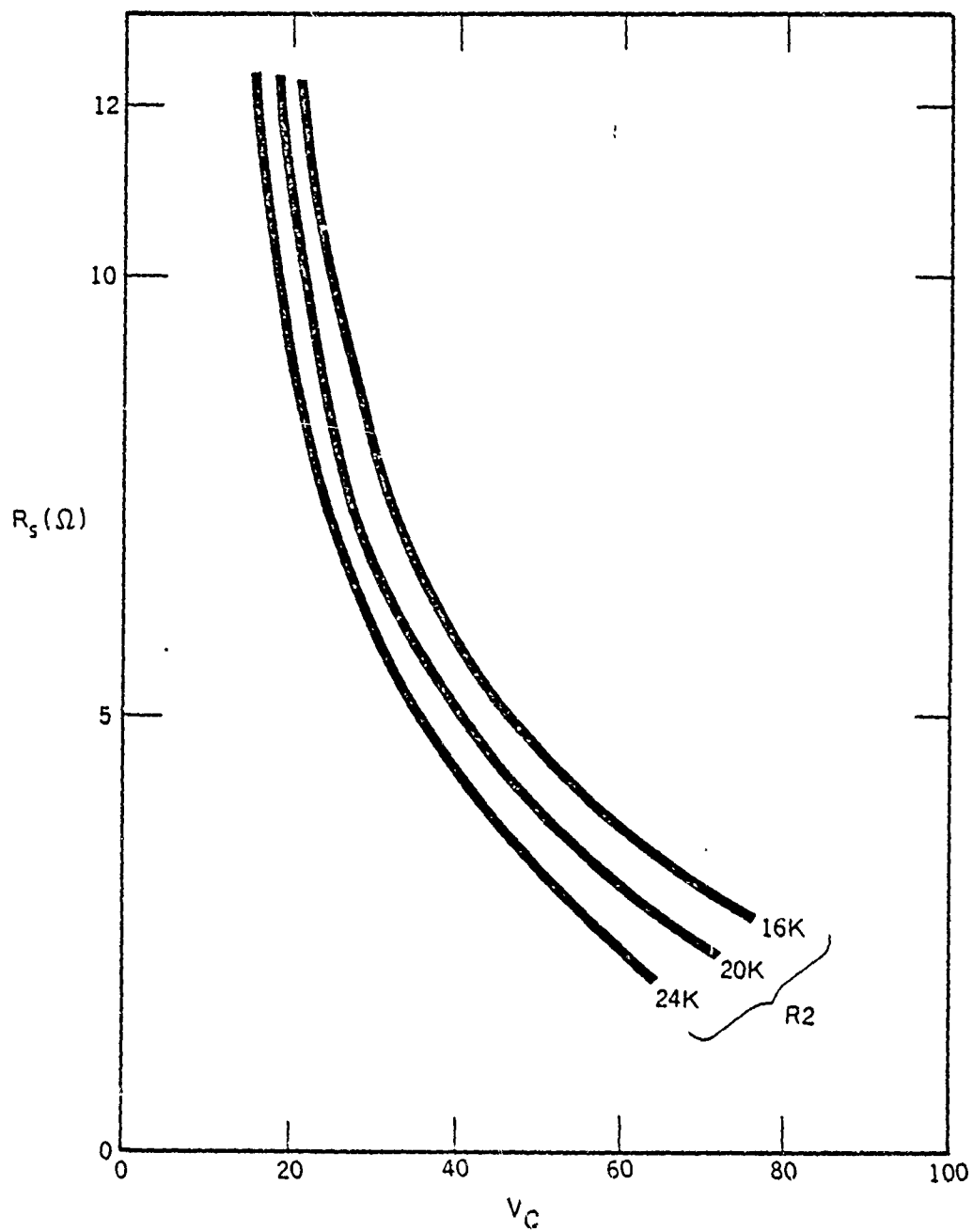


Figure 3-14. MILES Transmitter -  $R_S$  versus Capacitor Voltage

$C = 0.082 \mu f$   
 $T = -35^{\circ}C$

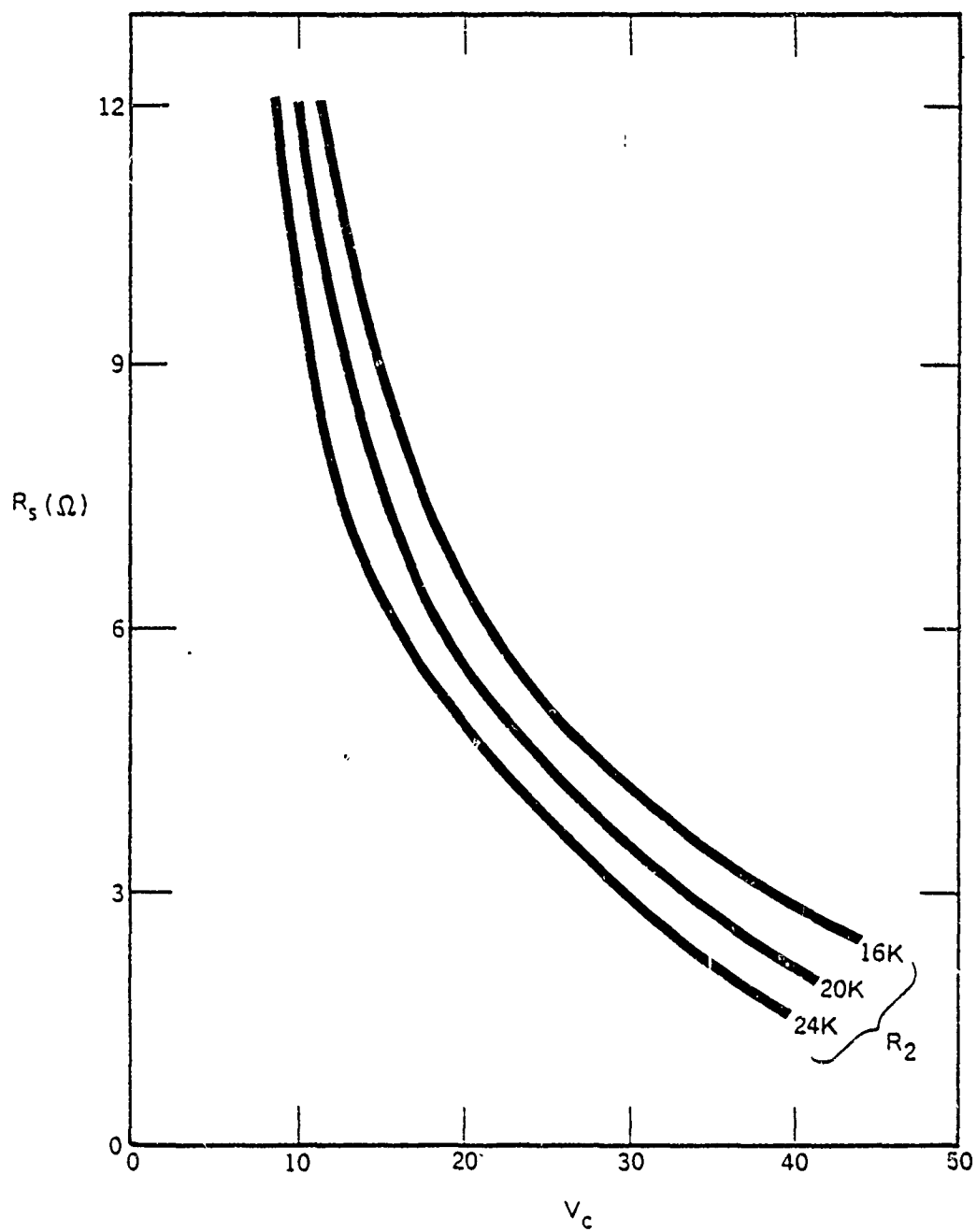


Figure 3-15. MILES Transmitter -  $R_s$  versus Capacitor Voltage

62055



$C = 0.12 \mu f$   
 $T = -35^{\circ}C$

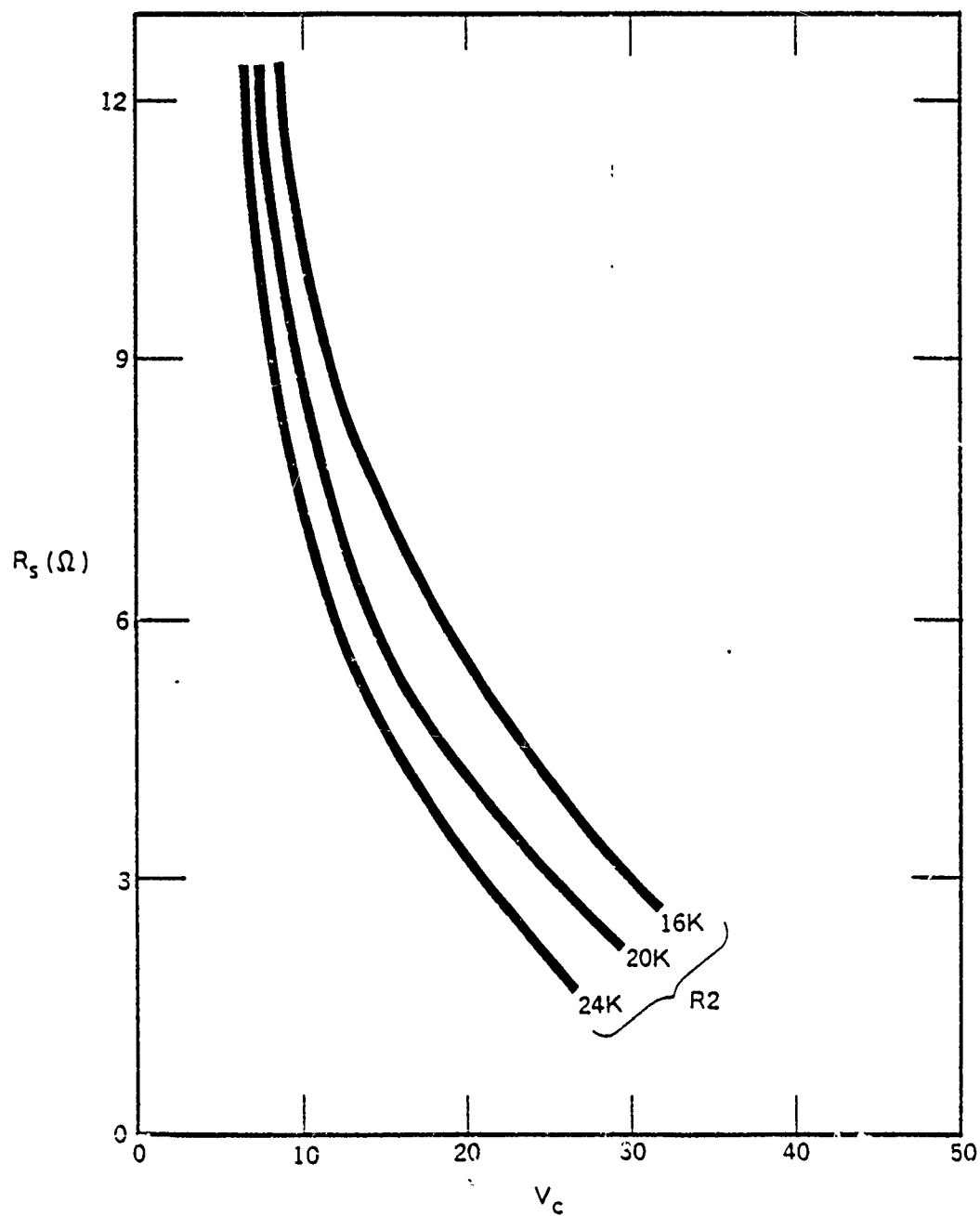


Figure 3-16. MILES Transmitter -  $R_s$  versus Capacitor Voltage

$C = 0.022 \mu f$   
 $T = +65^{\circ}C$

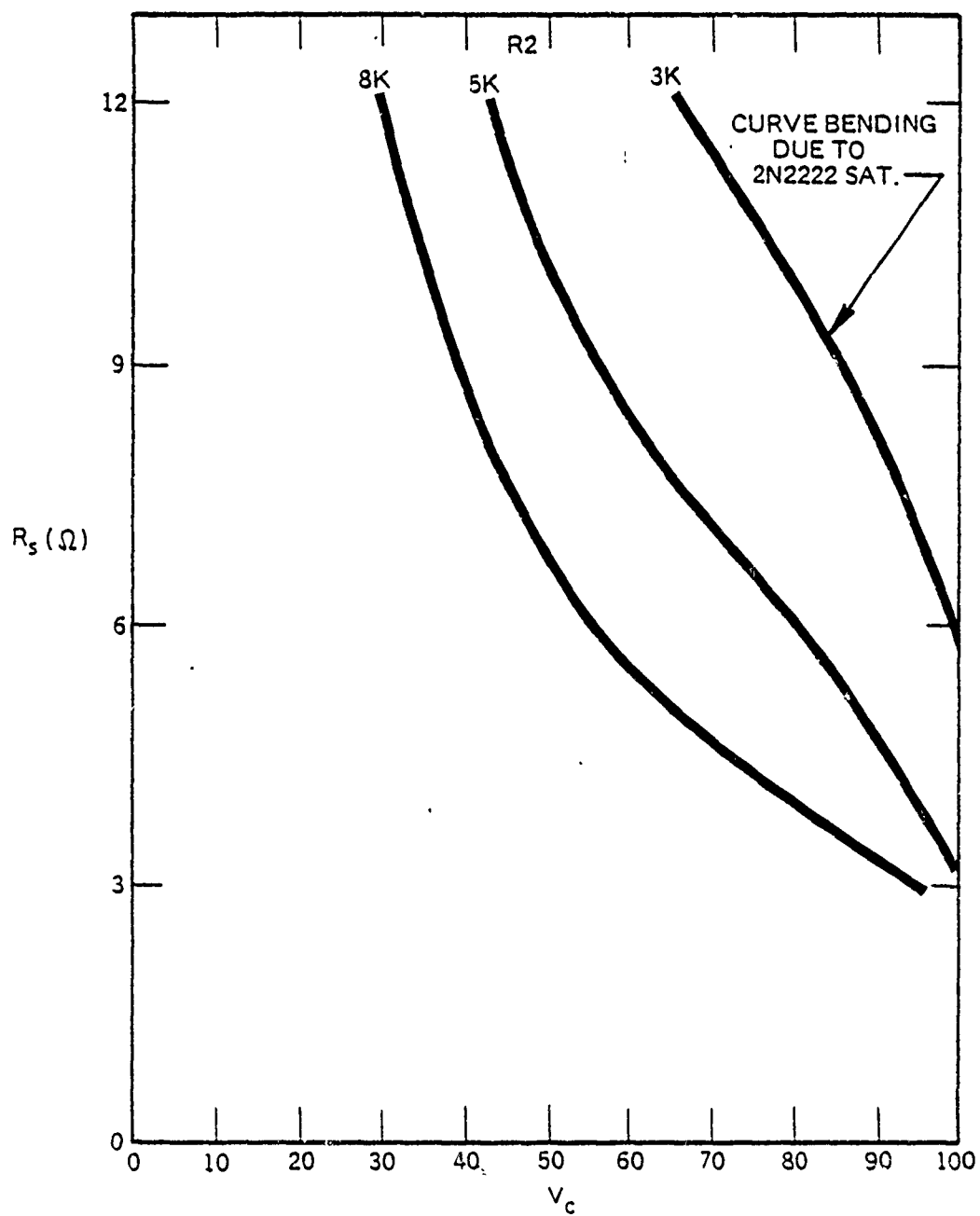


Figure 3-17. MILES Transmitter -  $R_s$  versus Capacitor Voltage

62046

$C = 0.082 \mu f$   
 $T = +65^{\circ}C$

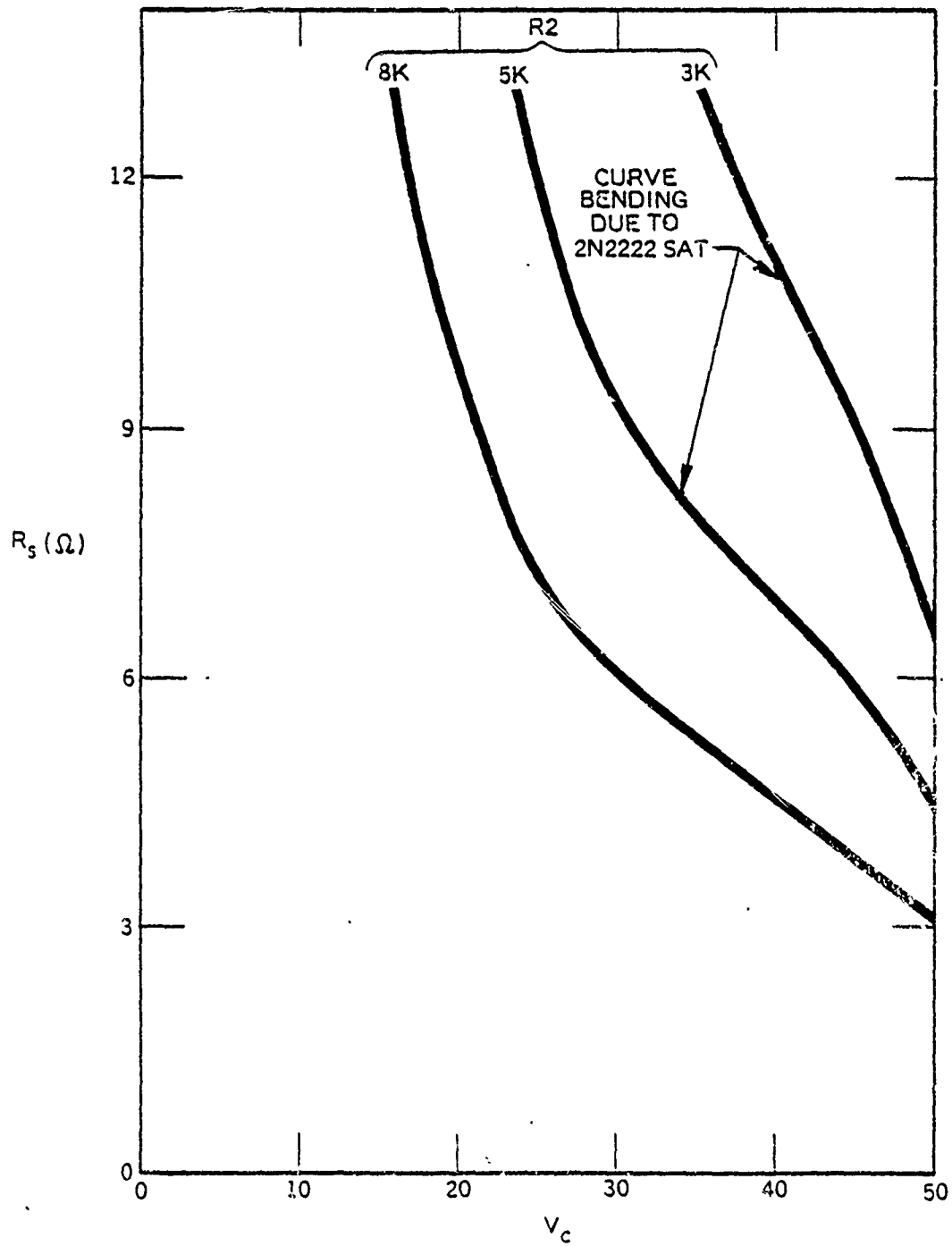


Figure 3-18. MILES Transmitter -  $R_S$  versus Capacitor Voltage

62054

$C = 0.12 \mu f$   
 $T = +65^{\circ}C$

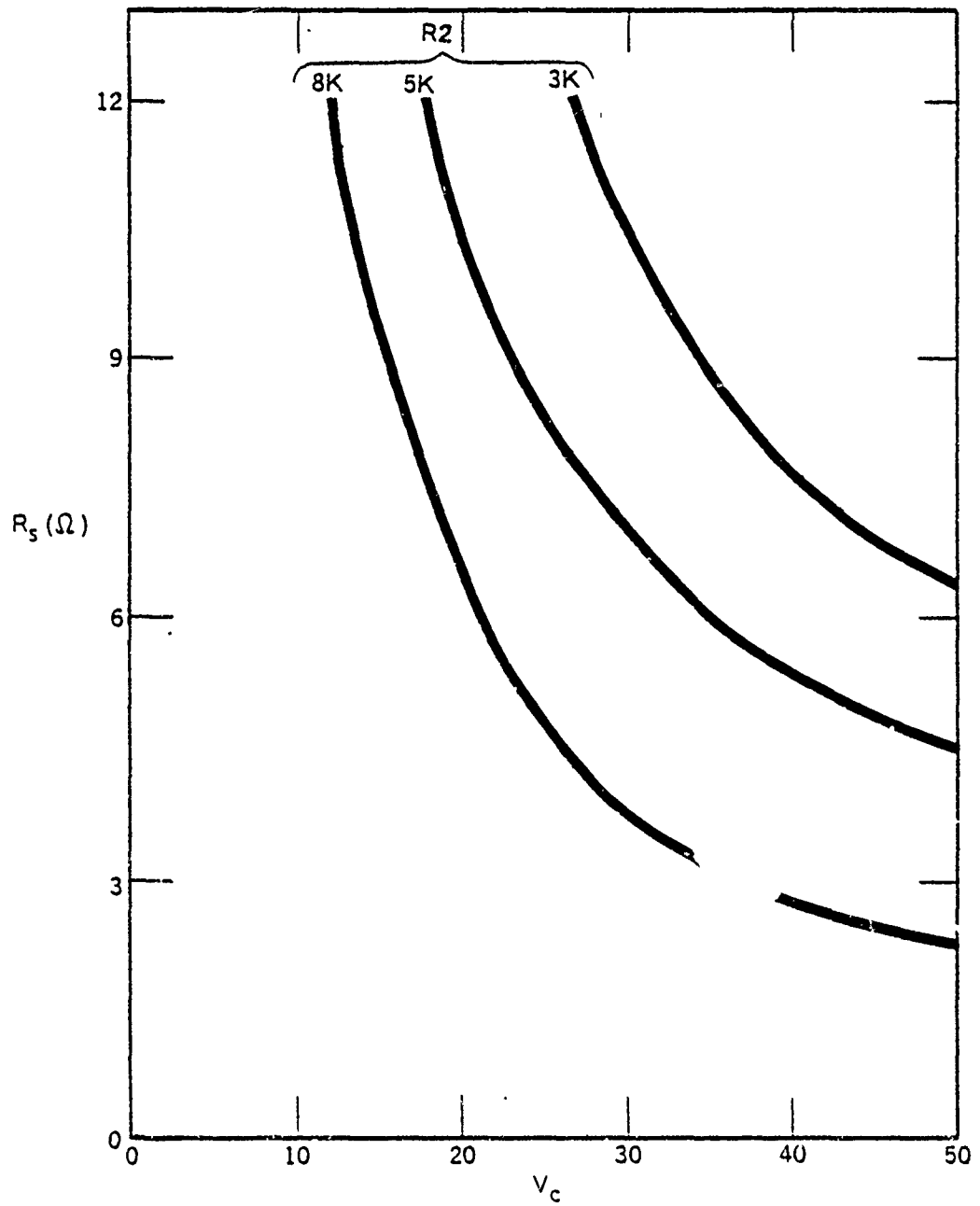


Figure 3-19. MILES Transmitter -  $R_s$  versus Capacitor Voltage

62047

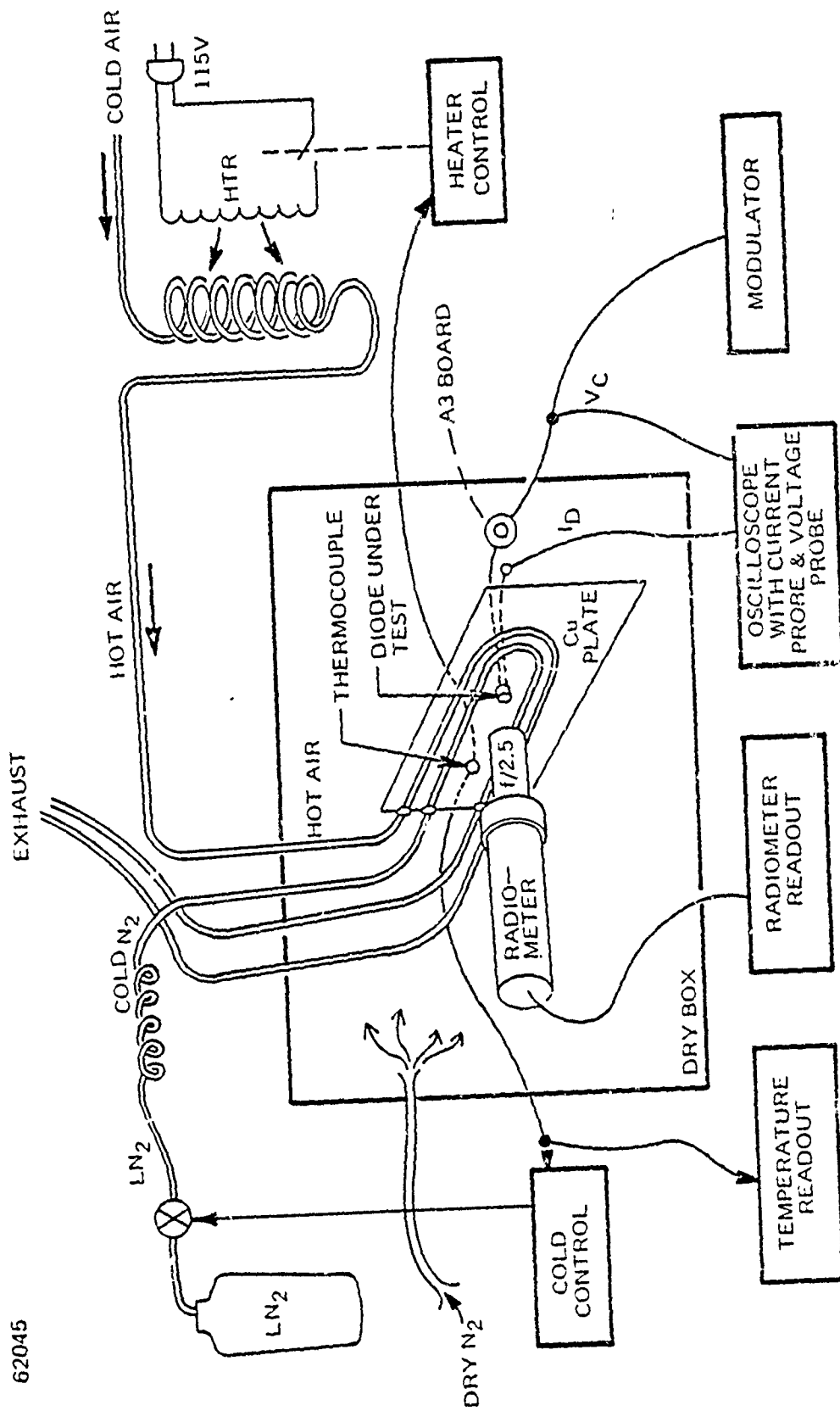


Figure 3-20. Test Setup, MILES Laser Diode Temperature Characteristics

Data was taken every 20°C. Temperature read-out and control is by a thermocouple attached to the plate near the diode.

### 3.6.3 POWER ADJUSTMENT

Laser output energy may be adjusted by varying current sense resistors R6 and R7 in figure 3-10. Kill energy is set by the sum of R6 and R7; near miss by R6 alone.

In production, these resistors are selected in test to adjust final laser output energy.

### 3.6.4 CALIBRATION IN PRODUCTION

Temperature compensation in ED was different for single heterostructure and multi-heterostructure devices. Multihet devices were found to be more stable in unit-to-unit temperature characteristics and were used exclusively in all three-mil applications (M16A1, M2, M85, M60, 105 coax, Viper and Controller Gun). Both types were used in all six-mil applications (Dragon, 105 mm main gun, 152 mm coax, 152 mm main, TOW, and Shillelagh). Three and six-mil refers to the length of the radiating laser junction.

Figure 3-21 shows the flow plan for calibrating transmitters. Incoming lasers are screened in the dry box for TC characteristics. Data from screening is used to decide on TC network values. For the diodes received in ED, all multihet diodes used in any single weapon type were given identical TC network values. All single-het diodes required customized TC networks which were installed at final test. Power resistors were installed in all units at final test.

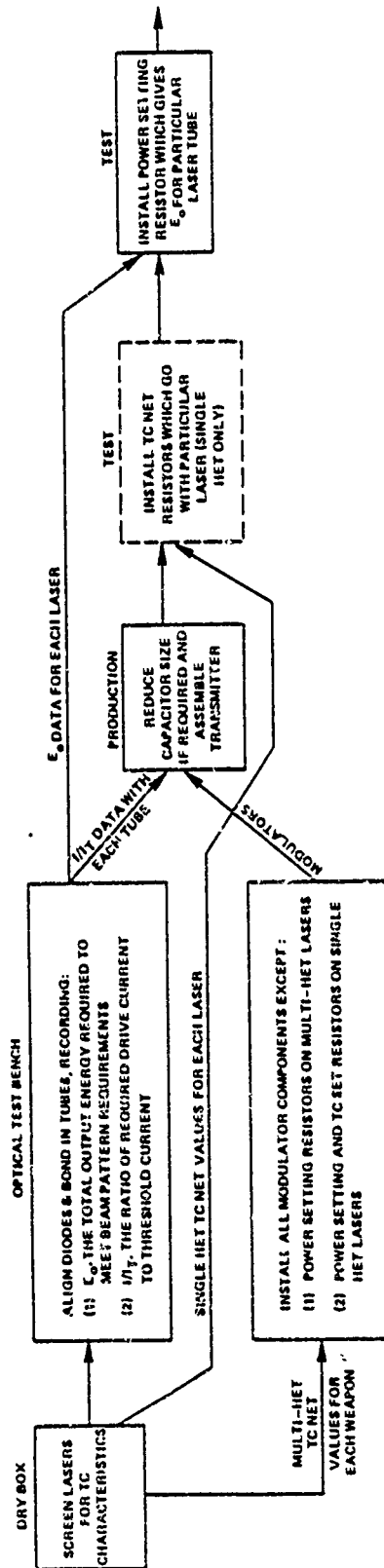


Figure 3-21. Flow Plan - MILES Transmitter Calibration

The diodes were aligned and bonded in transmitter optics tubes using an optical test bench. The alignment and power setting criterion was that the laser far field beam pattern fall between maximum and minimum energy profiles for each weapon. Each laser tube driver was adjusted to accomplish the desired beam pattern. The ratio of diode drive current to diode threshold current was measured and if less than 1.4, the capacitance was later lowered at tube assembly. (This to avoid diode operation near threshold where output energy is overly sensitive to drive current). The total energy ( $E_0$ ) exiting the transmitter output aperture was measured and recorded while the transmitter was operating within the allowable beam pattern profile tolerance.

At production test stations, after transmitter assembly, TC network select-in-test resistors were added to modulators if not already installed. The transmitters were then operated with adjustable resistors in place of sensing resistors R6 and R7. These were adjusted while total output energy was monitored until the output energy just matched  $E_0$ , the transmitter output energy which had been required to match beam energy profiles at the optical test bench. Resistance values matching the adjustable resistors were then installed and the output energy rechecked to complete the calibration.

### 3.7 LASER DIODES

#### 3.7.1 DEVELOPMENT DURING MILES ED

A contract was let early in the ED phase to develop multiheterostructure diodes which could reliably handle MILES energy levels. This program resulted in an antireflection coating being added to previous designs which reduced internal optical heating considerably.



The prototype lots were tested and found adequate for the MILES system, except for low collection efficiency when used with the MILES spherically uncorrected  $f/2.5$  plano-convex lens.

This was corrected by mounting the lens with the flat surface toward the diode, making more effective use of those portions of the lens near the perimeter of the aperture.

Once the multi-het diodes had been proven for MILES, an order for the entire MILES ED quantity of both three and six-mil diodes was placed, along with a back-up order for six-mil single het diodes in case production six-mil multi-hets did not meet requirements.

### 3.7.2 DEVELOPMENT OF PROCUREMENT SPECIFICATION

The laser diodes, in production, are set at a power level while monitoring the far field pattern out of the optical system. Each diode then has a specific power setting. The fact that each diode has a different operating power level seriously complicates procurement of the diode.

If the final operating power level is unknown during diode procurement, then a procurement document cannot be written which specifies exact testing levels and includes exact temperature compensated drives. Faced with that uncertainty, we have two choices:

- a. Specify the diode over all possible MILES operating levels and temperatures using a "standard" set of MILES temperature compensated drive currents, or
- b. Specify the diode at one operating level over temperature with a representative MILES temperature compensated drive current, and accept the risk and/or expense at production of using the diode at a different level.

In MILES ED, the second choice was selected and the MILES procurement document now specifies a single representative temperature compensated drive current and requires that diode output be above a minimum level over the temperature range when that curve is applied. This has resulted in a low price for the diode. Transmitter product specifications now allow system power to fall off or increase a factor of two over nominal at the temperature extremes to allow for operating point differences between the "representative" drive current in the diode spec and final power levels. Using these specifications, each MILES weapon has been able to use identical TC networks for multiheterostructure diodes. \*

The present spec does not guarantee that ED TC networks will work in future production. However, it is extremely likely that they will. Protection from future diode product changes may be had by lot testing of lasers in a dry box test fixture as described.

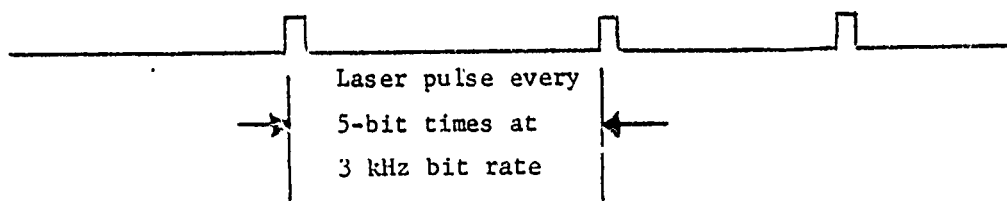
### 3.7.3 LIFE TESTING AND BURN-IN

We may calculate the amount of time a diode may be operated at 3KHz in order to simulate ten years of MILES use in the field. The weapon firing the most rounds would be a machine gun mounted on a tank. If that machine gun fired 2100 rounds per exercise, and there were 26 exercises per year, and each round contained four kill words and 20 near-miss words, and each word contained six active bits, then the total number of MILES pulses for the ten year lifetime would be  $10 \times 26 \times 2100 \times 24 \times 6 = 78.6 \times 10^6$ . This equates to a laser pulsed continuously at 3 kHz for 7.28 hours. Thus a MILES laser burned in at 3 kHz for 7.28 hours would equal a lifetime of use. The MILES laser specification calls out a design life of 35 hours minimum at with end-of-life defined as a 20% degradation in power output. The MILES specification requires burn-in of 16 hours at 3 kHz for all diodes.

This may appear excessive compared to the expected lifetime use of a MILES transmitter. However, 16 hours of burn-in are required in order to insure that infant mortality takes place prior to the 7.28 hour lifetime. Hours 17 through 23 are inherently more reliable than any 7 hour period earlier in the diode's life!

### 3.8 BORESIGHT MODE

The small arms transmitter is designed with a boresight mode. The boresight mode is accomplished by activating the boresight signal (BS\*) and the trigger signal (TRIG\*) with either the control key or weapon key inserted and engaged, refer to figure 3-1. A 600Hz boresight code is transmitted continuously if above conditions are met.



The boresight mode is employed by connecting a boresight adapter connector. Connecting the adapter activates both the boresight signal (BS\*) and the trigger signal (TRIG\*) by applying a logic level 0 (ground) to both input ports.

### 3.9 FIRE INDICATOR

It is desirable to indicate that actuation of the trigger switch, or firing a blank, is causing the unit to transmit a code. The fire indicator has been incorporated to satisfy this need.

This feature is provided on all MILES transmitter simulators other than those mounted on vehicles. A light emitting diode (LED) is caused to illuminate whenever the microprocessor is generating "fire" pulses. The LED is visible to the gunner while firing the weapon in the case of the M16A1 rifle and the machine guns. In the case of the Viper and Dragon, the firing indicator is the decimal point associated with the rounds-remaining display. It should be noted that operation of the "fire" indicator does not guarantee output from the associated laser, but only that "fire" signals are being generated by the microprocessor.

The circuitry required to perform this function is contained within LSI U6 (see figure 3-1). It consists of pulse stretching circuitry and an output stage capable of supplying 20mA to the LED. The pertinent portion of the circuit is shown in fig 3-22 which is typical of all MILES applications.

The input to Q8 is normally held low. When in this condition, C3 is charged through a constant current source delivering nominally 20uA. As a result of the charge on C3, Q10 is on, causing Q11, Q105, Q12 and Q13 to be off, so that no current flows in Firing Indicator CR2. When the brief (5uS) fire pulse is received at the base of Q8, C3 is discharged rapidly and the Firing Indicator is turned on. C3 must now charge to about 0.65V to again turn Q10 on, and the LED off. This charge time is about 1mS and since successive fire pulses occur every 333uS, the LED remains on until the fire pulses stop. Thus, the short fire pulse is lengthened and the LED's apparent brightness is greatly enhanced by this simple pulse stretching.

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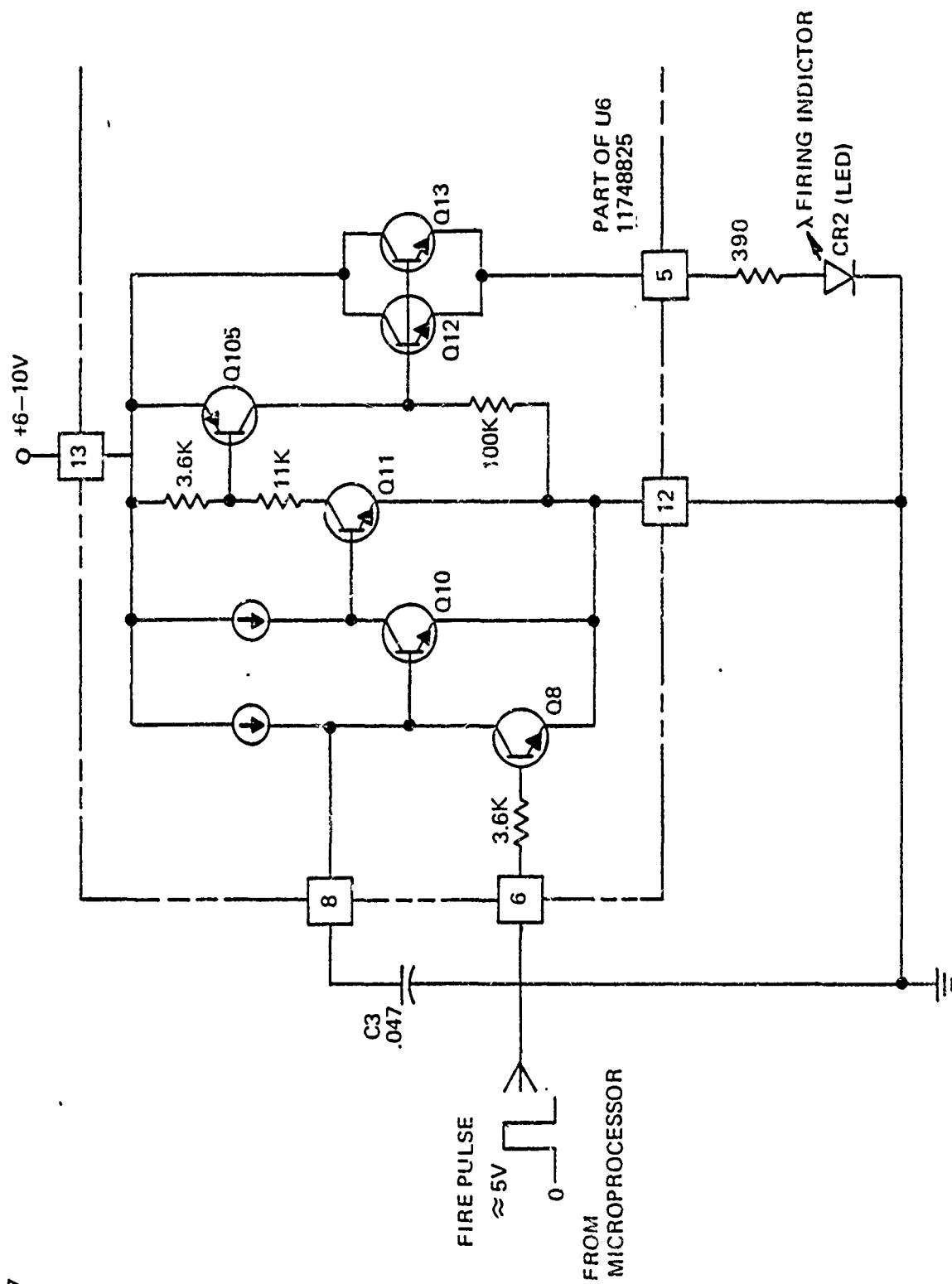


Figure 3-22. Firing Indicator Circuitry

### 3.10 DRY FIRE ROUND CONTROL

The small arms transmitter is designed with two operating modes of fire:

- a. Blank Fire Enable
- b. Dry Fire (Silent Fire)

In the Blank Fire Enable mode of operation, the possible number of rounds fired is the actual number of blank ammunition allotted to the operator. The rate of fire is the actual weapon rate of fire. In the Dry Fire mode of operation, round count is controlled by the software program. Refer to table 3-9.

### 3.11 ROUNDS COUNT INDICATOR

#### 3.11.1 VIPER/DRAGON/TOW

The Viper/Dragon/TOW transmitter is designed with a single digit seven-segment display with decimal point to indicate rounds remaining. The seven segments are driven through 390 $\Omega$  series resistors by a BCD-to-seven segment latch/decoder/driver chip circuit (U1-Display Driver). The BCD (binary coded decimal) data are inputted by four data lines from the 1802 microprocessor data bus and latched by two gated control and timing outputs from the microprocessor. The number of rounds remaining is controlled by the Viper/Dragon software program. The display is illuminated by depression of the rounds count display momentary switch which is connected to the display blanking input on U1-Display Driver. The display's decimal point is driven through a 910 $\Omega$  series resistor from the Laser Driver Interface circuit chip and is illuminated when fire pulses are generated to indicate firing (see figures 3-23 and 3-24).

TABLE 3-9

## DRY FIRE OPERATION - WEAPON PARAMETERS

|                     | <u>Allotted Rounds</u> | <u>Burst Rate (Rounds)</u> | <u>Transmitted Code Words</u> | <u>Fire Sequence Code Words per Round</u> |                                | <u>Firing Rate (rpm)</u> |
|---------------------|------------------------|----------------------------|-------------------------------|-------------------------------------------|--------------------------------|--------------------------|
|                     |                        |                            |                               | <u>Automatic</u>                          | <u>Semi-Automatic</u>          |                          |
| M16 Rifle           | 210                    | 30                         | Hit Code #27<br>Miss Code #29 | 4 Hit Words,<br>20 Miss Words             | 4 Hit Words,<br>128 Miss Words | 678                      |
| M60 Machine Gun     | 600                    | 30                         | Hit Code #27<br>Miss Code #29 | 4 Hit Words<br>20 Miss Words              | N/A                            | 678                      |
| M2, M85 Machine Gun | 1200                   | 30                         | Hit Code #24<br>Miss Code #29 | 4 Hit Words,<br>20 Miss Words             | N/A                            | 678                      |

↑  
For all modes  
of operation

### 3.11.2 LCA

The LCA and CIA electronics assemblies are designed with a front panel two-digit, seven-segment display. The segments are driven through 910 $\Omega$  series resistors and N-P-N transistor array circuit chips (U7 and U6) by two BCD-to-seven-segment latch/decoder/driver circuit chips (U5 and U4) (see figure 3-23). The BCD data are inputted by 8 data lines and from the 1802 microprocessor data bus. The data are latched by a gated timing signal and the appropriate control signal from the 1802 microprocessor. The control signal is dependent upon the desired display function which is selected by a front panel switch (see figure 3-24). The data displayed, rounds remaining, self-test, etc., are controlled by the LCA and CIA software program. The front panel display is illuminated by the depression of the press-to-read momentary switch located on the front panel. The momentary switch provides a closed path to ground for the common cathode digit display.

### 3.12 ATWESS TRIGGER CIRCUITRY

ATWESS is fired by actuating a solenoid which releases a sear. This allows a spring-loaded firing pin to impact a primer in the cartridge. A safe-arm mechanism inserts a plate between pin and cartridge when the device is placed in the safe position. The solenoid is fired from a storage capacitor which is recharged after firing.

ATWESS trigger circuitry is designed to prevent TOW, Dragon, and Viper gunners from fighting a "silent war." Care is taken to insure MILES cannot be fired without ATWESS firing also.

In order to do this, a microswitch is included in the safe-arm mechanism to close a circuit only when ATWESS is in the "armed" position. In series with this microswitch are two point contacts which engage a copper disc on



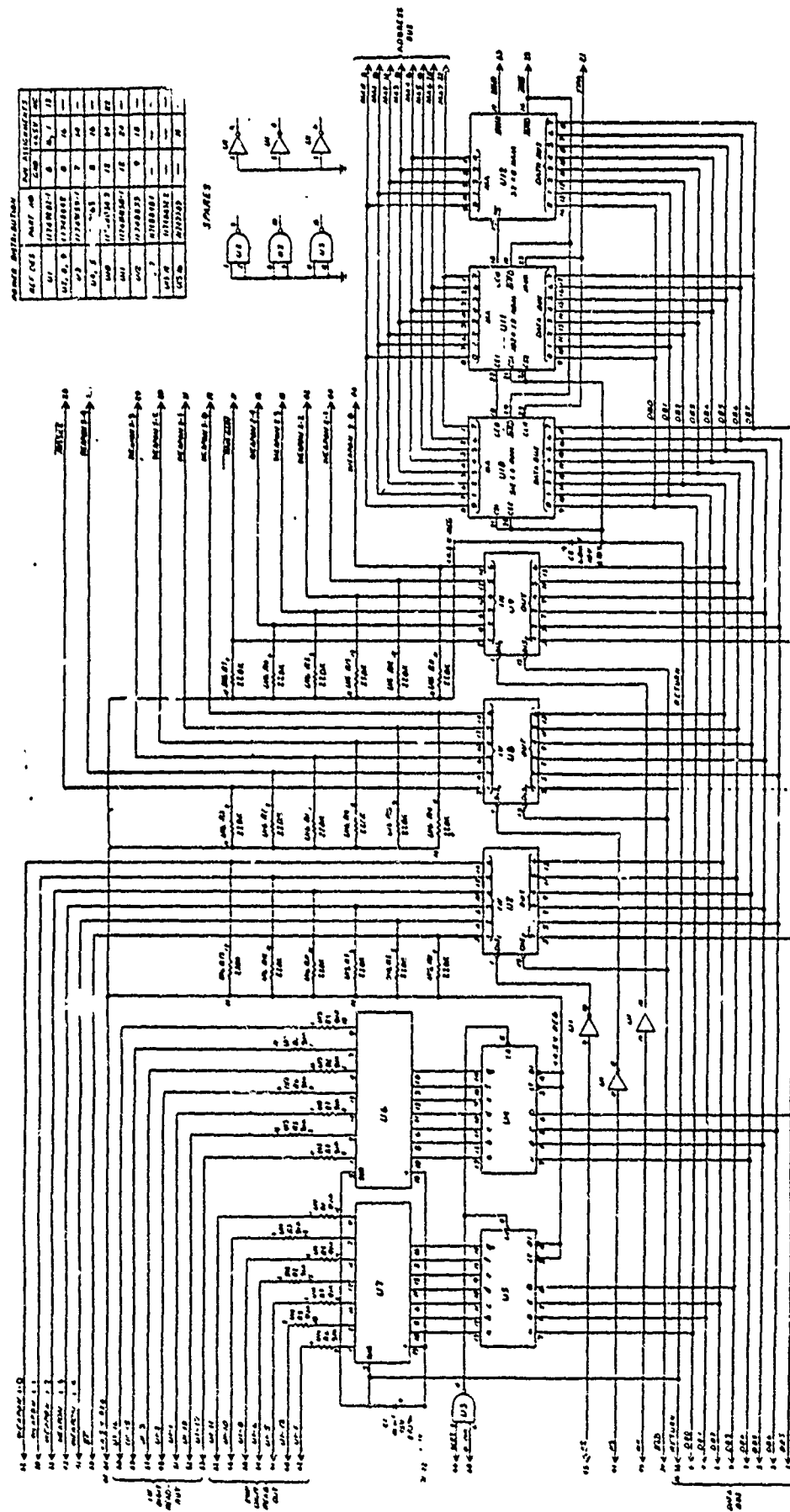


Figure 3-23. Weapon ID and Display Logic Diagram

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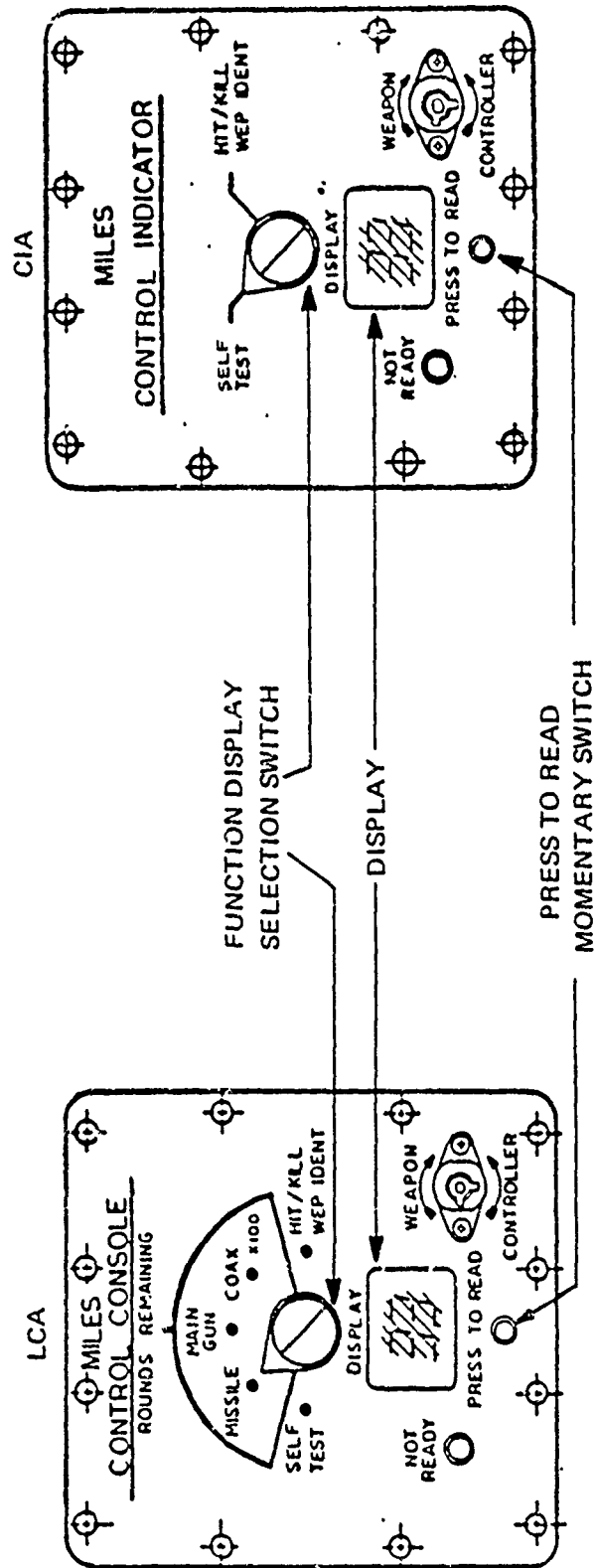


Figure 3-24. LCA and CIA Front Panel

Each unfired ATWESS cartridge. When the cartridge is fired, the disc is destroyed, opening the circuit. When used with ATWESS, MILES may only be fired when a live cartridge is in the ATWESS chamber and the ATWESS safe-arm mechanism is in the armed position.

Figure 3-25 shows the schematics. The logic is the same on all three applications. MILES will receive trigger signals when the weapon trigger is pulled and either of the following two conditions is true:

- a. The safe-arm lever on ATWESS is in the "armed" position and a live cartridge containing the conductive disc is in the ATWESS.
- b. The controller key switch is in the "dry fire" position.

The Boolean equations defining the logic follow:

$$M = (\bar{S}C + D) T = (\bar{S}C) T$$

where:

- A = ATWESS electrical trigger signal assertion
- M = MILES electrical trigger signal assertion
- $\bar{S}$  = unsafe or "armed" position of the ATWESS arming lever, as detected by a microswitch in the safe-arm mechanism
- C = presence of an unfired ATWESS cartridge in the ATWESS, as detected by continuity through the copper disc on the cartridge
- D = dry fire position of the controller key-actuated switch
- T = weapon trigger actuation

The following facts regarding ATWESS safety are pertinent:

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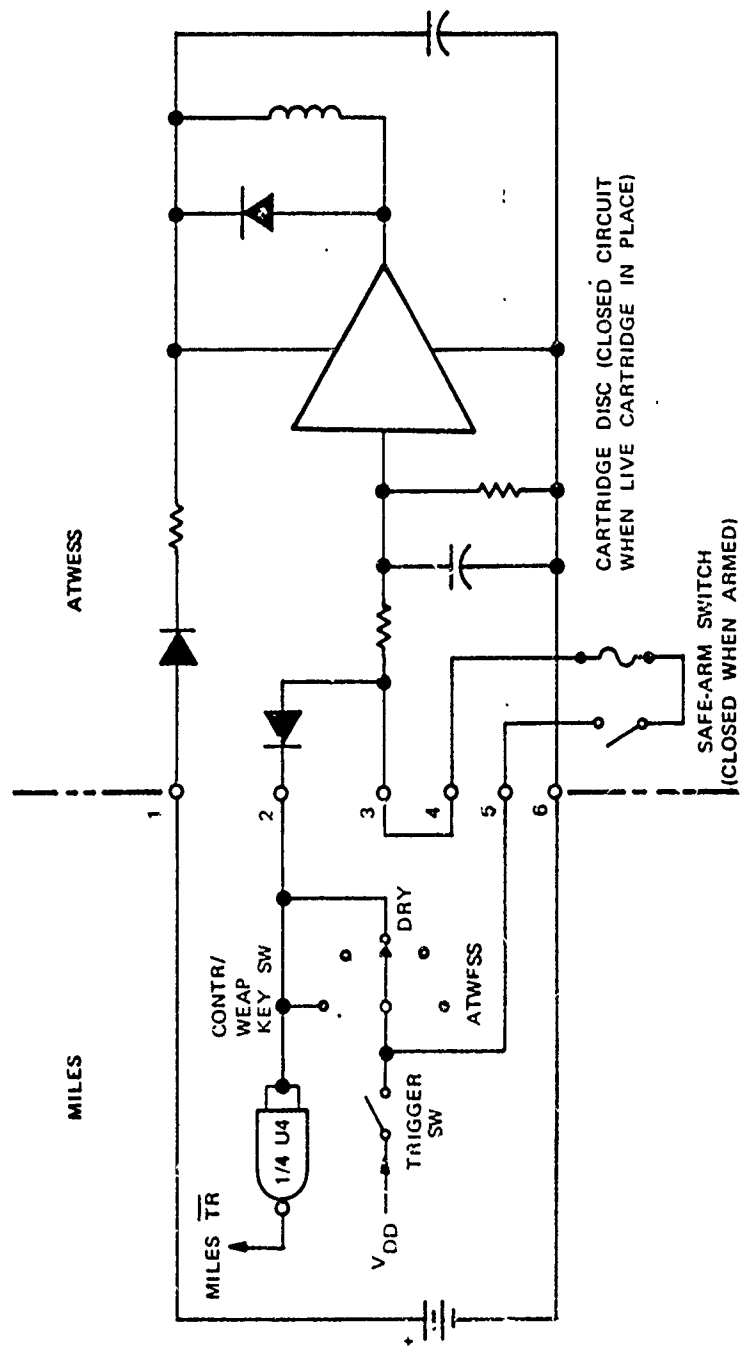


Figure 3-25. Typical MILES/ATWESS Interconnection

- a. The large storage capacitor in ATWESS will remain charged and ATWESS will remain dangerous for some time after the MILES ATWESS connector is disconnected. During this time a positive signal on the ATWESS trigger pin of the connector will release the sear on ATWESS regardless of safe-arm lever position. (A mechanical safety will prevent cartridge detonation if the lever is in the "safe" position.)
- b. Although MILES requires a weapon key or controller key to enable firing, ATWESS does not. Therefore, ATWESS may fire even when the MILES transmitter is not key-enabled.

In addition to the foregoing safety considerations, it should be noted that the MILES transmitter will fire even though a "dud" ATWESS cartridge is in place.

### 3.13 ATWESS ELECTROMECHANICAL INTERFACE

ATWESS receives its power and its trigger signal from MILES. It was initially designed to work with Viper, Dragon, and TOW simulators and, since the first two devices use a negative trigger signal, ATWESS was designed to use the same trigger polarity. This caused safety problems which were solved by using a positive trigger signal.

Figure 3-26 shows the very simple circuitry involved. A large electrolytic capacitor (36,000  $\mu$ F) is charged from the MILES battery through CR2 and R1, storing energy which later will be expended in the solenoid resulting in firing the ATWESS cartridge. The manner in which this is accomplished will be described below.

#### 3.13.1 CIRCUIT OPERATION

The MILES trigger signal is low until the trigger is actuated. Thus, since the trigger signal is applied at pin 2 of the terminal board, Q1 is normally on. As a consequence, Q2, Q3, and Q4 are off and the

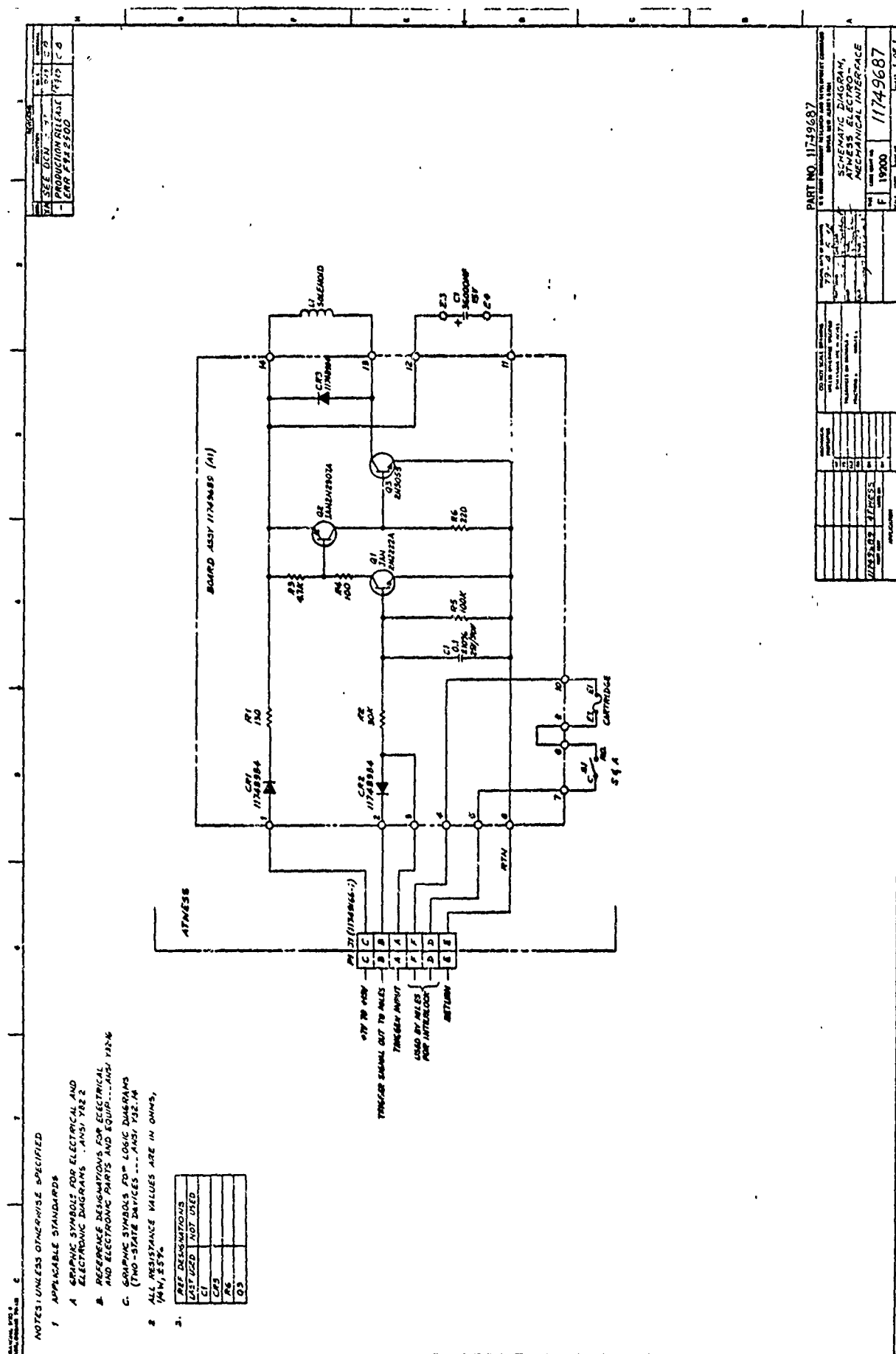


**Figure 3-26. ATWESS Electromechanical Interface Schematic Diagram**

electrolytic capacitor remains charged. When the trigger signal goes to ground, Q1 is turned off. As a consequence, Q2, Q3, and Q4 are turned on allowing the electrolytic capacitor to discharge through the solenoid with a peak current flow of about 4 amperes. At this point, if it is assumed that the ATWESS has been cocked and armed, the solenoid will pull back the sear, releasing the hammer which then strikes the firing pin and fires the cartridge. C2 has been introduced to avoid expected problems with excessive contact bounce in the trigger switch since the presence of C2 makes a regenerative loop around Q1 and Q2 keeping Q1 off after the first trigger pulse until the solenoid has actuated.

### 3.13.2 SAFETY DEVICES

In addition to the mechanical safety features incorporated into ATWESS, three electrical safeguards exist. These are the safe-and-arm switch, the cartridge fusible link, and the series trigger diode CR2. The major function of the first two features is to prevent firing of MILES unless ATWESS is armed and a cartridge inserted. As described in subsection 3.13, this feature is incorporated when the MILES system is operated in the ATWESS mode. In order to operate MILES without ATWESS, a "dry fire" mode of operation is selectable by means of the controller key. This position feeds a trigger signal to MILES only. The signal is blocked from ATWESS by CR1.

### 3.13.3 CONTEMPLATED ATWESS MODIFICATIONS

During OT II testing, several difficulties arose connected with the use of the ATWESS, which have resulted in some design changes to the electronics. Among these difficulties were the following:

- a. ATWESS would fire when battery power to MILES was removed.
- b. ATWESS would fire if its trigger lead was shorted to ground.
- c. In TOW, ATWESS would fire if the bridge clamp lever was moved to the "safe" position.

In each case, the action resulted in a low signal being placed on the trigger lead which was interpreted by ATWESS as a normal trigger. In order to alleviate this difficulty, it was decided to modify ATWESS so that a positive trigger would be required. Essentially, this was accomplished by removing Q1 from the circuit so that the trigger signal connects to the base of Q2. In addition, the safe-and-arm switch and cartridge fusible link are placed directly in series with the ATWESS trigger lead so that ATWESS will not receive a trigger unless armed nor will MILES fire. These changes have eliminated the electrical problems found during OT II testing and they are incorporated in future ATWESS units.

#### 3.14 RECEIVER

The MILES receiver amplifies the signals resulting from coded transmitter pulses impinging upon a group of detectors. It then passes the amplified signal through a threshold circuit the output of which responds only to signals which are above the predetermined threshold. The resulting uniform train of pulses may then be decoded by subsequent circuitry discussed in subsection 3.17. The following paragraphs of this section explain the operation of the MILES detection/receiver circuitry.

##### 3.14.1 DETECTORS

MILES employs a group of parallel connected silicon photovoltaic detectors (solar cells) to detect the presence of laser radiation from the transmitter. The number of detectors connected to a single



amplifier varies from four to eight depending upon the application. The number of detectors employed in a given case is determined by the particular requirements that the detector assemblage cover a specific area and range of directions from which signals might arrive.

The individual detectors have a nominal area of  $1 \text{ cm}^2$ . They are mounted in a hermetically sealed metallic housing having a glass window. In addition to providing mechanical protection for the detectors, the housing, together with a conductive grid on the inside of the glass window, provides shielding against impinging EMI. A visible light filter eliminates much solar background radiation while admitting infrared laser pulses.

#### 3.14.2 PREAMPLIFIER

The preamplifier/threshold circuit is shown in figure 3-28. Three amplifier stages precede the threshold circuit and serve to amplify the signal appearing across the detectors to an amplitude of about 0.25 volt or more. The threshold circuit then can differentiate between signal and noise pulses based upon the greater amplitude of the signal pulses. This section will describe the preamplifier portion of the circuit.

The first and third amplifier stages are similar in design and consist of inverting negative-feedback gain-stabilized amplifiers. The second stage is noninverting but is also gain-stabilized by negative feedback. The first and second stages are incorporated in LSI U1 of figure 3-27 and the third stage and the threshold detector are incorporated in LSI U2. A simplified circuit is shown in figure 3-28.

The signal from the group of parallel connected detectors is coupled to the input of the first amplifier stage through pulse transformer T1 and coupling capacitor C8.

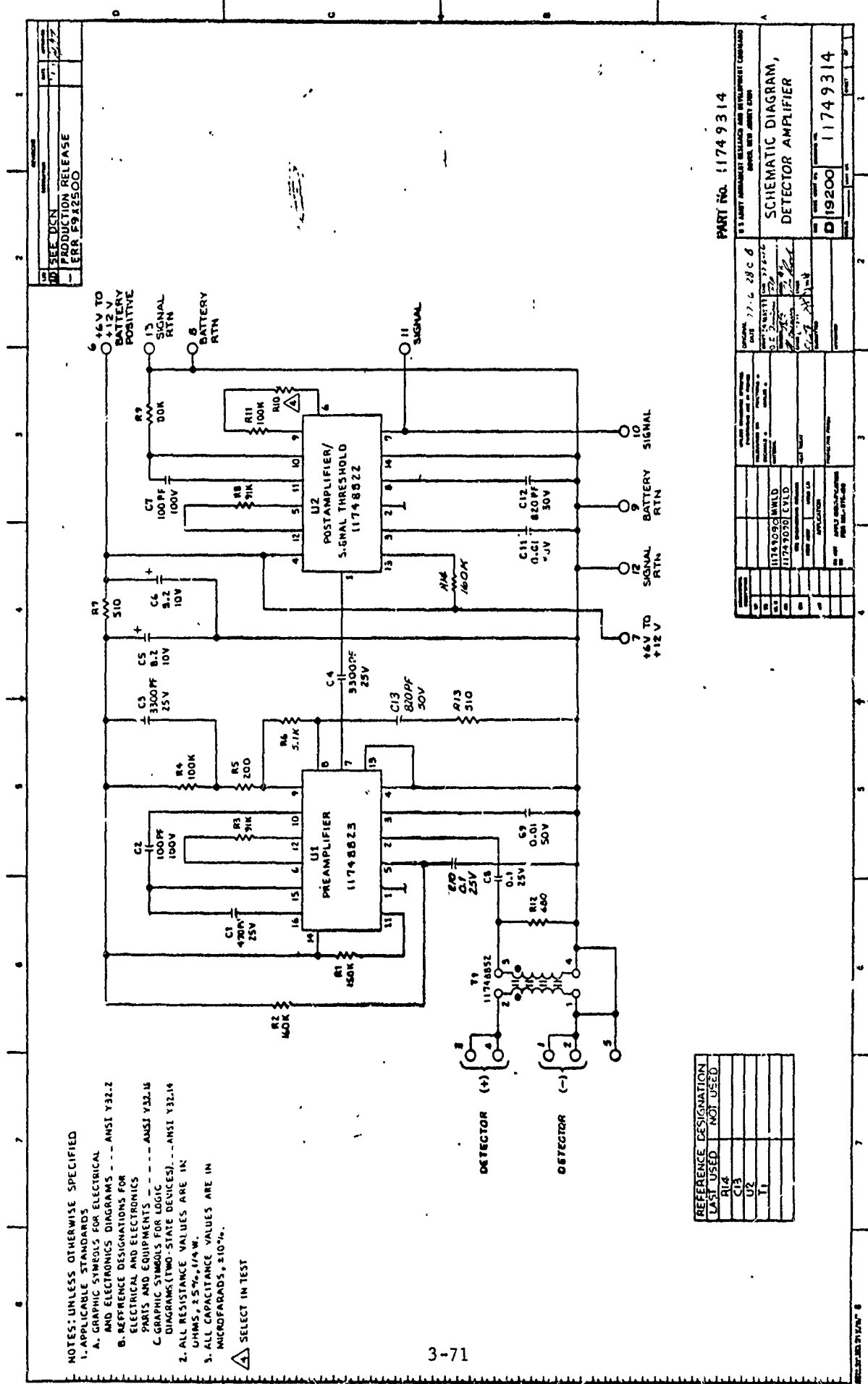


Figure 3-27. Detector Amplifier Schematic Diagram

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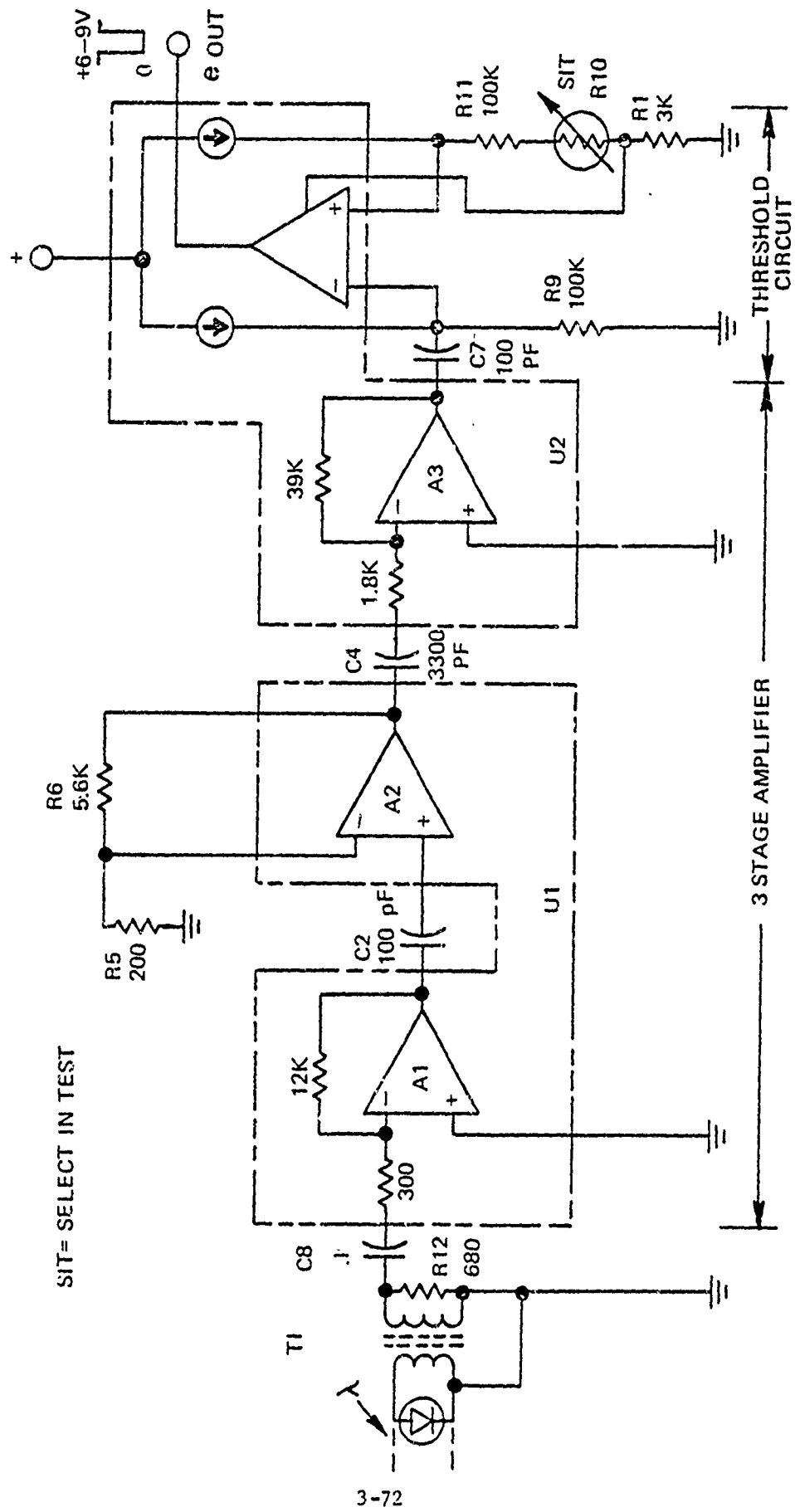


Figure 3-28. Simplified Schematic Preamplifier/Threshold

The amplifier section provides a total gain of about 15,000 and a bandwidth extending from about 100 kHz to about 1.5 MHz. The worst case input noise-equivalent-energy with eight detectors is about 7  $\mu$ ergs. A primary consideration in preamplifier design was that it should have low power consumption to insure good battery life. Total current drain including threshold circuit is approximately 1 mA.

The low frequency rolloff is determined by the response of the input transformer and the interstage coupling capacitors. The high frequency limitation is brought about by the combination of parasitic capacitances in the LSI circuits and the limited gain-bandwidth of the LSI transistors at their necessarily low operating currents.

### 3.14.3 THRESHOLD CIRCUIT

The output of the three stage amplifier contains both signal pulses and noise pulses. Noise originates mainly from two sources, the input stage of the first amplifier and from sunlight-induced current flowing in the detectors. It is the function of the threshold detector to separate the desired signal pulses from noise pulses based upon the difference in their respective amplitudes. Since any noise pulse which reaches the threshold level will be accepted as a valid signal, it is important that the threshold be set high enough so that relatively few noise pulses reach this amplitude. It has been calculated that about 90 noise pulses per second may be accepted without an excessive false kill rate in the man worn system and a somewhat higher number in the vehicle systems. The threshold level is regularly set to accept no more than 30 noise pulses per second under worst case conditions so as to provide a significant safety factor.

The threshold detector consists of a simple balanced amplifier. Bias for the amplifier is obtained from two resistors, R9 and the series combination R11, R10, and R13. In this latter group, R10 is selected

in test to set the threshold level. Current is supplied to these resistors by two matched constant current sources housed within LSI U2. R13 is a hysteresis resistor which is short circuited during a pulse in order to provide more reliable triggering of the threshold circuit with marginal signal levels.

The output of the threshold detector is a single negative pulse approximately 10  $\mu$ sec long for each input pulse which is above the threshold level. This output signal is then fed to the subsequent logic circuitry which performs the task of code recognition.

#### 3.14.4 THRESHOLD ADJUSTMENT

The selection of R10 to set the threshold level was mentioned in the preceding subsection. At the present time, the selection of R10 is accomplished by feeding noise into the amplifier from a group of standard detectors irradiated by simulated sunlight. The noise resulting from this sun current together with amplifier noise then appears at the threshold input. The normal operating current of U1 is increased to simulate worst case (low temperature) performance by shunting the current set resistor for U1, R3 of figure 3-27. The value of R10 needed to give a count rate of 20 to 30 pulses per second less is then determined and compared with the expected range of values. The actual R10 used is an empirically determined value obtained by exposing a detector with the desired energy density of laser signal of about 25  $\mu$ ergs per pulse. In this way, close control of receiver sensitivity is maintained.

#### 3.15 INDUCTIVE LOOP

In the man-worn detection system, it is necessary to have an array of detectors on the helmet as well as the torso since the head is the most frequently exposed, vulnerable portion of the body. Since it is

undesirable and, in fact, unsafe to have a wire connection between the helmet and the harness, a scheme has been developed to transmit helmet signals to the torso harness without a wire connection. This scheme involves a loop of wire around the helmet which is used to transmit the helmet signal to a similar loop at the shoulders of the user, the shoulder loop being connected to a receiver which then sends the coded signal to the decoder in the harness electronics. This arrangement is the inductive loop which is described in this section.

#### 3.15.1 TRANSMITTER (HELMET)

The helmet transmitter contains a preamplifier-threshold circuit which is identical to that used to detect coded laser signals for the torso electronics and vehicle belts as described in subsection 3.15. This circuitry is followed by an additional circuit, however, which causes a pulse of current to flow in the helmet loop each time a laser pulse is detected by the preamplifier-threshold circuit. This action is produced by a silicon controlled rectifier (SCR). A capacitor is charged to the battery voltage. When a pulse is received, the SCR is fired. The SCR acts like a fast switch which connects the charged capacitor across the single turn helmet loop. The sudden current pulse produces a magnetic field which is sensed by the receiving loop associated with the torso or harness electronics. Charging of the capacitor and firing of the SCR is repeated for each received laser pulse.

#### 3.15.2 RECEIVER (TORSO)

The two-turn receiving loop, lying on the user's shoulder, is completed in the harness by means of a cloth strap which contains the wires forming the loop and crosses the chest. The loop is tuned to about 1 MHz which corresponds to the nominal resonant frequency of the transmitting loop described above. \*

The sudden pulse in the magnetic field caused by the helmet transmitter induces a voltage into the receiving loop. A threshold circuit, very similar to that used in the receiver, is used to sense the voltage across the loop and to produce an output pulse when the voltage exceeds the threshold. This output is "or-ed" with the output of the harness preamplifier-threshold before being fed to the decoder so that signals striking either helmet or harness or both may be detected.

### 3.15.3 SENSITIVITY ADJUSTMENT

It is necessary to adjust the loop receiver sensitivity in order to avoid undesired response to noise. This is accomplished in much the same fashion as the receiver threshold adjustment. A fixed resistor is selected in test so that the reference voltage for the threshold circuit is set to cause the circuit to trigger at the desired level.

The major sources of noise are various forms of EMI. These can come from radio transmitters, automotive ignition, and similar sources. The resonant frequency chosen for the receiving loop is in the AM band. Hence, it is unlikely that large field strengths would be encountered in an area where training was being conducted. High frequency radios, such as might be used for military communication, will not produce large loop voltages. There are two reasons for this. First, these signals occur at frequencies far removed from the resonant frequency of the loop. Second, the leads from the loop pass through feedthrough capacitors which serve to strip off undesired signals before they reach the threshold circuit. Most lower frequency signals are eliminated by the appropriate setting of the receiver sensitivity as described above. In this way it is possible to maintain reasonable sensitivity to desired signals while effectively rejecting undesired signals.

### 3.16 DECODER

#### 3.16.1 MAN WORN LASER DETECTOR (MWLD)

The basic component of the MWLD decoder is a custom-designed CMOS digital LSI circuit (refer to figure 3-29). The basic clock rate for the MWLD decoder is 48KHz which is generated by a clock oscillator incorporated in LSI design in conjunction with a 48KHz crystal. Code reception consists of a data signal received from 8 solar detectors mounted on the body harness, or a conditioned data signal (loop signal) received from 5 solar detectors mounted on the helmet. Codes transmitted from weapons are 11 bits long (weight 6) at 3 KHz, with active bits of 1 to 8  $\mu$ sec duration at the decoder input. The decoder samples and shifts the incoming data through two serial shift registers at a 48KHz rate. Boolean union decoding takes the union of incoming bits with bits from the previous word. This is accomplished by taking the logic "OR" of the output of the first shift register with the incoming data and feeding it to the input of the second serial shift register. Eleven taps spaced every 16 bins through the second serial shift register are continuously monitored.

A 5-bit up/down counter keeps track of the total number of active bits shifting through the second serial shift register, and resets the shift register to all nonactive bits if 32 or more active bits are accumulated.

From the 11 taps, the MWLD decoder has the capability of decoding 8 different codes, 6 hit codes-code #00, #21, #22, #23, #24, #27, and 2 miss codes-#29, #20. Nine data lines of which one is a gated combination of 3 data points are brought to the LSI output pins for use in the LCA and CIA decoder electronics section. When either of the





**Figure 3-29. MWLD Decoder Schematic Diagram**

two miss codes is decoded the LSI circuit generates a miss signal which is outputted to the Loop Receiver/Horn Driver circuit chip (U1, Dwg. #11748826) which in turn activates the buzzer (horn) for approximately 0.5 second. Decoding any one of the 6 hit codes sets the kill latch in the LSI circuit. Also at power turn on, a power on reset signal (POR\*) generated in U1 sets the kill latch. Additionally, if the weapon key is inserted and engaged before an actual kill the kill latch is set. The kill latch is only reset when the control key is inserted and engaged. When the kill latch is set without the weapon key inserted and engaged, a continuous active kill signal is outputted to U1 which in turn activates the buzzer (horn) continuously.

### 3.16.2 LCA AND CIA

The decoder in the LCA and CIA is designed to decode up to 32 different MILES codes (refer to figure 3-30). Code data is received from the vehicle detection belts and inputted into a MWLD decoder LSI (U5). The decoder LSI circuit samples and shifts the data and outputs the nine data lines as stated in Section 3.16.1. The nine data lines are used as address lines to the valid code ROM (Read Only Memory), U14. When one of the 32 codes is received, the valid code ROM with additional timing signals strobes a 6-bit identification data code into an input data port (U15) which in turn interrupts the 1802 microprocessor to signal that a valid code has been received. The 1802 microprocessor, under program control, accepts identification data code and clears the input port to allow reception of the next valid code. The software program processes and analyzes the identification data code to determine the transmitted weapon's lethality against the Vehicle (LCA or CIA).



### 3.17 VEHICLE KILL PROBABILITY

The microprocessor structured electronics in the Loader's Control Assembly (LCA) and the Control Indicator Assembly (CIA) receives incoming MILES coded weapon hit signatures and then, based upon the weapon/target relationship, performs a decision of hit or kill based on predetermined first round kill probabilities. The kill probability is assessed after each "hit detection". For vehicle systems (LCA and CIA) a hit or miss detection consists of receiving two identical code words within a variable window time of 128msec to 256msec, with the window time starting at the reception of the first code word. An exception to this, is the reception of tracking missile weapon codes where a hit detection requires the reception of 22 to 32 missile code words and a miss detection, 2 to 21 words within a ten second window time with the window time starting at the reception of the first missile code word.

In the MILES weapon array there are many weapons that transmit more than 2 hit code words per round, example - 105 mm main gun transmits 8 hit code words per round. Thus for an 8 hit word coded "round", the kill probability is exercised 4 times if all 8 hit code words are received. Therefore, the vehicle kill probabilities stored as ROM data constants for weapons that transmit more than two hit code words per round are less than the first round kill probabilities. The accumulated effect if all words are received is equal to the first round kill probability. Refer to "Vehicle Kill Probabilities" (table 3-10).

The probabilities are related as follows:

$$P_R = 1 - (1 - P_D)^{[(N+1)/2]}$$

where

TABLE 3-10  
KILL PROBABILITIES

| CODE NO. | WEAPON                                   | HIT WORDS<br>PER ROUND | KILL PROBABILITY PER ROUND<br>VEHICLE TYPE |                   |                   |                    |
|----------|------------------------------------------|------------------------|--------------------------------------------|-------------------|-------------------|--------------------|
|          |                                          |                        | TRUCK/JEEP                                 | AC/HELICO         | APC               | TANK               |
| 00       | 100% Univ. Kill                          | 16                     | 100.0%                                     | 100.0%            | 100.0%            | 100.0%             |
| 01       | Nevrick                                  | 8                      | 100.0%                                     | 100.0%            | 100.0%            | 100.0%             |
| 02       | Hellfire                                 | M                      | 100.0%                                     | 100.0%            | 100.0%            | 93.75              |
| 03       | Sagger                                   | M                      | 100.0%                                     | 95.3125           | 98.4375           | 70.3125            |
| 04       | 60 mm, 81 mm, 4.2 inch                   | 8                      | 100.0%                                     | 100.0%            | 73.4375<br>28.125 | 1.5625<br>1.5625   |
| 05       | M15A Mine (Track Cutter)                 | 4                      | 100.0%                                     | 100.0%            | 98.4375<br>87.5   | 98.4375<br>87.5    |
| 06       | Weapon X                                 | 8                      | 100.0%                                     | 100.0%            | No Effect         | No Effect          |
| 07       | TOW, SMILGELACH                          | M                      | 100.0%                                     | 98.4375           | 100.0%            | 85.9375            |
| 08       | DRAGON                                   | M                      | 100.0%                                     | 100.0%            | 98.4375           | 76.5625            |
| 09       | M202 Flame                               | 4                      | 100.0%                                     | 100.0%            | 62.5<br>39.0625   | 78.125<br>53.125   |
| 10       | M21 Anti-Tank                            | 4                      | 100.0%                                     | 100.0%            | 100.0%            | 79.6875<br>54.6875 |
| 11       | Claymore M18A1 & M16                     | 4                      | 85.9375<br>62.5                            | 78.125<br>53.125  | No Effect         | No Effect          |
| 12       | 105 mm                                   | 8                      | 96.875<br>57.8125                          | 100.0%            | 96.875<br>57.8125 | 87.5<br>40.625     |
| 13       | 152 mm                                   | 8                      | 96.875<br>57.8125                          | 100.0%            | 100.0%            | 78.125<br>31.25    |
| 14       | 2.75 in. Rocket                          | 8                      | 96.875<br>57.8125                          | 92.1875<br>46.875 | 78.125<br>31.25   | 42.1875<br>12.5    |
| 15       | VIPER                                    | 8                      | 96.875<br>57.8125                          | 92.1875<br>46.875 | 81.25<br>34.375   | 48.4375<br>15.625  |
| 16       | 120 mm                                   | 8                      | 96.875<br>57.8125                          | 100.0%            | 100.0%            | 93.75<br>50.0      |
| 17       | 90 mm                                    | 8                      | 96.875<br>57.8125                          | 100.0%            | 90.625<br>45.3125 | 34.375<br>9.375    |
| 18       | 8 inch, 105 How, 122 mm,<br>155 mm       | 8                      | 96.875<br>57.8125                          | 100.0%            | 95.3125<br>53.125 | 1.5625<br>1.5625   |
| 19       | Grenade (40 mm)                          | 8                      | 56.25<br>18.75                             | 84.375<br>37.5    | 10.9375<br>3.125  | 4.6875<br>1.5625   |
| 20       | Rockeye (CB)                             | 2                      | 81.25                                      | 81.25             | 15.625            | 20.3125            |
| 21       | Bushmaster (25 mm), GAU-8,<br>AH (30 mm) | 2                      | 84.375                                     | 43.75             | 9.375             | 6.25               |
| 22       | FU23-4                                   | 2                      | 43.75                                      | 50.0              | 6.25              | No Effect          |
| 23       | Vulcan (20 mm)                           | 2                      | 43.75                                      | 23.4375           | 6.25              | No Effect          |
| 24       | M2, M83 (50 CAL)                         | 4                      | 37.5<br>10.3125                            | 4.6875<br>3.125   | 4.6875<br>3.125   | No Effect          |
| 25       | Chaparral                                | 8                      | No Effect                                  | 96.875<br>57.8125 | No Effect         | No Effect          |
| 26       | Stinger                                  | 8                      | No Effect                                  | 92.1875<br>46.875 | No Effect         | No Effect          |
| 27       | M16, M60, Coax (7.62 mm)                 | 4                      | 9.375<br>4.6875                            | 3.125<br>1.5625   | No Effect         | No Effect          |
| 28       | Heavy Weapon Miss                        | —                      | Miss                                       | Miss              | Miss              | Miss               |
| 29       | Light Weapon Miss                        | —                      | Miss                                       | Miss              | Miss              | No Effect          |
| 30       | Light Weapon Miss Spare                  | —                      | Miss                                       | Miss              | Miss              | No Effect          |
| 31       | Heavy Weapon Miss Spare                  | —                      | Miss                                       | Miss              | Miss              | Miss               |
| Code 30. | 0 thru 27-Hit Codes                      | M = Missiles           | Kill Probability                           |                   |                   |                    |
|          |                                          |                        | Per Round                                  |                   |                   |                    |
|          |                                          |                        | Per 2 Code Words Received                  |                   |                   |                    |

$P_R$  = first round hit probability  
 $P_D$  = probability stored in ROM  
 $N$  = number of words transmitted  
 $[ ]$  = largest integer in the argument

The kill probability function is under the control of the microprocessor software program and is accomplished by comparing the ROM stored weapon versus vehicle kill probability data with a number generated from a random number generator. The random generator is an internal microprocessor scratch pad register set aside for this function only. The random number generator register is continuously incremented by one during all slack periods, and multiplied by the constant 19 after each hit detection not resulting in a kill for the generation of a random number.\*

### 3.18 AUXILIARY OUTPUT FROM MWLD

The TES MWLD decoder is designed with an auxiliary output (signal "Remote") which is generated in conjunction with buzzer (horn) drive signal in the Loop Receiver/Horn Driver circuit, U1. Refer to figure 3-29. This signal is active whenever the buzzer (horn) is activated, approximately 0.1 second for near miss and continuous for kill. The use of the auxiliary output is for possible future adaption of TES MWLD decoder to target practice simulation.

### 3.19 COMBAT VEHICLE KILL INDICATOR (CVKI)

As its name implies, the CVKI is used to indicate to surrounding players that a vehicle has been near-missed, hit, or killed. To that end, it contains an amber strobe light.

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\*Abramowitz and Stegun: Random Number Generation  
Handbook of Mathematical Function, National Bureau of Standards

Figure 3-31 shows the schematic. The strobe light is powered by vehicle 28V power, since it represents an excessive current surge to the MILES batteries. Diode CR2 prevents damage to the strobe light from an inadvertent polarity reversal of vehicle power.

Dip relay, U1, is energized by the LITE signal applied by switching an open collector 2N2222A transistor in the LCA or CIA. When U1 is energized, the strobe light will flash one time. CR1 prevents inductive kickback from the relay coil.

### 3.20 POWER CONDITIONING

The term "power conditioning" can mean many things, from perhaps the simple filtering of a fluctuating power bus to the generation of voltages quite different from the original source voltage. In MILES, as in most complex electronic devices, it is necessary to provide filtering on power lines to avoid adverse effects from the high impedance of aging batteries. However, this is quite straight-forward and will not be discussed further here. The present section will concern itself with the methods used to produce regulated voltages to operate certain specialized parts of the circuitry.

#### 3.20.1 MWLD POWER CONDITIONING

The torso electronics contains the CMOS decoder circuitry. This custom LSI cannot operate satisfactorily over the full range of battery voltage because of certain specialized fabrication techniques which were employed. Consequently, although the operating voltage need not be carefully regulated, it is necessary that it be restricted to the range of about four to six volts.

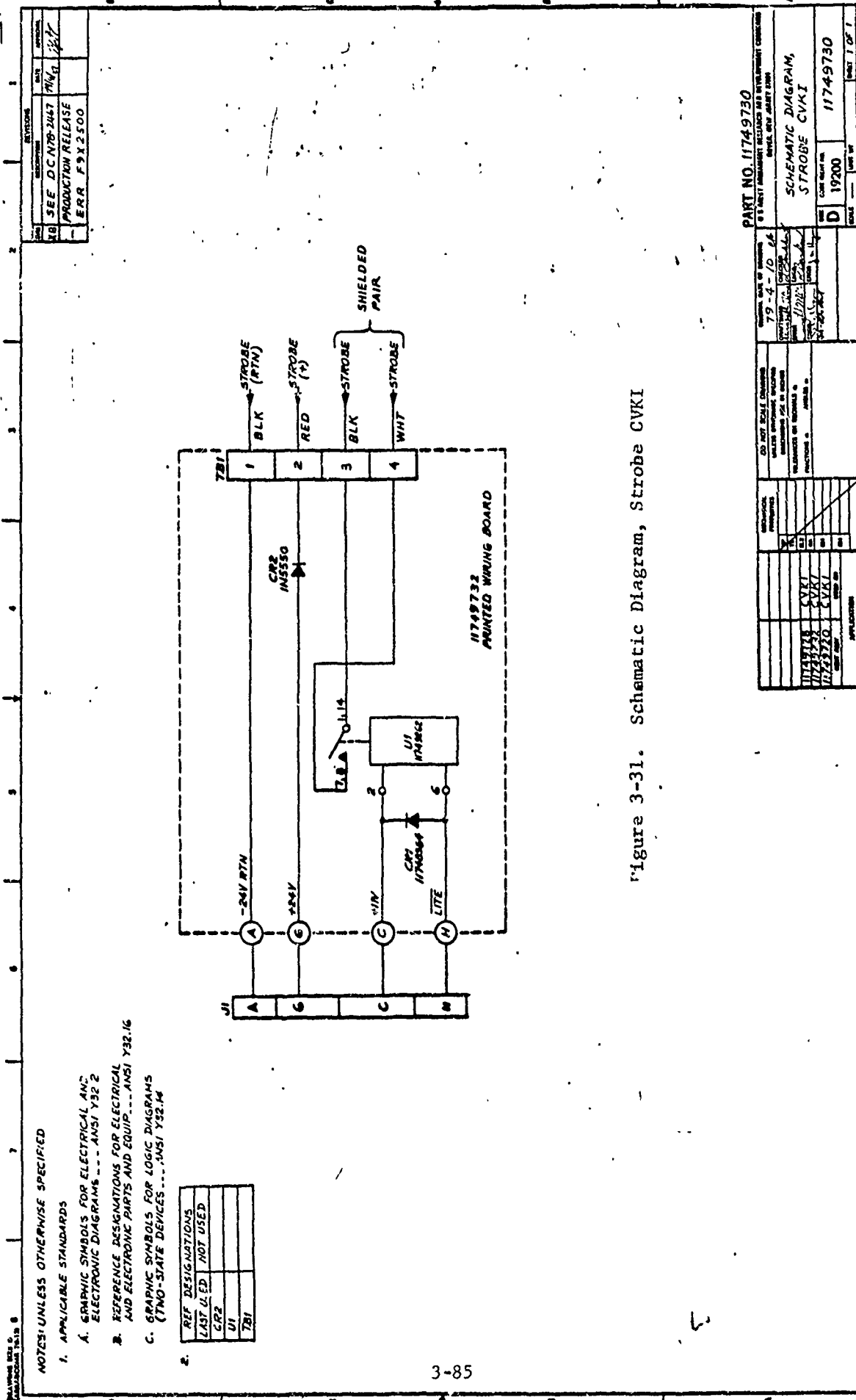


Figure 3-31. Schematic Diagram, Strobe CVKI



The regulating circuit to provide the small required current of about one milliampere is located within the LSI chip known as the Loop Receiver/Horn Driver. It consists of a simple emitter follower, the base of which is held at a reference voltage generated by eight diodes in series. A current mirror delivering about forty microamperes supplies current to both the diode string and the base of the emitter follower. This simple circuit can supply up to two milliamperes at about 4.5 volts at room temperature. Since the CMOS circuitry is not sensitive to voltage changes within the acceptable bounds, no attempt is made at temperature compensation. As a consequence, the output voltage has a temperature coefficient of about - 14mV per degree Celsius. This means that the nominal output voltage will be about 5.2 volts at -31°C and about 4.0 volts at +62°C. Thus the supply voltage for the CMOS decoder is controlled to a satisfactory degree with the additional expenditure of only 40 microamperes of battery current.

### 3.20.2 INDEPENDENT TRANSMITTERS

A somewhat similar situation arises in the independent transmitters such as the M16A1 rifle, the machine guns, and the Viper, Dragon, and TOW. In these cases several devices require reduced voltage, the primary device being the microprocessor. Again, since the regulated voltage is being provided to CMOS units, its actual value is not very critical so that the temperature coefficient is not of great concern.

In this case, however, a different problem comes to bear on the design. In the case of the Dragon, Viper, and TOW, the rounds count displays must be operated. Since the decoder-latch for these displays must connect to the microprocessor, interfacing is simpler if the displays also operate from the regulated voltage. Hence the load regulation must be good since the load may vary from about 1 mA to perhaps 35 mA if the display is interrogated.

The regulator for the transmitters is integrated into the Laser Driver Interface LSI. In this case a differential error amplifier senses the difference between a portion of the output voltage and a reference voltage generated by two diode drops. The differential amplifier drives a Darlington connected emitter follower to produce the regulated voltage. All of the components including the voltage divider are within the LSI chip. The only external components required are two tantalum capacitors for control of impedance and stability.

Both the emitter and base of the output transistor of the Darlington pair are brought to pins on the chip. Originally, the base terminal pin was provided only to permit connection of a stabilization capacitor. Later, it was learned that the microprocessor tended to be marginal with regard to the required clock rate when at minimum voltage. It was found practical to split the load so that the high current for the display was taken from the emitter terminal of the regulator while the microprocessor and ROM were powered from the base terminal. This provided about 0.7 volt additional for the microprocessor and has helped eliminate any problems with device speed.

The nominal ratings at room temperature are 4.5 V at 40 mA for the high current output and 5.2 V at 3 mA for the low current output. Because uncompensated diodes are used to generate the reference voltage, the temperature coefficient is again about -14 mV per degree Celsius. The regulator circuit in this case requires about 175  $\mu$ A of battery current. More than one-half of this current is expended in the voltage divider which produces a suitable portion of the output voltage for comparison with the reference voltage. The divider current is also used as a bleeder current so that the regulator remains in its linear region even though the external load current may become very small.

### 3.20.3 LCA AND CIA

The same regulator employed in the transmitters is used for the LCA and CIA. In this case the higher voltage output is not used and the CMOS circuitry is operated at the nominal 4.5 volt level. This voltage proves acceptable in this more complex case because of higher capacitive loading which eliminates timing problems. These timing problems associated with the microprocessor were the reason that a higher operating voltage was needed for the transmitters where existing parasitic capacitance was lower.

In the case of the LCA and CIA it is unnecessary for the regulator to supply the current for the two digit display. The larger board size makes it practical to arrange the logic-display interface so that current for the display is taken from the raw battery supply.

### 3.21 CABLING, GROUNDING, AND SHIELDING

The methods used to interconnect MILES units while providing satisfactory EMI performance are described in this section. Two methods are described: portable simulator systems (the MWLD, M16A1 rifle, machine guns, Dragon, and Viper) and the vehicular systems.

#### 3.21.1 PORTABLE SIMULATORS

In all cases, the electronics assembly is mounted in a metal box which is used as the main shielding element. In general, leads external to the housing are twisted and shielded to minimize radiation as well as susceptibility. The housing is the primary ground point for shields as well as the electronic circuitry.

In the case of the MWLD, there are separate detector and horn enclosures. Cable shields are tied to these housings as well as to the main electronics box to complete the shielding. In the case of the MWLD, a conductive gasket is used to seal the cover of the electronics housing.

### 3.21.2 VEHICULAR SIMULATORS

The problem of shielding and grounding is more complex in the case of vehicles since there are four classes of major assemblies to be interconnected: the detector belts, the control unit, the transmitter assembly and the vehicle kill indicator.

The grounding scheme selected was to use the control unit as the central point at which all circuitry is tied to the vehicle. All other circuits return to the control unit through their cables to reach ground. Cable shields are grounded to the frame of each unit where those units can be isolated from the vehicle. Otherwise the shield is insulated at the remote point. In this way potential differences between various portions of the vehicle cannot cause shield currents to flow, thereby lessening the possibility of coupling vehicle noise into the MILES system. The central system ground is at the control unit. Since vehicle power is used only to operate the vehicle kill indicator and since this power is switched by relays, there is no conductive connection between the vehicle electrical system and MILES.

## SECTION 4

### HARDWARE DESCRIPTION

#### 4.1 MILES SYSTEMS

MILES currently consists of eleven systems. These systems include infantry, armor, and anti-armor weapons plus three items of operational test equipment: (1) a Small Arms Alignment Fixture (SAAF) for boresighting the M16 Rifle and M60 Machine Gun; (2) a Vehicle System Test Set; and (3) a Controller Gun for checking the detection systems. A 12<sup>th</sup> MILES system (for the M60A2 tank) was developed but was not procured, however, the MILES design for this tank system is described in this section. Since there is considerable commonality at the assembly and subassembly levels, this section groups systems by their commonality. Rather, the common assemblies are discussed in detail. At the system level, the assemblies are identified and where there are specific system differences they are shown in the system descriptions. The detailed differences are discussed in the subsections that follow.

Table 4-1 is a matrix of the MILES systems showing the common assemblies and quantity of each used in the systems. This matrix is also a key to the assembly detailed discussions that follow the general system descriptions. In the detailed assembly discussions, for example, transmitters are discussed in two basic categories: [1] dependent transmitters, and [2] independent transmitters. Within these basic categories, the differences between various laser transmitters are described.

The MILES systems and their basic tactical operational scenarios are first summarized and then the key assemblies are described in detail. Other operational aspects of the system, such as weapon hierarchy, weapon simulation, and safety, are also discussed as general subjects rather than treated with each weapon system.

##### 4.1.1 SIMULATOR SYSTEM, FIRING, LASER: M60 For M16A1 RIFLE (MILES DEVICE A17A60)

###### System description

The A17A60 M16A1 rifle system, shown in figure 4-1, consists of one each of the following items:

- a. Laser Transmitter, M16A1 rifle, 5.56 mm
- b. Weapon Key (yellow)
- c. Laser Detector, Man Worn (MWLD)

###### Tactical Scenario

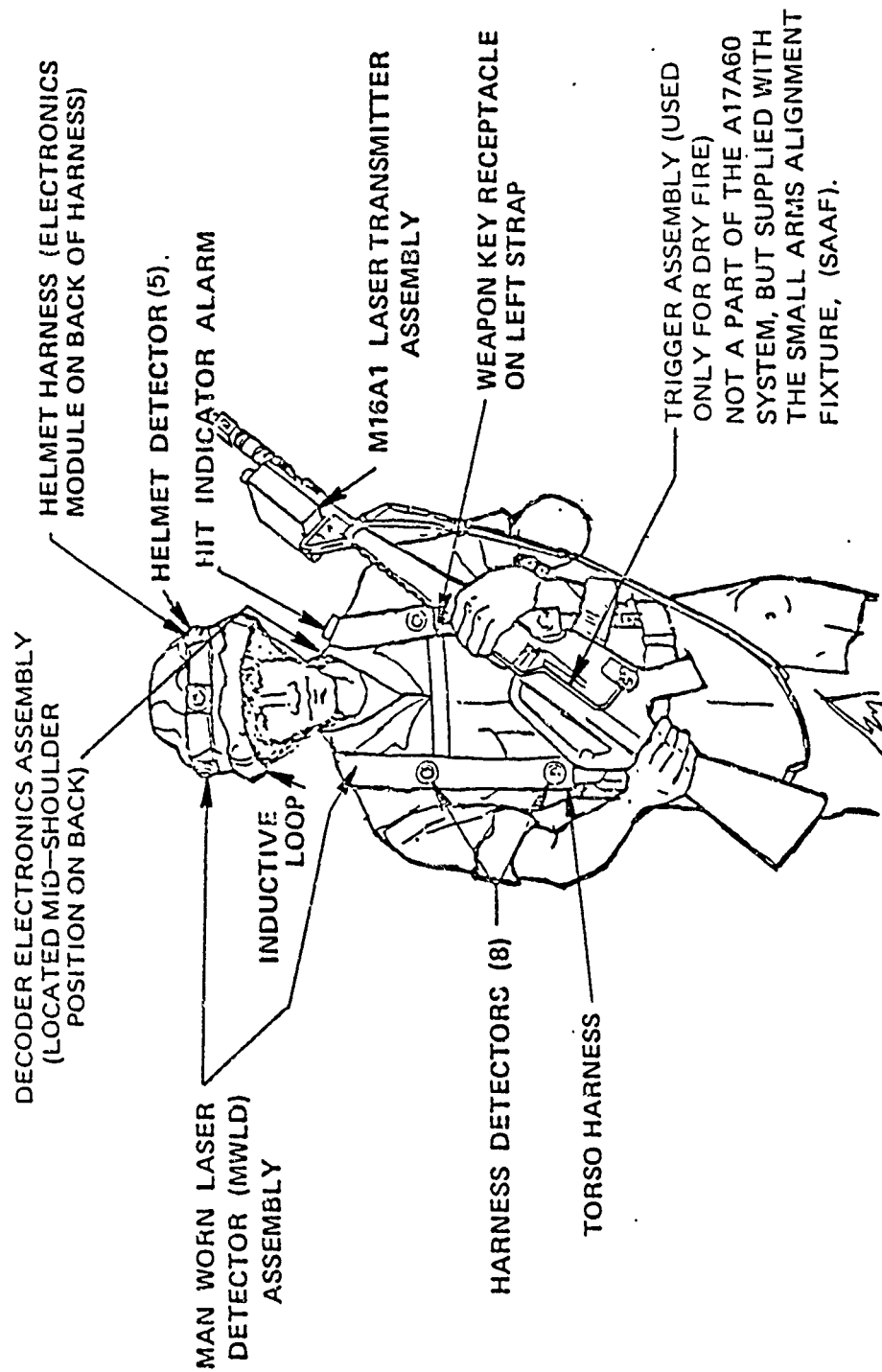
- ☐ The infantryman is killed by any weapon in the MILES hierarchy.
- ☐ A kill sets off the hit indicator alarm on the MWLD harness.

TABLE 4-1  
ASSEMBLY COMMONALITY AT SYSTEM LEVEL

| Assemblies<br>(Sec. 4.1)<br>Systems | (4.4) Detectors/Hit Indicators |                |    |    |    |                           |     |                   |                              |                       | (4.2, 4.3) Transmitters |                  |                      |  |                   |                   | Organi-<br>zation<br>Checkout              | (4.6)<br>ATMSS<br>Firing<br>Assy. |
|-------------------------------------|--------------------------------|----------------|----|----|----|---------------------------|-----|-------------------|------------------------------|-----------------------|-------------------------|------------------|----------------------|--|-------------------|-------------------|--------------------------------------------|-----------------------------------|
|                                     | (4.4.1)<br>M16                 | (4.4.2.1) CVID |    |    |    | (4.4.2.2) Control Console |     | (4.4.2.3)<br>CVK1 | (4.2) Independent Laser Xmts |                       |                         |                  | (4.3) Sol. Packaging |  | (4.3.1)<br>105 mm | (4.3.2)<br>152 mm |                                            |                                   |
|                                     |                                | #1             | #2 | #3 | #4 | LCA                       | CIA |                   | (4.2.1)<br>M16               | (4.2.2)<br>M60 M2 M85 | (4.2.3)<br>DRAGON       | (4.2.4)<br>VIPER | (4.3.3)<br>TOM       |  |                   |                   |                                            |                                   |
|                                     |                                |                |    |    |    |                           |     |                   |                              |                       |                         |                  |                      |  |                   |                   |                                            |                                   |
| M16A1 Rifle<br>(4.1.1)              | 1                              |                |    |    |    |                           |     |                   |                              |                       | 1                       |                  |                      |  |                   |                   | (4.1.10)<br>Contr.<br>Gun<br>Xmt.<br>Assy. |                                   |
| M60 Machine Gun<br>(4.1.2)          | 1                              |                |    |    |    |                           |     |                   |                              |                       | 1                       |                  |                      |  |                   |                   |                                            |                                   |
| M60A1/A3 Tank<br>(4.1.3)            | 3                              |                |    | 2  | 1  | 1                         |     |                   | 1                            |                       |                         | 1                |                      |  |                   |                   |                                            |                                   |
| M551 AARV<br>(4.1.5)                | 3                              |                |    | 2  | 1  | 1                         |     |                   | 1                            |                       | 1                       |                  |                      |  |                   |                   |                                            |                                   |
| M113 APC<br>(4.1.6)                 |                                | 2              | 2  |    |    |                           |     |                   | 1                            | 1                     |                         |                  |                      |  |                   | 1                 |                                            |                                   |
| TOM<br>(4.1.7)                      | 2                              |                |    |    |    |                           |     |                   |                              |                       |                         |                  |                      |  |                   |                   |                                            |                                   |
| DRAGON<br>(4.1.8)                   | 1                              |                |    |    |    |                           |     |                   |                              |                       |                         |                  |                      |  | 1                 |                   | 1                                          |                                   |
| VIPER<br>(4.1.9)                    |                                |                |    |    |    |                           |     |                   |                              |                       |                         |                  | 1                    |  |                   |                   | 1                                          |                                   |
| CONTROLLER GUN<br>(4.1.10)          |                                |                |    |    |    |                           |     |                   |                              |                       |                         |                  | 1                    |  |                   |                   | 1                                          |                                   |
| SMALL ARMS<br>ALIGNMENT FIXTURE     |                                |                |    |    |    |                           |     |                   |                              |                       |                         |                  |                      |  |                   |                   | 1                                          |                                   |
| VEHICLE SYSTEMS<br>TEST SET         |                                |                |    |    |    |                           |     |                   |                              |                       |                         |                  |                      |  |                   |                   |                                            |                                   |

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61005



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Figure 4-1. M16A1 Rifle System (A17A60)

- ☐ Inserting the yellow weapon key into the MWLD receptacle shuts off the alarm. In so doing, the weapon is deactivated. Reinsertion of the weapon key into the transmitter reactivates the laser transmitter, but removal of the key from the MWLD causes the alarm to sound. Only the controller key will reset the MWLD and shut down the alarm.
- ☐ Blank Fire Mode - The laser transmitter is triggered by the firing of blanks. Laser rounds equal blanks issued.
- ☐ Dry Fire Mode - Different only in that the laser transmitter is provided with a basic store of "ammunition." When its basic store is expended through firing, the transmitter is deactivated and must be reset and resupplied with a controller key. Closure of the trigger switch with a controller key inserted supplies the weapon with 210 rounds of ammunition. The transmitter has a single burst limit of 30 rounds when used in the "automatic" mode.

#### 4.1.2 SIMULATOR SYSTEM, FIRING, LASER: M61 FOR M60 MACHINE GUN (MILES DEVICE A17A61)

##### System Description

The A17A61 M60 Machine Gun system, shown in figure 4-2, consists of one each of the following items:

- a. Laser Transmitter, M60 Machine Gun (7.62 mm)
- b. Weapon Key (yellow)

The M60 gunner also wears a Man-Worn Laser Detector (MWLD) which is not part of the M60 Machine Gun System. The gunner receives the MWLD from an M16A1 Rifle System which he was previously issued.

\*

##### Tactical Scenario

- ☐ A crew of one is assumed - the M60 gunner.
- ☐ Kill the M60 gunner - his hit indicator alarm can be shut down by inserting his or another yellow weapon key in the MWLD receptacle.
- ☐ The squad leader can sacrifice rifles to save the machine gun by using the weapon key from any rifle to deactivate the MWLD alarm.
- ☐ Blank Fire/Dry Fire functions are same as M16A1 except for the basic store of ammunition. In the Dry Fire Mode, the M60 basic store is 600 rounds, and the transmitter has a burst limit of 100 rounds. No Trigger Cable Assembly is provided with the M60. For dry fire operation, a cable assembly available from the Controller must be used.



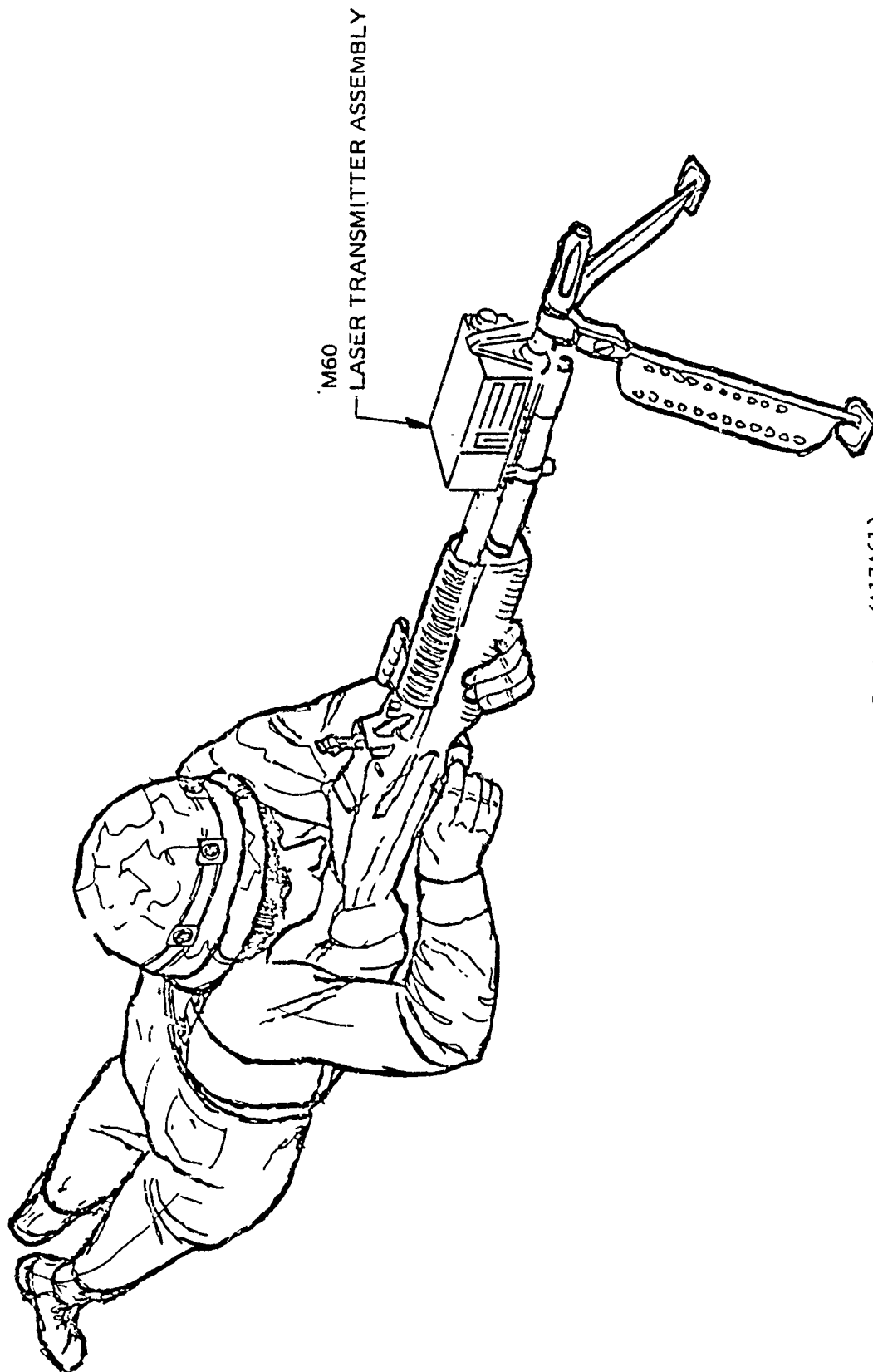


Figure 4-2. Machine Gun System (A17A61)

#### 4.1.3 SIMULATOR SYSTEM, FIRING, LASER: M65 FOR M60A1/A3 TANK (MILES DEVICE A17B8)

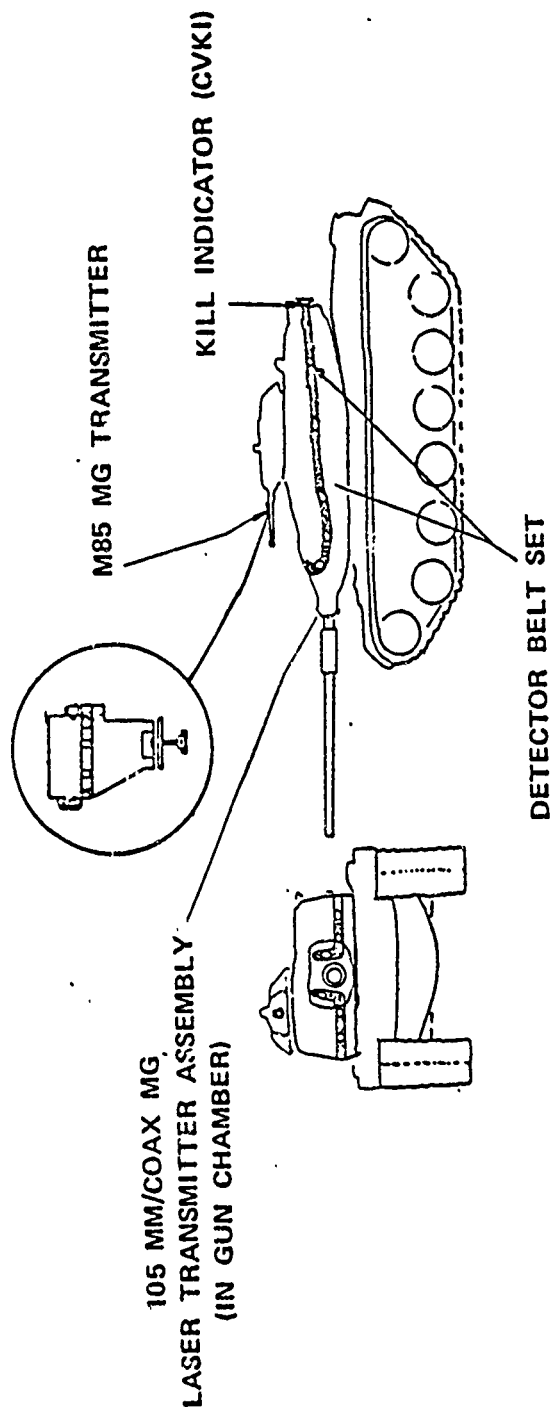
##### System Description

The A17B8 M60A1/A3 Tank system, shown in figure 4-3, consists of one each of the following items except where otherwise noted:

- a. 105mm Transmitter assembly
  - Laser Transmitter, 105 mm Tank Gun
  - Laser Transmitter, Coax Machine Gun, 7.62 mm
  - Extractor Stop Assembly
  - Retainer Assembly
- b. Laser Transmitter, M85 Machine Gun Cupola Mounted, 50 caliber
  - Weapon Key (orange)
- c. 1 each M60A1/A3 Belt Set
  - Detector Belt Assembly Segment No. 3 (2 each)
  - Detector Belt Assembly Segment No. 4
- d. Loader Control Assembly (LCA)
- e. Kill Indicator, Combat Vehicle (CVKI)
- f. Battery Box
- g. Adapter Kit, M60A1/A3 Tank
  - Trigger Cable Assembly
  - Breech Cable Assembly
  - CVKI Cable Assembly
  - Coax Adapter Microphone Assembly
  - Detector Belt Wedge Assembly (10 each)
  - Console Mounting Adapter Assembly
  - Weapon Keys (yellow) (3 each)
  - Ground Strap
- h. Laser Detectors, Man Worn (3 each) - The tank commander, gunner, and loader wear MWLDs.

##### Tactical Scenario

- ☐ One Weapon Key (orange) in Cupola Machine Gun



NOTE:  
THE TANK COMMANDER, GUNNER,  
AND LOADER WEAR MWLD  
THE LOADERS CONTROL ASSEMBLY (LCA)  
IS LOCATED INSIDE TURRET.

- ☐ Tank kill - all weapons automatically disabled except cupola machine gun. Intercom alarm and CVKI activated.
- ☐ Intercom alarm shuts off when commander removes weapon key from cupola machine gun and inserts it in Loaders Control Assembly. This disables cupola machine gun and shuts down intercom alarm.
- ☐ Three MWLD (yellow) weapon keys are provided - one each for the tank commander, gunner, and loader to shut down their MWLD hit indicator alarms when they are "killed."

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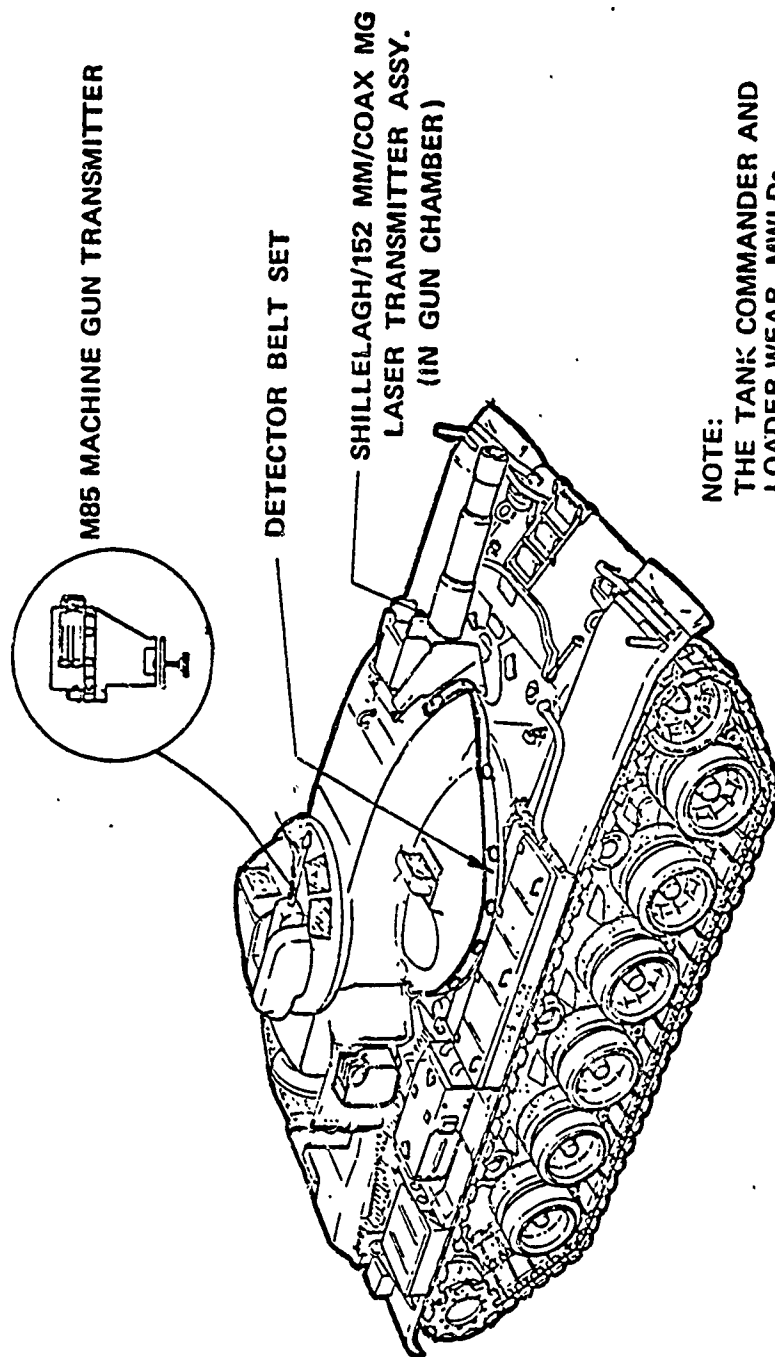
#### 4.1.4 SIMULATOR SYSTEM, FIRING, LASER: M66 FOR M60A2 TANK (MILES DEVICE A17B9)

MILES system design was initiated for the M60A2 tank, however, the system was not procured. A system description of the proposed MILES equipment and an installation diagram are described in the following paragraphs.

##### System Description

The A17B9 M60A2 Tank System, shown in figure 4-4, consists of one each of the following items:

- a. M60A2 Laser Transmitter Assembly
  - Laser Transmitter, 152 mm Main Gun
  - Laser Transmitter, Shillelagh Missile
  - Laser Transmitter, Coax Machine Gun, 7.62 mm
- b. Laser Transmitter, M85 Machine Gun, 50 caliber
  - Weapon Key (orange)
- c. 1 each M60A2 Belt Set
  - Detector Belt Assembly, Segment No. 3 (2 each)
  - Detector Belt Assembly, Segment No. 5
- d. Loader Control Assembly (LCA)
- e. Kill Indicator, Combat Vehicle (CVKI)
- f. Battery Box
- g. Adapter Kit, M60A2
  - Kill Indicator Cable Assembly
  - Breech Cable Assembly
    - Breech Interlock Plug Assembly



- Trigger Cable Assembly
- Coax Adapter Microphone Assembly
- Console Mounting Adapter Assembly
- Weapon Keys -yellow (3 each)
- Ground Strap

h. Laser Detectors, Man-Worn (3 each). The tank commander, gunner, and loader wear MWLDs.

#### Tactical Scenario

The tactical scenario is the same as that described for the M60A1 tank (refer to subsection 4.1.3).

#### **4.1.5 SIMULATOR SYSTEM, FIRING, LASER: M67 FOR M551 VEHICLE (MILES DEVICE A17B10)**

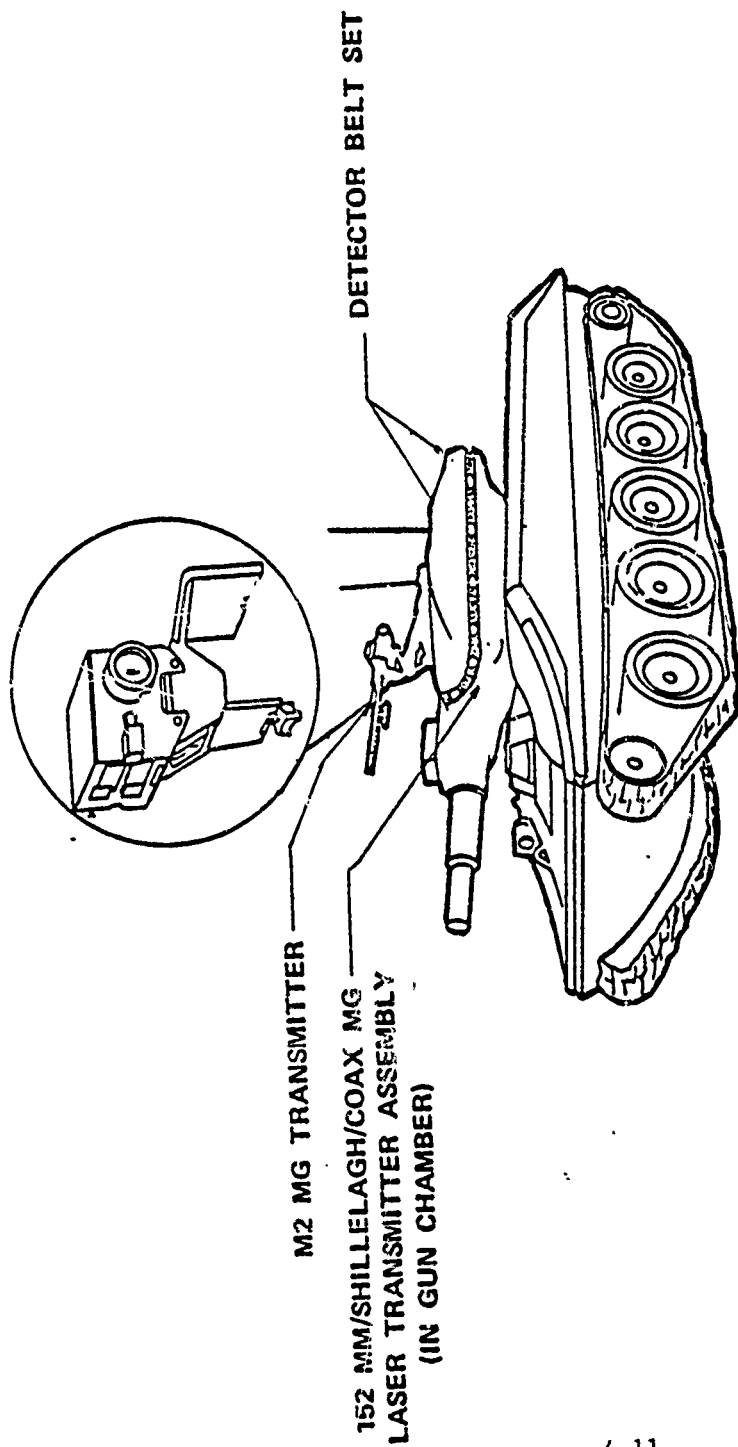
#### System Description

The A17B10 M551 AARV system, shown in figure 4-5, consists of one each of the following items except where otherwise noted:

- a. M551 Laser Transmitter Assembly
  - Laser Transmitter, 152 mm Main Gun
  - Laser Transmitter, Shillelagh Missile
  - Laser Transmitter Coax Machine Gun, 7.62 mm
- b. Laser Transmitter M2 Machine Gun, 50 caliber
  - Weapon Key (orange)
- c. M551 Belt Set
  - Detector Belt Assembly, Segment No. 3 (2 each)
  - Detector Belt Assembly, Segment No. 4 (1 each)
- d. Loader Control Assembly (LCA)
- e. Kill Indicator, Combat Vehicle (CVKI)
- f. Laser Detector, Man-Worn (3 each). The tank commander, gunner, and loader wear MWLDs
- g. Battery Box
- h. M551 Adapter Kit
  - Trigger Cable Assembly

\*

60995



NOTE: THE TANK COMMANDER, GUNNER,  
AND LOADER WEAR MWLD  
THE LOADERS CONTROL ASSEMBLY  
(LCA) IS LOCATED INSIDE TURRET.

Figure 4-5. M551 AARV System (A17B10)

- Breech Cable Assembly
- Breech Interlock Plug Assembly
- Kill Indicator Cable Assembly
- Coax Adapter Microphone Assembly
- Detector Belt Wedge Assemblies (14 each)
- Console Mounting Adapter
- Ground Strap
- Weapon Keys - yellow (3 each)

#### Tactical Scenario

The tactical scenario is the same as that described for the M60A1 Tank (refer to subsection 4.1.3).

#### **4.1.6 SIMULATOR SYSTEM, FIRING, LASER: M63 FOR M113 APC (MILES DEVICE A17A62)**

#### System Description

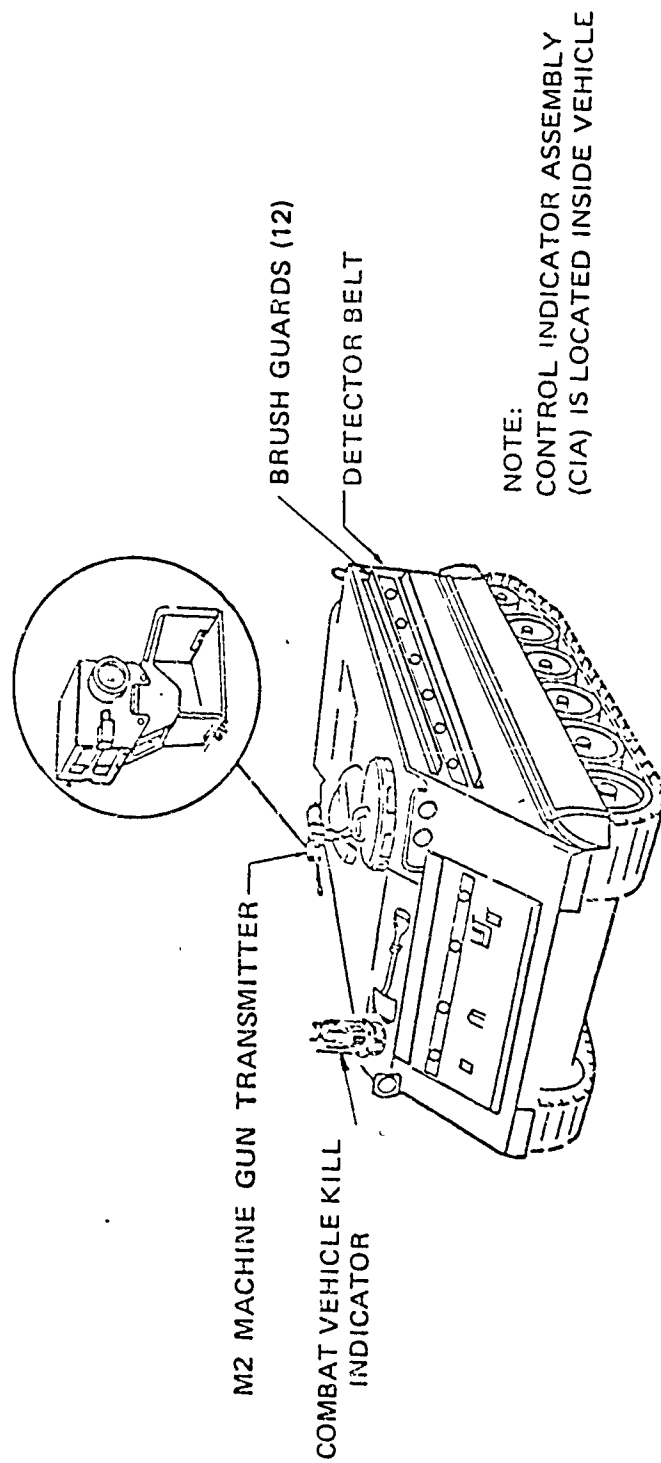
The A17A62 M113 Armored Personnel Carrier system, shown in figure 4-6, consists of one each of the following items except where otherwise noted:

- a. Laser Transmitter, M2 Machine Gun, 50 caliber
  - Weapon Key (orange)
- b. M113 APC Belt Set, Laser Detector
  - Detector Belt Assembly, Segment No. 1 (2 each)
  - Detector Belt Assembly, Segment No. 2 (2 each)
- c. Brush Guards (12 segments)
- d. Control Indicator Assembly (CIA)
- e. Kill Indicator, Combat Vehicle (CVKI)
- f. Battery Box
- g. Adapter Kit, M113 APC
  - Kill Indicator Cable Assembly
  - Control Indicator Mounting Adapter (Left and Right)
  - Control Indicator Adapter Plate and Mount (TOW equipped vehicles)
- h. Laser Detector, Man Worn

The crew consists of a driver. The M2 weapon is manned by a squad member.



61000



\*

Figure 4-6. M113 APC/M2 System (A17A62)

### Tactical Scenario

A crew of one (the driver) is assumed; all other personnel are passengers. A squad member mans the M2 50 caliber machine gun. When the vehicle is killed, the intercom audio alarm and CVKI strobe light are activated. The M2 orange weapon key is used to shut off the intercom audio alarm. All personnel aboard are "dead" by controller decision if the vehicle is killed. The CVKI strobe light continues flashing until reset by the Controller.

#### **4.1.7 SIMULATOR SYSTEM, FIRING, LASER: FOR TOW**

### System Description

The TOW weapon system, shown in figure 4-7, consists of one each of the following items:

- a. Laser Transmitter, TOW Missile
- b. TOW/ATWESS Tube Assembly
- c. Missile Guidance Set Simulator

\*

### Tactical Scenario

A crew of five infantrymen with M16A1 rifle systems is assumed. The TOW system has laser detectors permanently installed on the tracker head.

Situation - The Tow weapon is "killed" by a tank or antitank weapon.

- a. Audio indicator (located in the MGS Simulator) is activated.
- b. The TOW is automatically disabled.
- c. No TOW weapon key.
- d. Audio alarm is shut down by the Controller resetting the system with his key. Crew may shut off alarm by unplugging the coil cord from the MGS simulator.

\*

#### **4.1.8 SIMULATOR SYSTEM, FIRING, LASER: FOR DRAGON MISSILE (MILES DEVICE A17C5)**

### System Description

The A17C5 DRAGON Missile system, shown in figure 4-8, consists of one each of the following items:

- a. Laser Transmitter, DRAGON Missile
  - Weapon Key (yellow)

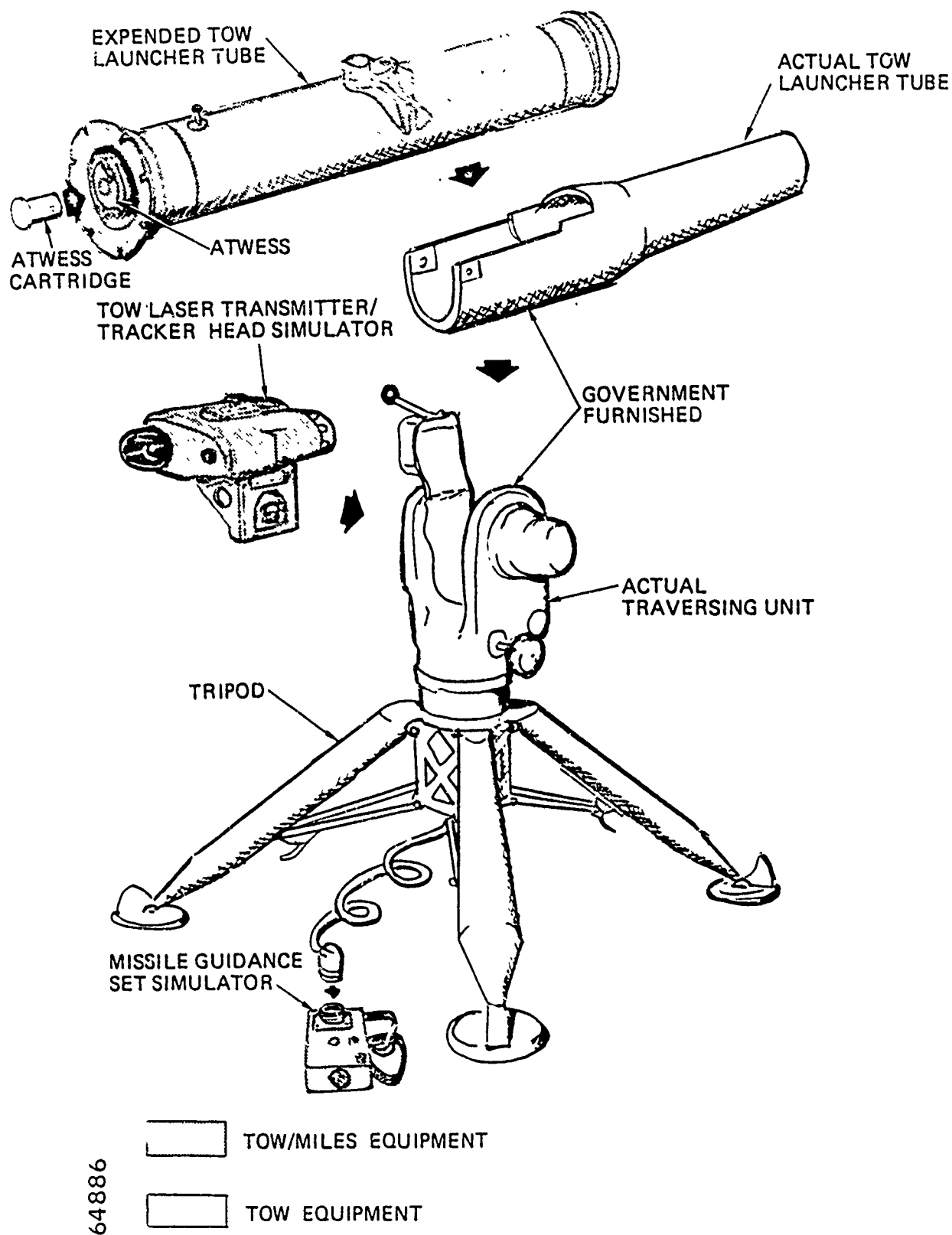
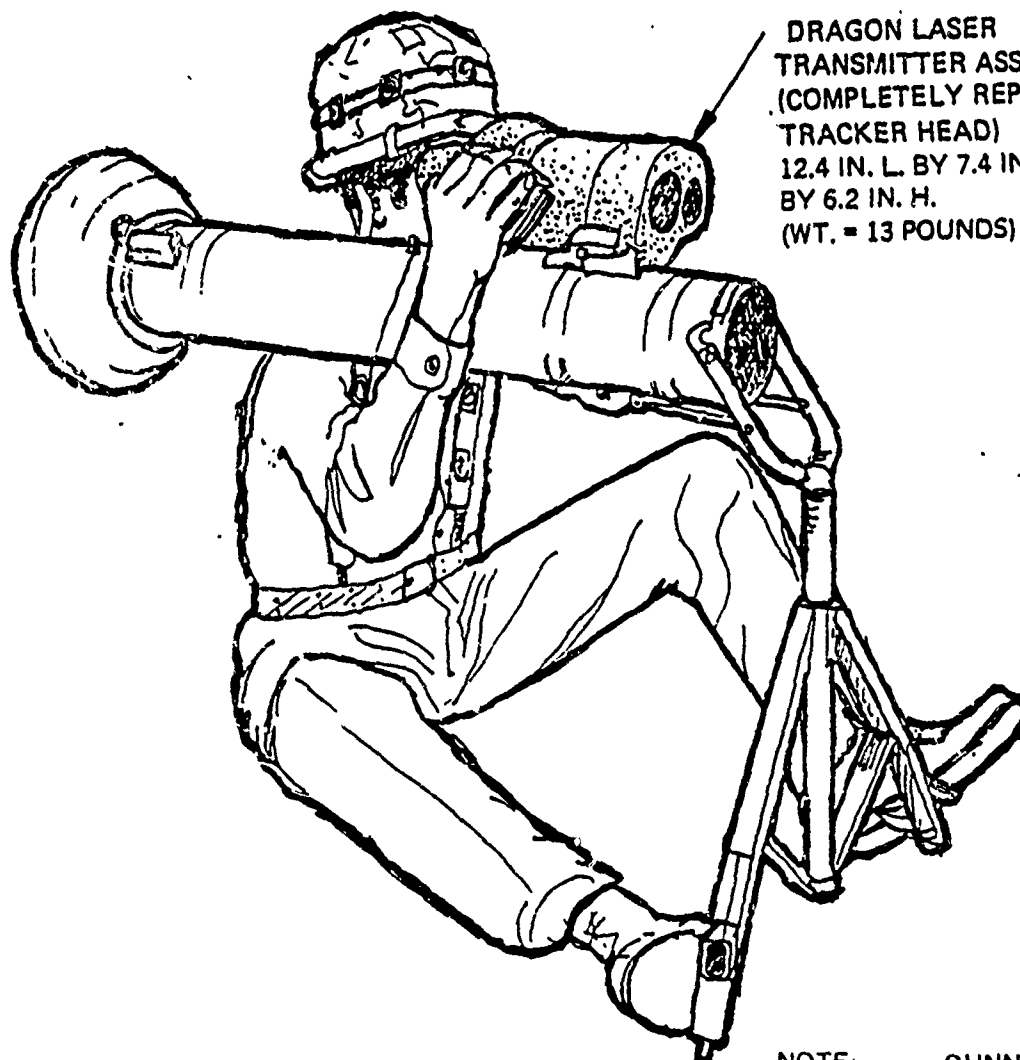


Figure 4-7. TOW Weapon System



DRAGON LASER  
TRANSMITTER ASSEMBLY  
(COMPLETELY REPLACES  
TRACKER HEAD)  
12.4 IN. L. BY 7.4 IN. W.  
BY 6.2 IN. H.  
(WT. = 13 POUNDS)

NOTE: GUNNER IS AN  
INFANTRYMAN WHO IS ALREADY  
EQUIPPED WITH THE M16A1 RIFLE  
SYSTEM (A17A60)

56223

Figure 4-8. Dragon Missile System (A17C5)

- b. Laser Detector, Man-Worn (MWLD)
- c. Tube Assembly, Simulator, Antitank Missile Fire
- d. ATWESS Firing Device Assembly

#### Tactical Scenario

A crew of one is assumed, the DRAGON gunner. The scenario is the same as for the M60 machine gun (refer to subsection 4.1.2) except for basic store of ammunition. The DRAGON has a basic store of 4 rounds and a firing rate of 4 rounds per minute.

#### **4.1.9 SIMULATOR SYSTEM, FIRING, LASER: M68 FOR LAW/VIPER ROCKET (MILES DEVICE A17C7)**

##### System Description

The A17C7 VIPER Missile system, shown in figure 4-9, consists of one each of the following items:

- a. Laser Transmitter, VIPER Missile
- b. ATWESS Firing Device Assembly

The VIPER gunner is an infantryman who is already equipped with an M16A1 rifle system.

##### Tactical Scenario

- ☐ VIPER gunner also carries rifle (M16A1) with weapon key.
- ☐ Kill VIPER gunner - he removes the yellow weapon key from his M16 rifle, thus disabling it, and shuts down the MWLD hit indicator alarm by inserting the weapon key from the M16 Laser Transmitter into the weapon key receptacle on the MWLD Torso Harness.
- ☐ No VIPER weapon key.
- ☐ VIPER simulator remains active and can be fired by other infantrymen until the basic store of four rounds is expended. Its firing rate is 6 rounds per minute.

#### **4.1.10 CONTROLLER GUN, SIMULATOR SYSTEM, LASER (MILES DEVICE A17A63)**

The controller gun is a lightweight handheld device capable of interrogating both the man-worn and vehicle-mounted laser detection systems in the field to determine if the systems are operational. The controller has the capability of resetting both systems when a kill has been effected and of restoring basic ammunition loads. This is accomplished with the green controller key included as a part of the system.

ATWESS INSTALLED  
IN AFT END OF  
LAUNCH TUBE

VIPER LASER  
TRANSMITTER  
(MOUNTED IN TUBE)



NOTE: THE VIPER GUNNER IS AN  
INFANTRYMAN WHO IS ALREADY  
EQUIPPED WITH THE M16A1 RIFLE  
SYSTEM (A17A60)

60998

Figure 4-9. Viper System (A17C7)

Figure 4-10 depicts an earlier version of the controller gun. The sighting is done with iron sights. The sights are factory aligned to the laser beams and there is thus no need for field alignment. The controller key is attached to the controller gun lanyard. The difference between this configuration and the latest is that the mode selector switch which was used to select either a kill or near miss signal has been replaced with two pushbutton switches. In the new configuration, if the trigger alone is depressed, the transmitter sends out a near miss signal. If one of the pushbuttons and the trigger are depressed together, the transmitter sends out a man kill signal. The third signal the controller gun transmits is a vehicle kill signal. This is generated by depressing the second pushbutton and the trigger together.

This change in configuration was prompted by field testing which indicated it was desirable to be able to kill infantry who were located close to vehicles without killing the vehicles themselves. Also, accidental selection of the universal hit code resulted in unintentional killing of vehicles or personnel when it was only desired to inflict a near miss. The need to simultaneously activate two buttons to transmit kill signals will prevent this accidental killing. Figure 4-11 is an outline drawing of the new configuration.

The controller gun has an interrogation range greater than 500 meters, which field testing indicates is ample. The transmitter will fire continuously as long as the trigger is depressed. There is no ammunition limit for the controller gun.

#### Controller Reset Key

The controller key is readily distinguished by its green color. The controller key fits in the same receptacle as the weapon keys. When inserted, the controller key restores the basic ammunition load of the weapon simulator. The laser transmitter will then operate normally once the weapon key is reinserted.

The controller key, when inserted in the control console weapon key receptacle of a "killed" vehicle or in the MWLD weapon key receptacle, will cause the system to reset to the unkilld state.

Both the weapon key and controller reset key, as well as their mating guides, are configured to prevent incorrect insertion and to preclude the key from falling out of the receptacle during operation. Further detail on the use of the weapon and controller keys is given in subsection 4.9.

#### 4.1.11 ASSEMBLY INTERRELATIONSHIPS

The MILES systems are comprised of numerous assemblies which exhibit considerable commonality. These assemblies are discussed in detail in subsections 4.2 through 4.6. Sections 4.7 through 4.9 treat the more important functions and operation of the assemblies that are common to all.

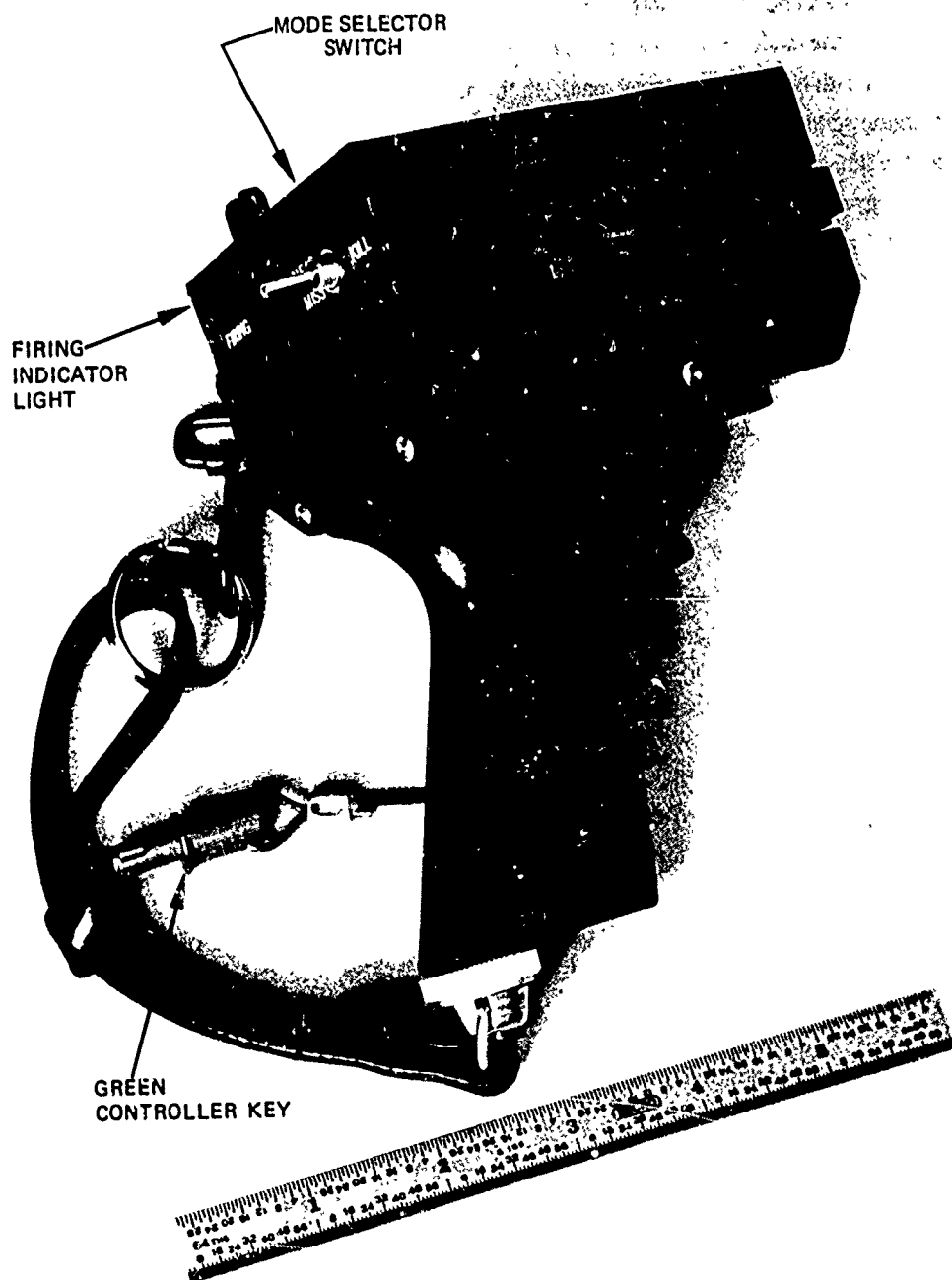


Figure 4-10. Controller Gun



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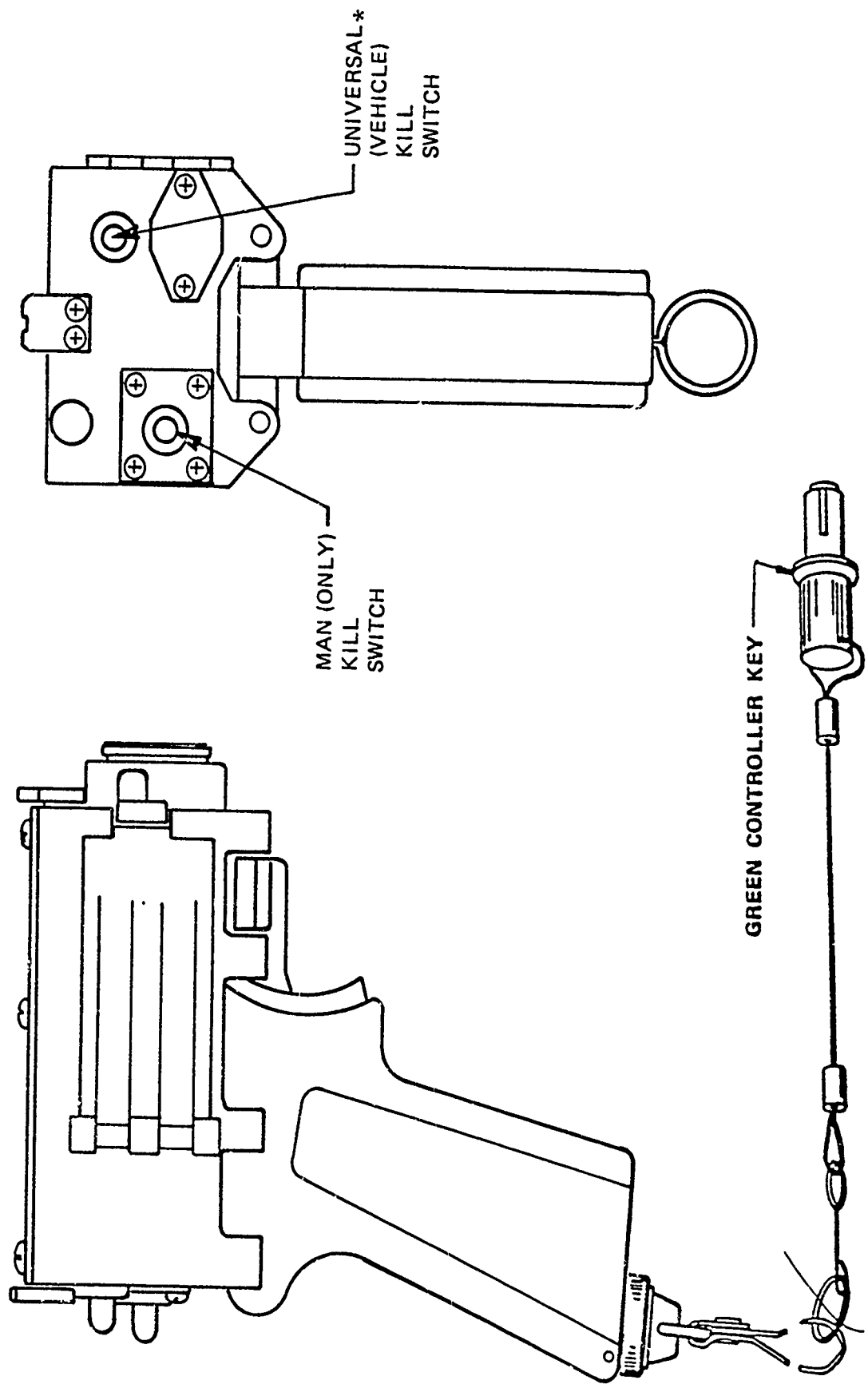


Figure 4-11. Controller Gun Outline Drawing

Figure 4-12 is included as a guide to show how the various MILES assemblies interrelate to each other in the forming of MILES systems. The reader should have a good understanding of this chart before proceeding with the detailed discussions in the subsections that follow.

## **4.2 INDEPENDENT LASER TRANSMITTERS**

The independent laser transmitters are so called because they are self-contained including a 9 volt battery for power and require no other companion units for operation. Figure 4-13 is a block diagram typical of most of the independent laser transmitters. All functions from weapon triggering to laser message transmission are completed within the assembly. The TOW, although an independent transmitter, differs slightly and its block diagram is shown in figure 4-14.

### **4.2.1 M16A1 LASER TRANSMITTER ASSEMBLY**

The M16 transmitter is typical of most of the MILES transmitters and is therefore discussed in detail in this subsection. Other independent laser transmitters are discussed in following subsections only insofar as they differ from the M16.

#### **4.2.1.1 General Description**

The M16 rifle simulator consists of a small, lightweight laser transmitter that attaches to the barrel of the M16 rifle forward of the front sight. The battery-powered transmitter is operated by use of a trigger switch and cable in the dry fire (no blanks) mode, or remotely by use of a microphone which fires the laser each time a blank cartridge is fired in the weapon.

The M16 transmitter is contained in a single housing and cover. A hinged door provides access to the single 9 volt battery. A receptacle located on the rear of the transmitter housing accepts the weapon key which is used to enable the unit and to disable the unit after its operator has been "killed" by an opponent.

All electronic components required for providing signals to the laser driver and laser tube assembly are contained on three printed wiring board assemblies.

#### **4.2.1.2 External Configuration**

Figure 4-15 shows the M16 laser transmitter rear, side, and top views, and figure 4-16 is a photograph of the rear. Visible in these views are:

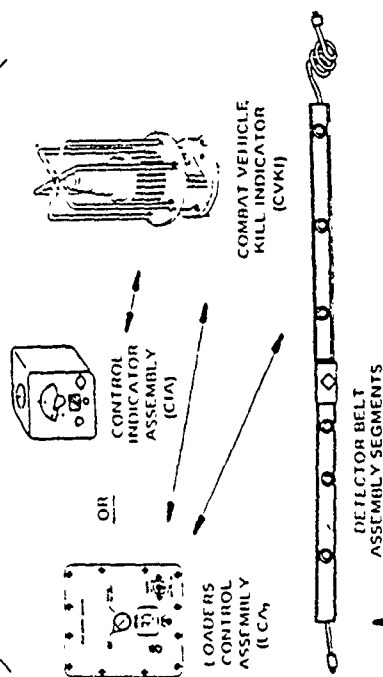
##### **a. Side View**

The hinged door to the battery compartment. An over-center latch when released allows the door to open for installation or removal of batteries.

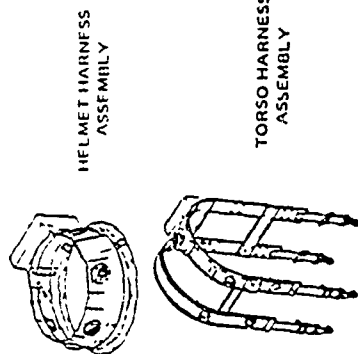
B 61092

# DETECTION SYSTEMS

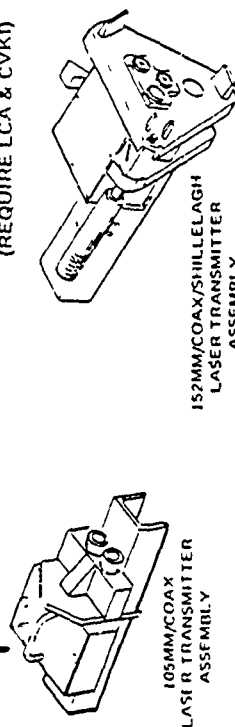
## COMBAT VEHICLE LASER DETECTOR (CVLD)



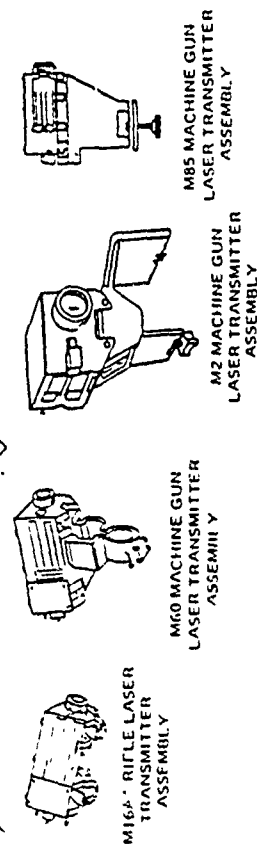
## MAN WORN LASER DETECTOR (MWLD)



## DEPENDENT LASER TRANSMITTERS (REQUIRE LCA & CVKI)



## INDEPENDENT LASER TRANSMITTERS



## ATWESS

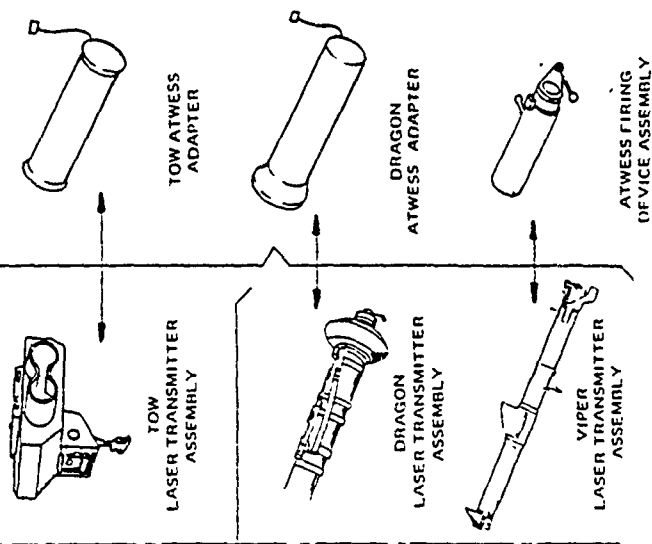


Figure 4-12. MILES Major Assemblies

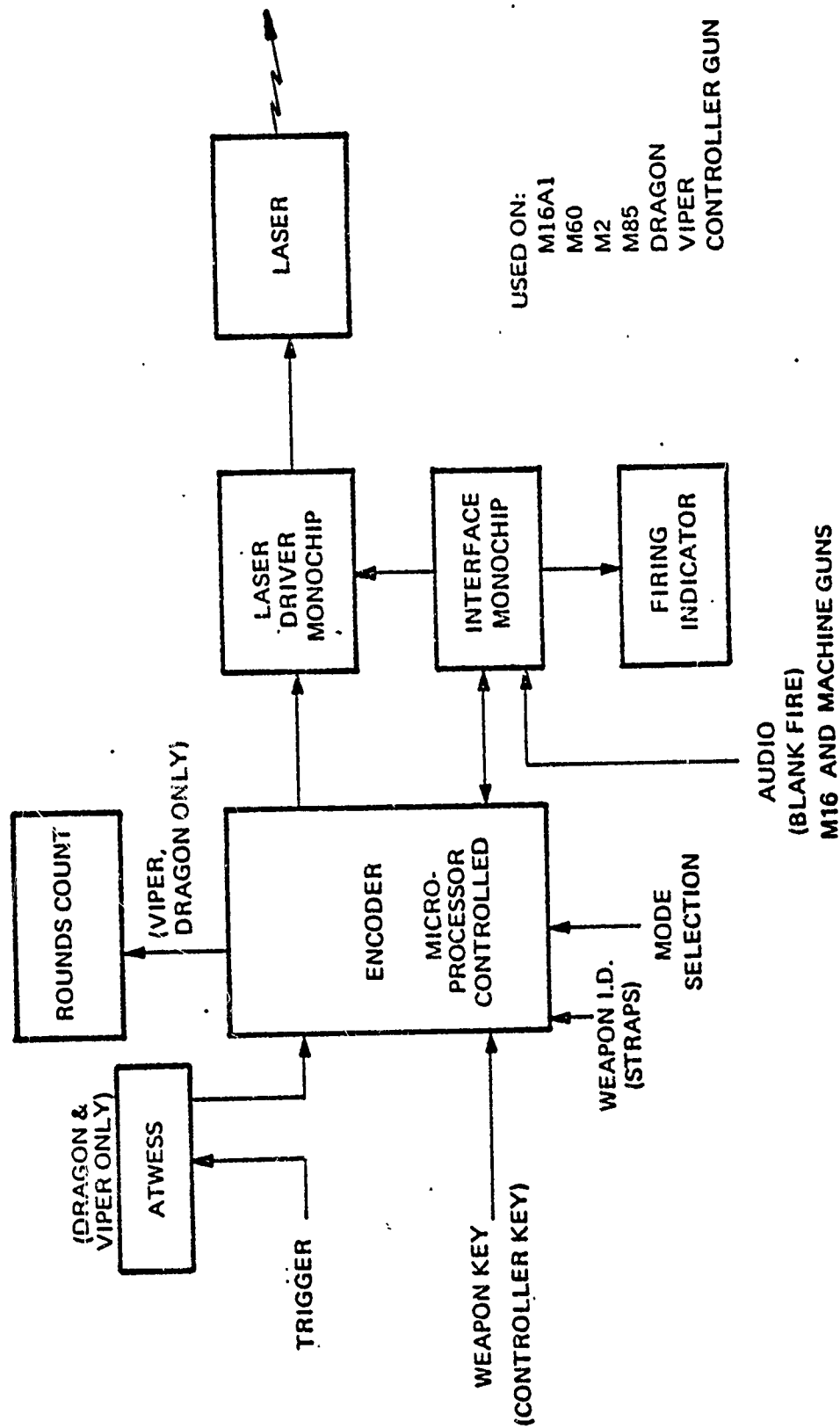
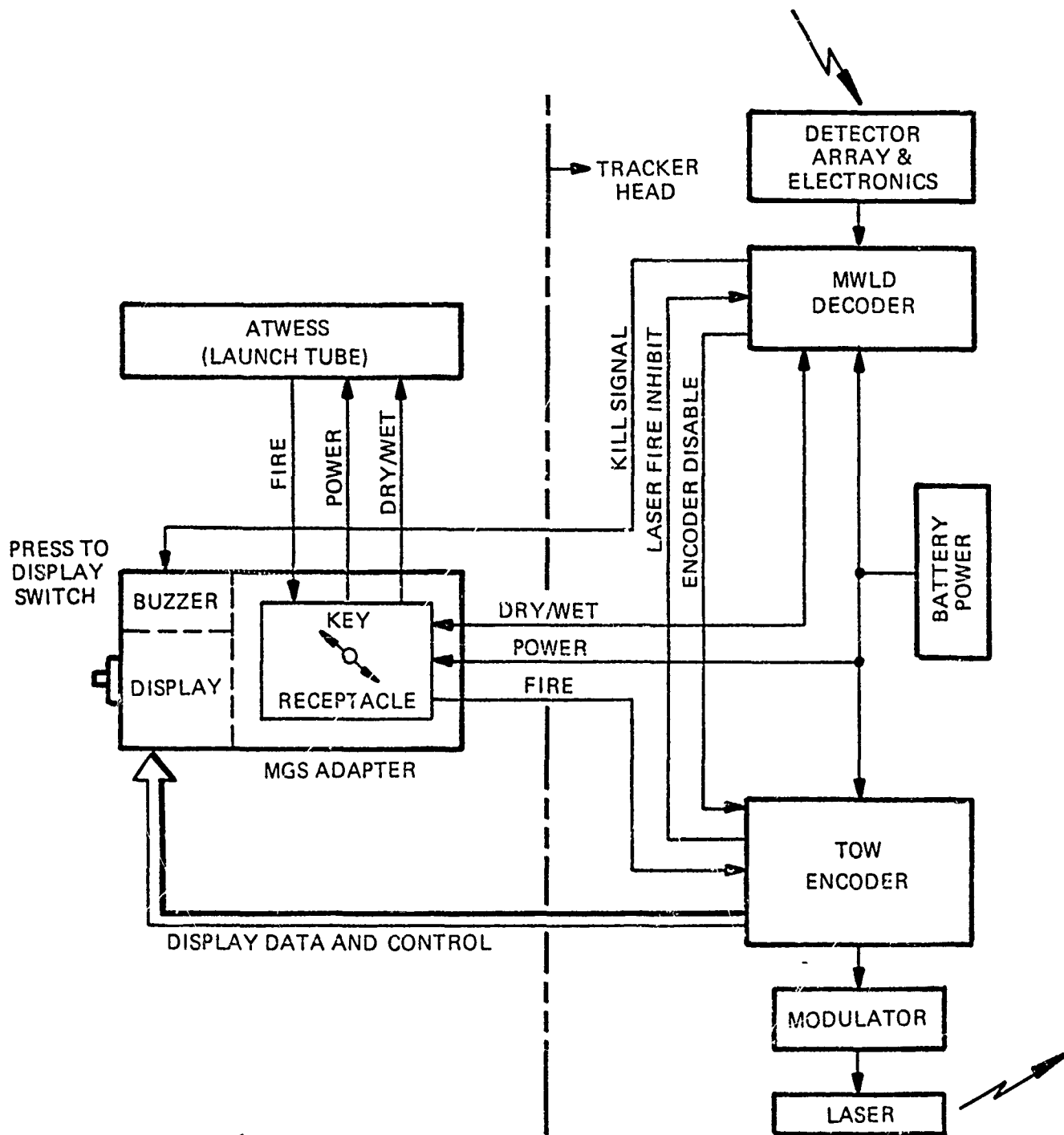


Figure 4-13. Independent Laser Transmitter Functional Block Diagram



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Figure 4-14. TOW Electrical Interface

|                                      |                                         |                           |
|--------------------------------------|-----------------------------------------|---------------------------|
| WEAPON KEY<br>MAN SYSTEM<br>(YELLOW) | WEAPON KEY<br>VEHICLE SYST.<br>(ORANGE) | CONTROLLER KEY<br>(GREEN) |
|--------------------------------------|-----------------------------------------|---------------------------|



**Figure 4-15. M16A1 Laser Transmitter and Weapon Key Configurations**

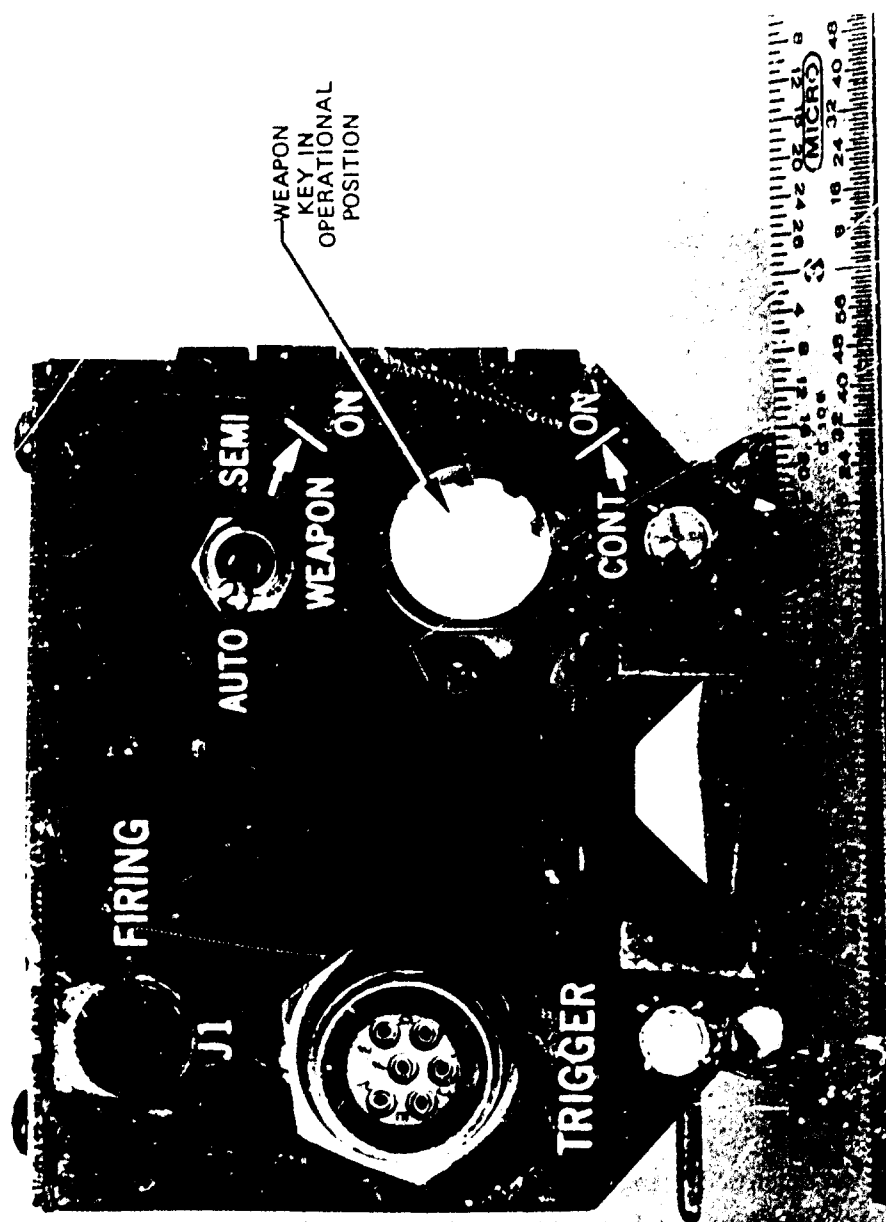


Figure 4-16. M16A1 Transmitter, Rear View

b. Rear View (see figure 4-16)

- o Firing Indicator - a red LED flashes each time the laser fires.
- o Trigger Connector - a six pin connector which mates to the trigger assembly for:
  - (1) Dry fire operation
  - (2) External power
  - (3) Boresight code
- o Selector Switch - A toggle switch used to select either automatic or semiautomatic firing when in the dry fire mode. This switch is used only on the M16A1 rifle transmitter.
- o Weapon Key Receptacle - this receptacle mates with the weapon key and with the controller key. Functions of these keys are explained in detail in subsection 4.9. The weapon key must be in the receptacle and turned to the on position for the laser transmitter to operate.

c. Top View

- o Laser Tube - the housing which contains the laser diode, optics, and a portion of the electronic circuitry. This tube is purged, sealed, and filled with dry nitrogen.
- o Cover - this top cover when removed allows access to the transmitter electronics contained on three printed wiring boards.

The insert on figure 4-15 shows the keying arrangement of the tabs on the three different weapon/controller keys used in the MILES system. The yellow weapon key is used with the M16A1 rifle and other man-carried weapons.

4.2.1.3 Construction

The general construction and assembly of the M16 transmitter is shown in figure 4-17. This exploded view shows the relationship of all the transmitter component parts or replaceable assemblies. With the exception of the toggle switch (used only on the M16A1 transmitter) this is the same construction used on the M60, M2, and M85 machine gun laser transmitters. Minor differences in the electronic assemblies or laser tube assembly differentiate between the laser transmitter assemblies for these weapons.

The basic materials of construction are aluminum for the metal parts and copper clad fiberglass for the printed wiring boards. Corrosion resistant steel is used where added strength is required - door hinge pins, etc. The housing, battery door, and door latches are castings, and the housing cover is a stamped



[illegible]

**Figure 4-17. M16 Transmitter Construction**

aluminum plate. The laser tube housing is a machined aluminum tube. An aluminum retaining ring positions and secures the glass optical lens.

#### **4.2.1.4 Weapon Interface Attachment**

The primary difference between the various small arms laser transmitters is the method of attachment to the weapon interface.

The M16A1 laser transmitter weapon attachment adapter is shown in figures 4-18 and 4-19. This adapter is permanently attached to the laser transmitter during manufacturing and the laser tube mounting hole is machined in line with the V-grooves on the attachment. These V-grooves are used to interface the weapon barrel. Thus, the laser tube is accurately aligned with the weapon barrel as a function of the manufacturing process.

Installation of the transmitter on the weapon locates the transmitter parallel to the barrel and registers it axially by the rear attachment adapter which straddles the front sight post. Installation is completed by bringing the flat springs up against the bottom of the rifle barrel and then closing the bowed springs over the round support posts of the flat springs. To remove the transmitter the bowed spring is unsnapped with the thumb and the above procedure reversed.

#### **4.2.1.5 Weight and Center of Gravity**

The M16 laser transmitter including its GFE 9 volt battery weighs 25.4 ounces. The effect of this added weight to the transmitter is a shift in the center of gravity (CG) of the weapon toward the muzzle. This shift is shown pictorially in figure 4-20. The CG shift has a minimal effect in the carrying and handling of the weapon.

#### **4.2.1.6 Laser Alignment**

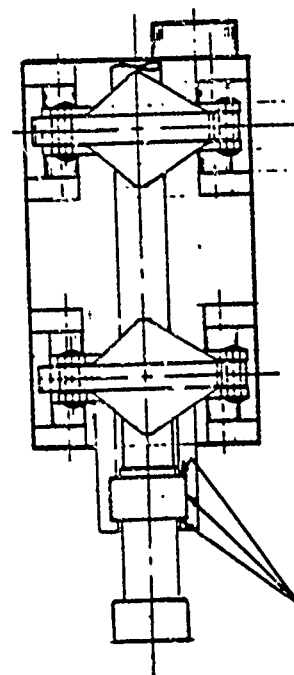
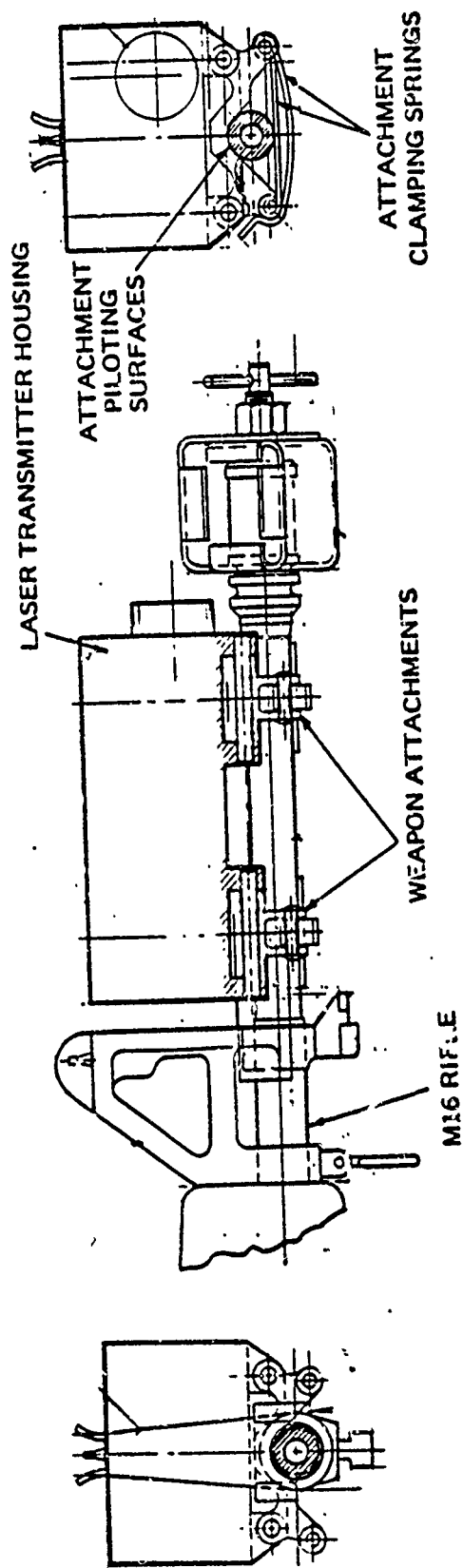
As shown in figure 4-21, the M16 laser transmitter is mounted forward of the front sight. It is sufficiently low in height that it does not interfere with the weapon sight line. In the field, the weapon sights are aligned to the laser beam using the arms alignment fixture. Once aligned, the transmitter can be removed and reinstalled with alignment repeatability.

#### **4.2.1.7 Dry Fire Mode**

The M16 laser transmitter is provided with a dry fire mode of operation (no blanks). To operate the weapon simulator in this mode, the trigger assembly must be attached to the weapon and connected to the transmitter. Figure 4-22 shows the weapon with the trigger switch installed.

The switch portion of the trigger assembly is a trigger overlay switch that slides over the normal weapon trigger (see figure 4-23). The laser is fired by squeezing the trigger in the normal manner.

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AXIAL REGISTER SURFACES

Figure 4-18. M16A1 Laser Transmitter Weapon Attachment

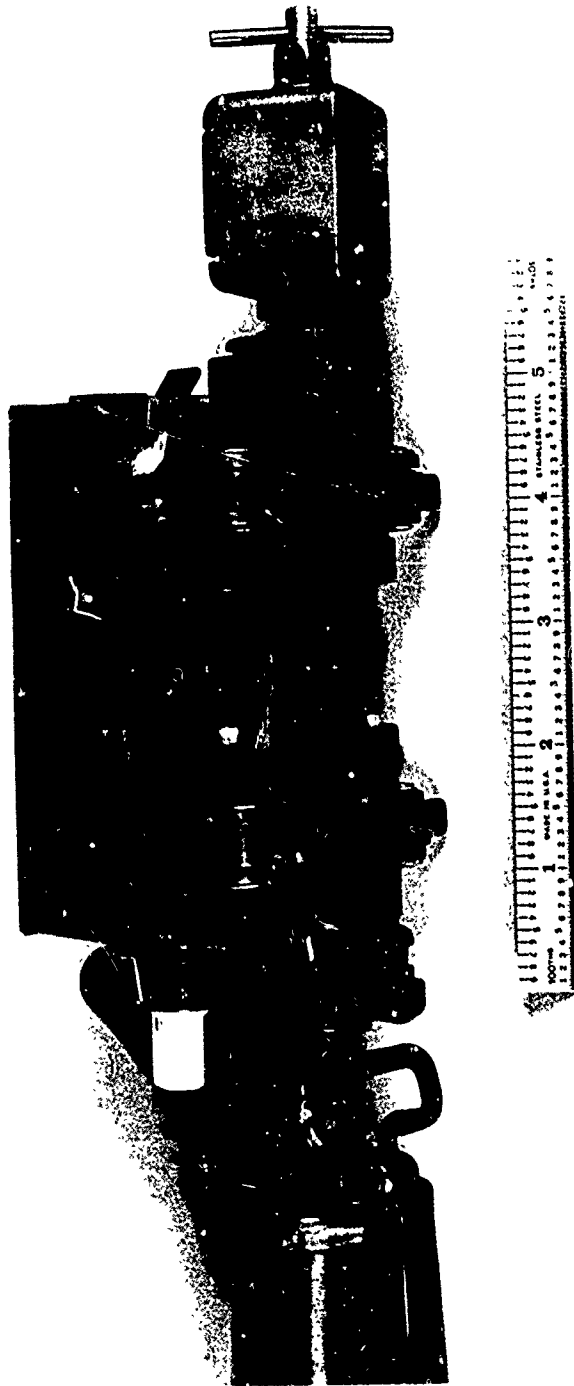
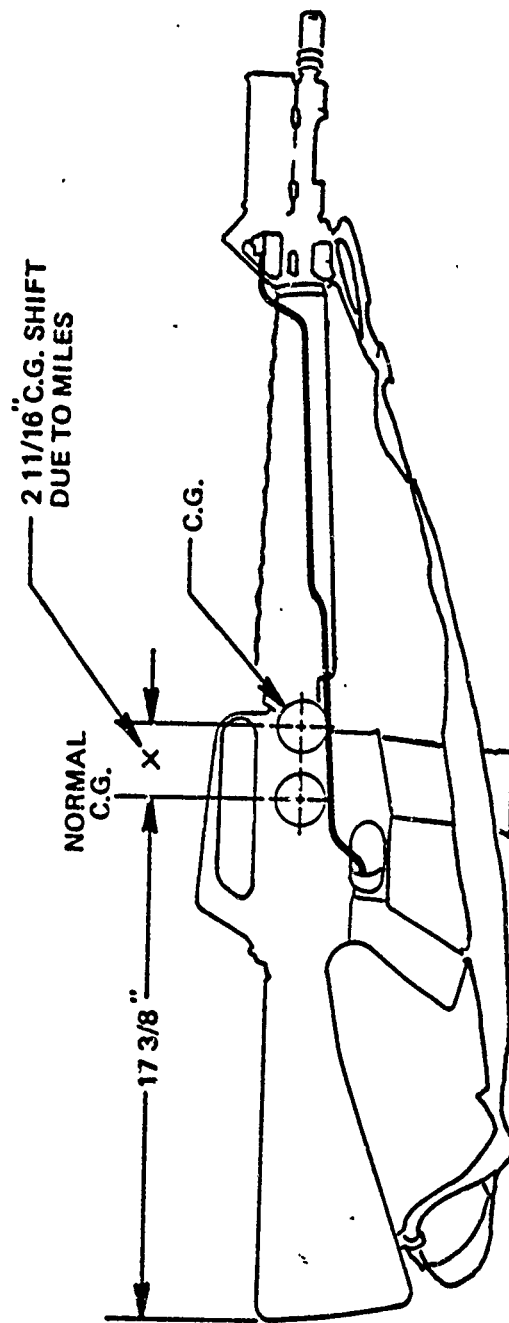


Figure 4-19. M16 Laser Attachment



WITH 30 ROUND MAGAZINE 9#, 10.4 OZ.  
TOTAL INCLUDES 25.4 OZ. MILES TRANSMITTER

Figure 4-20. M16A1 Rifle Center of Gravity

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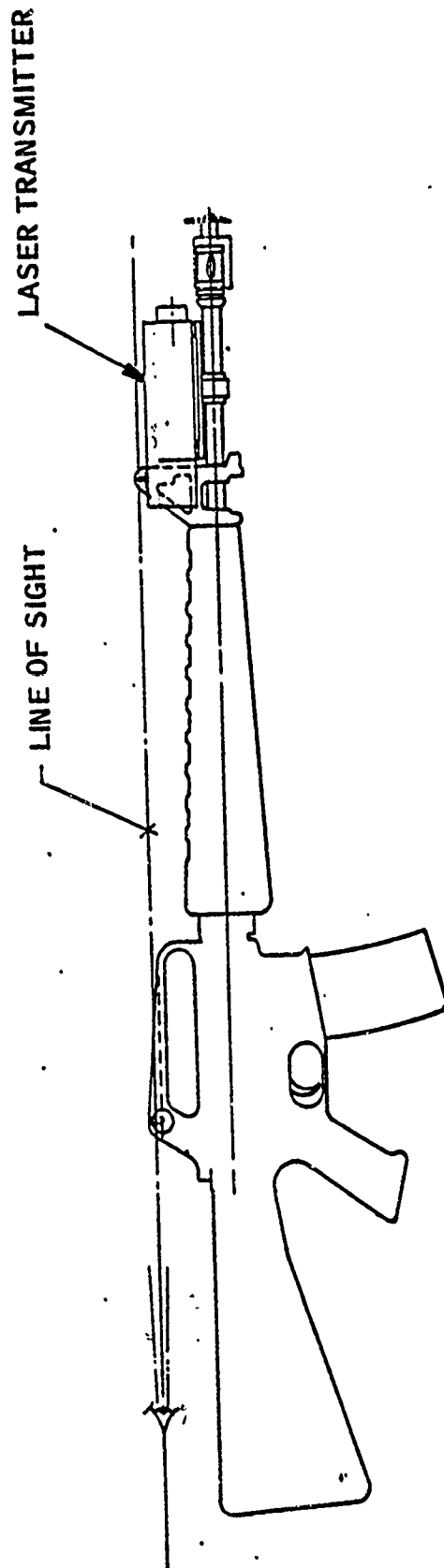


Figure 4-21. M16A1 Rifle Laser Beam Weapon Alignment

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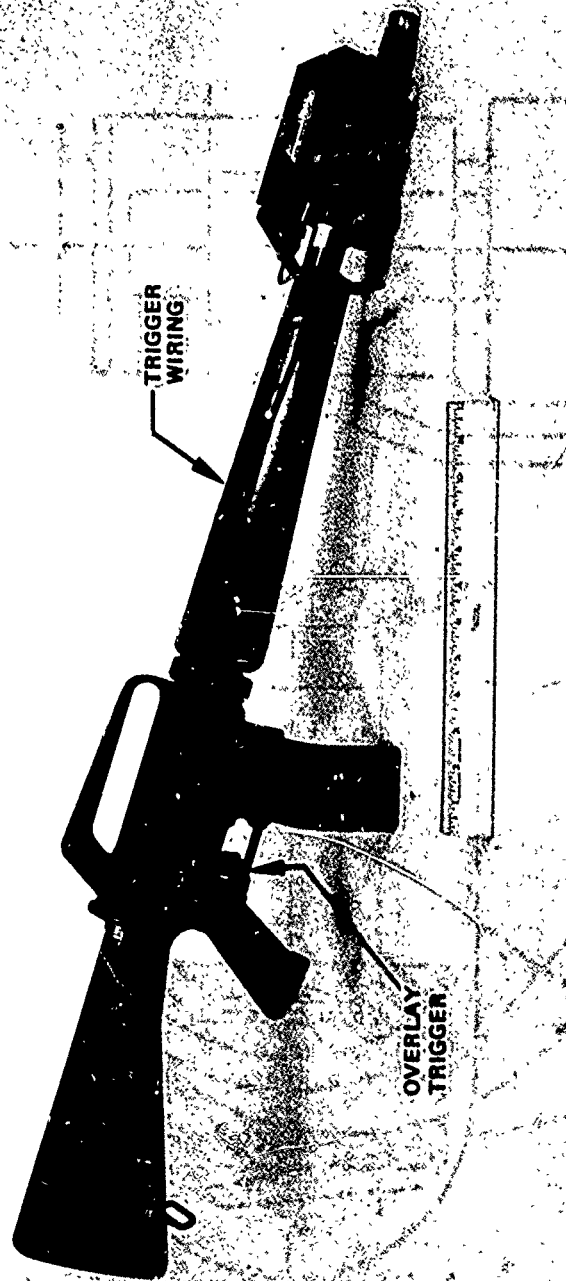


Figure 4-22. Trigger Wiring Installation

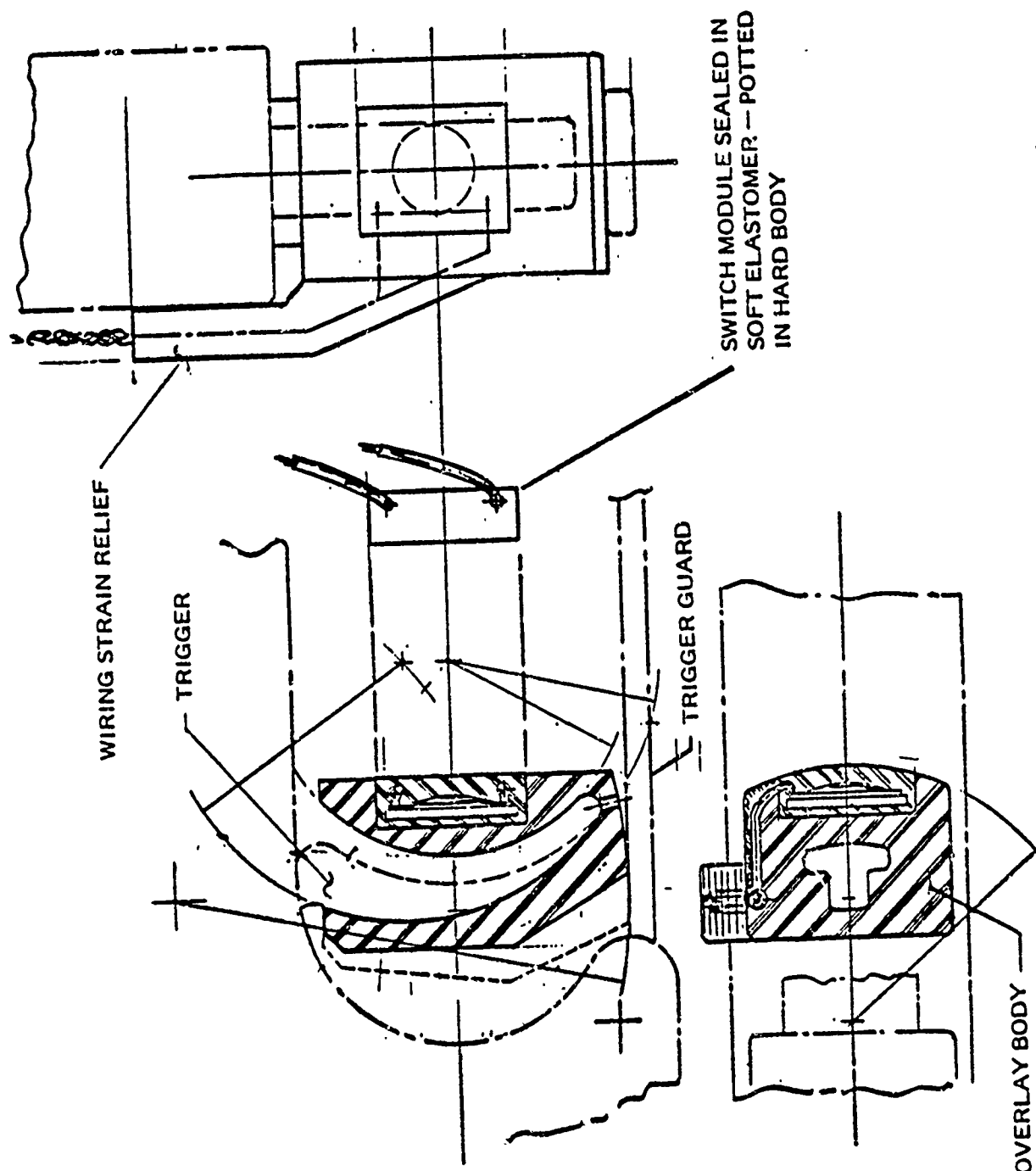


Figure 4-23. M16 Transmitter Trigger Overlay Switch



The laser transmitter must be turned on by the Controller in the dry fire mode. This is done as follows:

- a. Insert Controller key in the transmitter weapon key receptacle and switch to the ON position.

This operation turns the weapon on and supplies it with a basic load of 210 rounds of ammunition (30 rounds per magazine). Engineering Development Models required a second operation - a single squeeze of the trigger. \*

Firing mode selection is made by a switch on the rear of the transmitter. For single shot operation, the switch is turned to SEMI. For rapid fire operation, the switch is turned to AUTO. In the AUTO mode, the laser transmitter fires at a rate of 678 rounds per minute and is burst limited to 30 rounds, the equivalent of a magazine. The trigger must be released before another 30 rounds can be fired. The firing indicator light flashes every time a laser round is fired.

When all rounds are expended, the firing indicator light ceases to flash and the laser will no longer transmit. The laser can be resupplied with a basic load of ammunition only by the Controller with his green key.

#### 4.2.1.8 Blank Fire Mode

The trigger switch assembly is removed and not used when operating in the blank fire mode. In this mode of operation, a microphone senses the blank firing and triggers the laser transmitter each time a round is fired. The total laser rounds are limited only by the number of blank rounds issued to the infantryman.

The M16 blank fire attachment is necessary when firing blanks. It should be oriented on the weapon so that the blast effects are not directed toward the laser transmitter. Some carbon will still collect on the transmitter lens and the lens should be cleaned after every field exercise.

#### 4.2.2 M60, M2, and M85 Machine Gun Transmitters.

These three transmitters are similar to the M16 transmitters with only minor differences. The three primary physical differences are external to the assembly. The first difference is that the machine gun transmitters do not have the "AUTO/SEMI" selector switch. The second is the attachment adapters that provide interface with the weapons. All are different one from another. The mounting of the M60 machine gun is to the weapon barrel as shown in figure 4-24. The M2 and M85 machine guns mount to the external jacket of the weapons shown in figures 4-25 through 4-27. The third difference is the weapon key. Its configuration is identical for the M16 and M60 and is identified by its yellow color. The M2 and M85 weapons are used in vehicles and their keys are different from the keys used in ground weapons. This changed configuration is identified quickly by the orange color of the key. In each case, GFE Blank Fire Adapters, unique to the weapon class, are required. \*

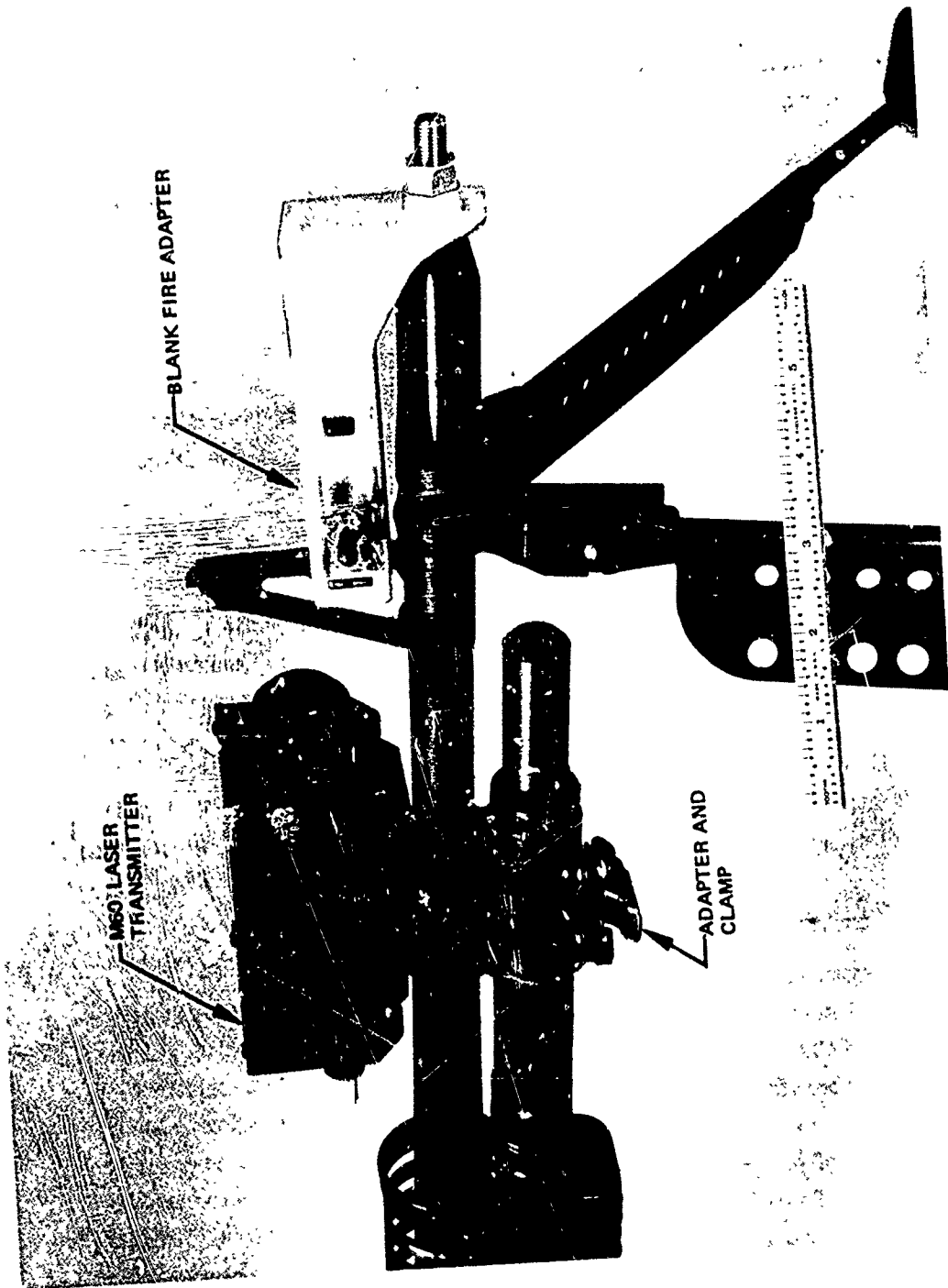


Figure 4-24. M60 Laser Transmitter Attachment

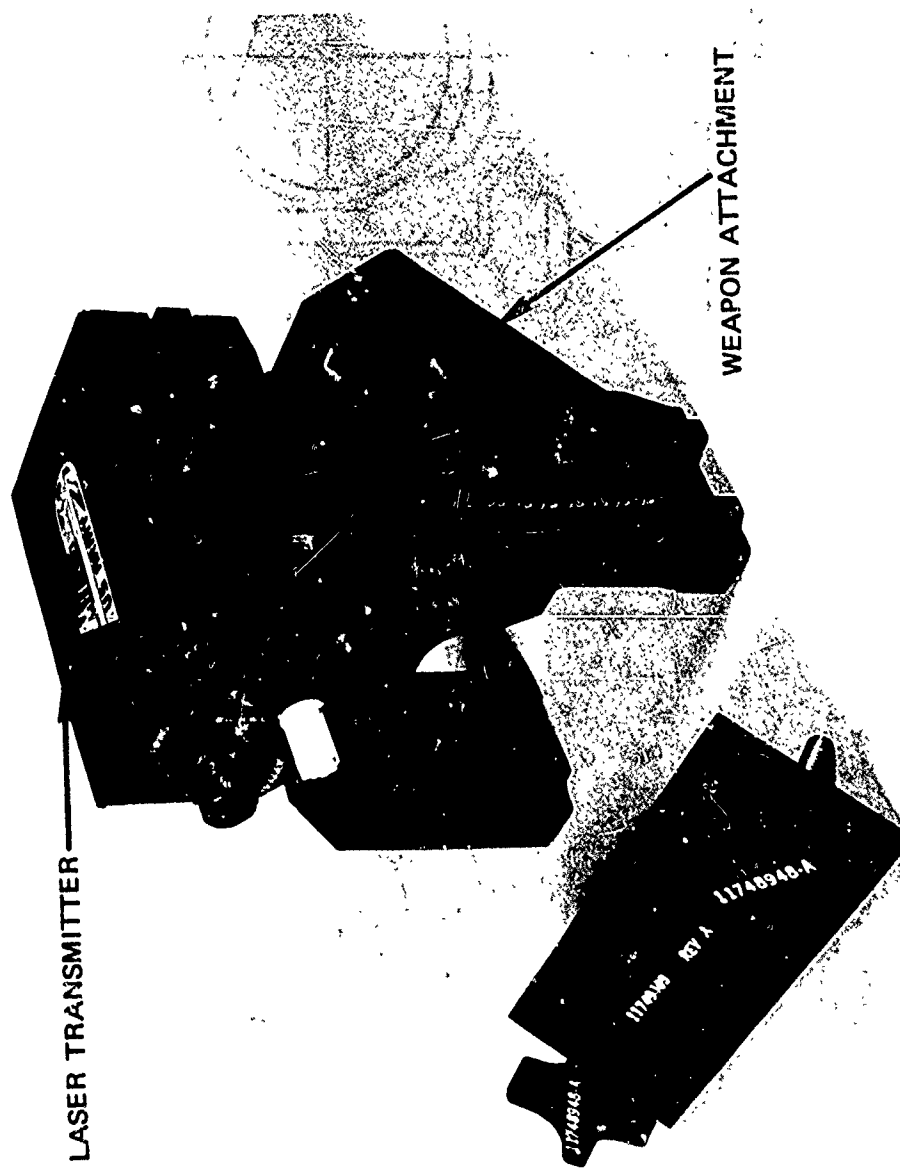


Figure 4-25. M85 Laser Transmitter and Weapon Attachment

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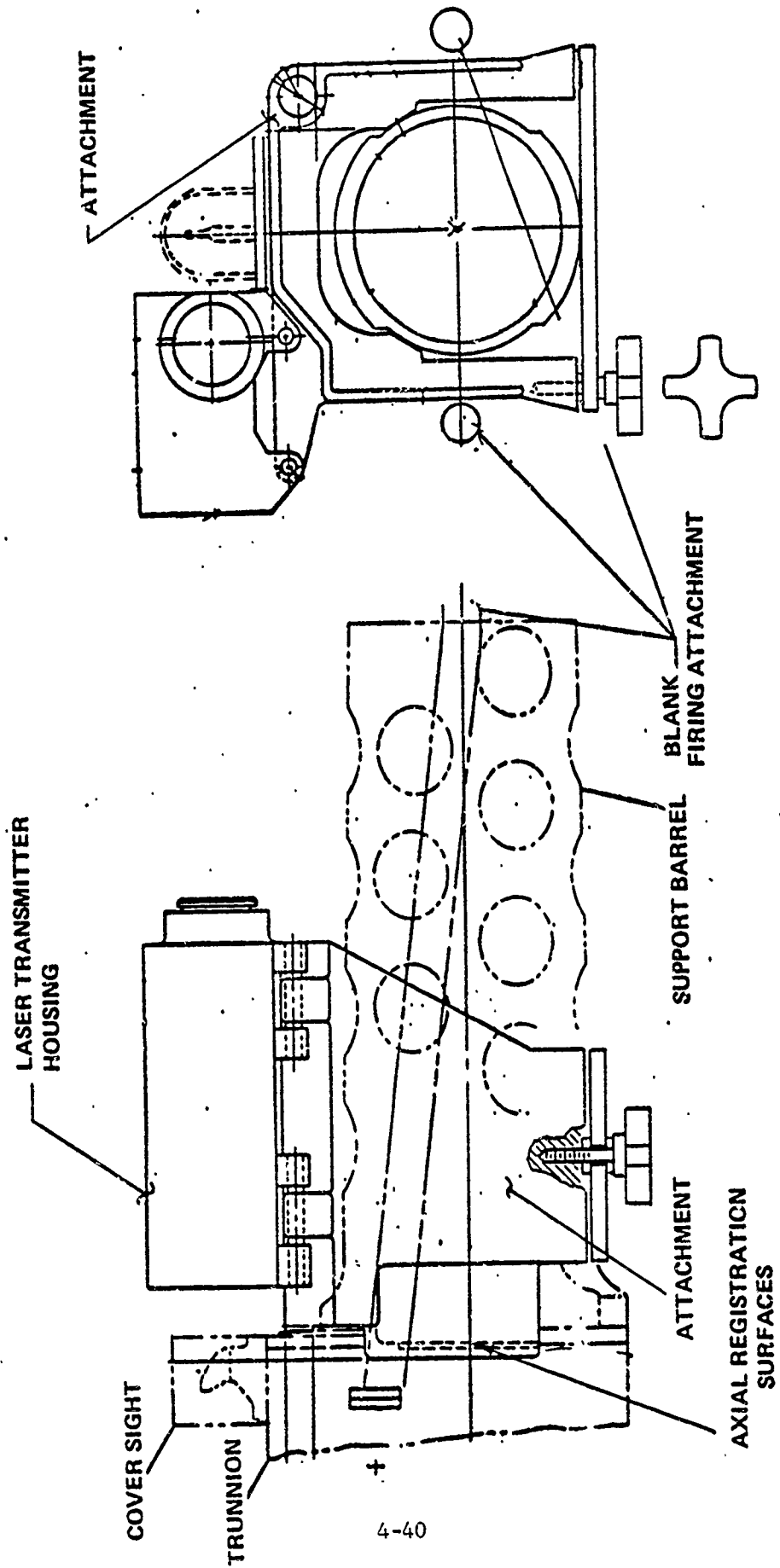


Figure 4-26. M2 Laser Transmitter

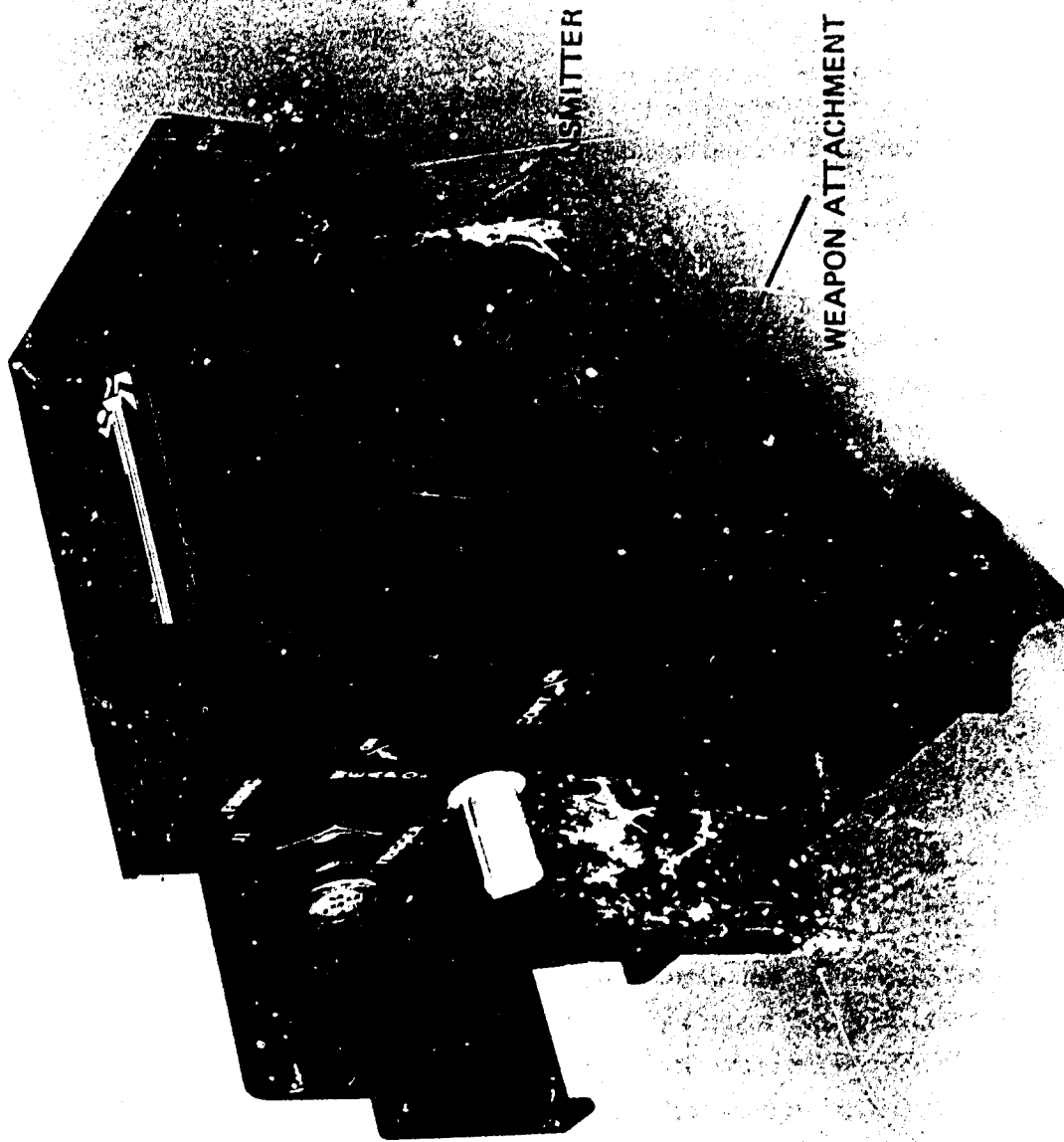


Figure 4-27. M2 Laser Transmitter and Weapon Attachment

Internally, there are slight differences, but only involving component values on the printed wiring boards. The change in component values accommodates the differences in simulation of weapon characteristics which includes the weapon codes. The machine guns have a different basic load of ammunition and different burst limits:

- a. M60 - 600 rounds - 200 round burst limit
- b. M2 - 1200 rounds - 200 round burst limit
- c. M85 - 1200 rounds - 200 round burst limit

#### 4.2.3 DRAGON LASER TRANSMITTERS

The DRAGON transmitter, although functionally much like the previously described laser transmitters, is packaged in an assembly that simulates and replaces the DRAGON sight for tactical training (see figures 4-28 and 4-29). This simulator has a built-in telescope that is factory aligned to the laser transmitter so that no adjustments are required in the field. The tracker simulator mates with a simulated DRAGON launch tube in a manner similar to the normal DRAGON sight. The launch tube assembly contains the ATWESS firing device.

The laser transmitter is operable in two modes (Dry Fire and ATWESS) selectable only by the Controller. Selection is made with the controller key at the DRAGON transmitter weapon key receptacle. ATWESS is the normal mode with Dry Fire used primarily for testing. The Controller must also turn this weapon ON with his key for either ATWESS or Dry Fire mode. In so doing he sets the basic load of 4 rounds for the simulator.

##### 4.2.3.1 Dry Fire Mode

In the Dry Fire mode, the weapon is fired in the normal manner by pressing the thumb trigger release, then squeezing the trigger. The gunner must track the target for a total of 7 seconds to score a hit. There is a one second delay after triggering before laser transmission starts, and the laser transmits for 6 seconds. The ATWESS will fire in the Dry Fire mode if the ATWESS is loaded and armed. However, the ATWESS cartridge is not required in the dry fire mode for the MILES laser transmitter to operate.

##### 4.2.3.2 ATWESS Mode

In the ATWESS mode it is required to have an intact ATWESS cartridge in the firing chamber and the ATWESS firing device loaded and armed before the MILES laser will operate. The one added operation with ATWESS is to pull out the ARM lever just before firing the DRAGON. When the trigger is squeezed, ATWESS fires immediately. There is a one second delay before laser transmission begins. Again, the gunner must track the target as described above. Before the simulator will fire another laser transmission, a new cartridge must be installed. The laser will not fire with an expended cartridge in the ATWESS firing chamber. Sighting is done in the normal manner.

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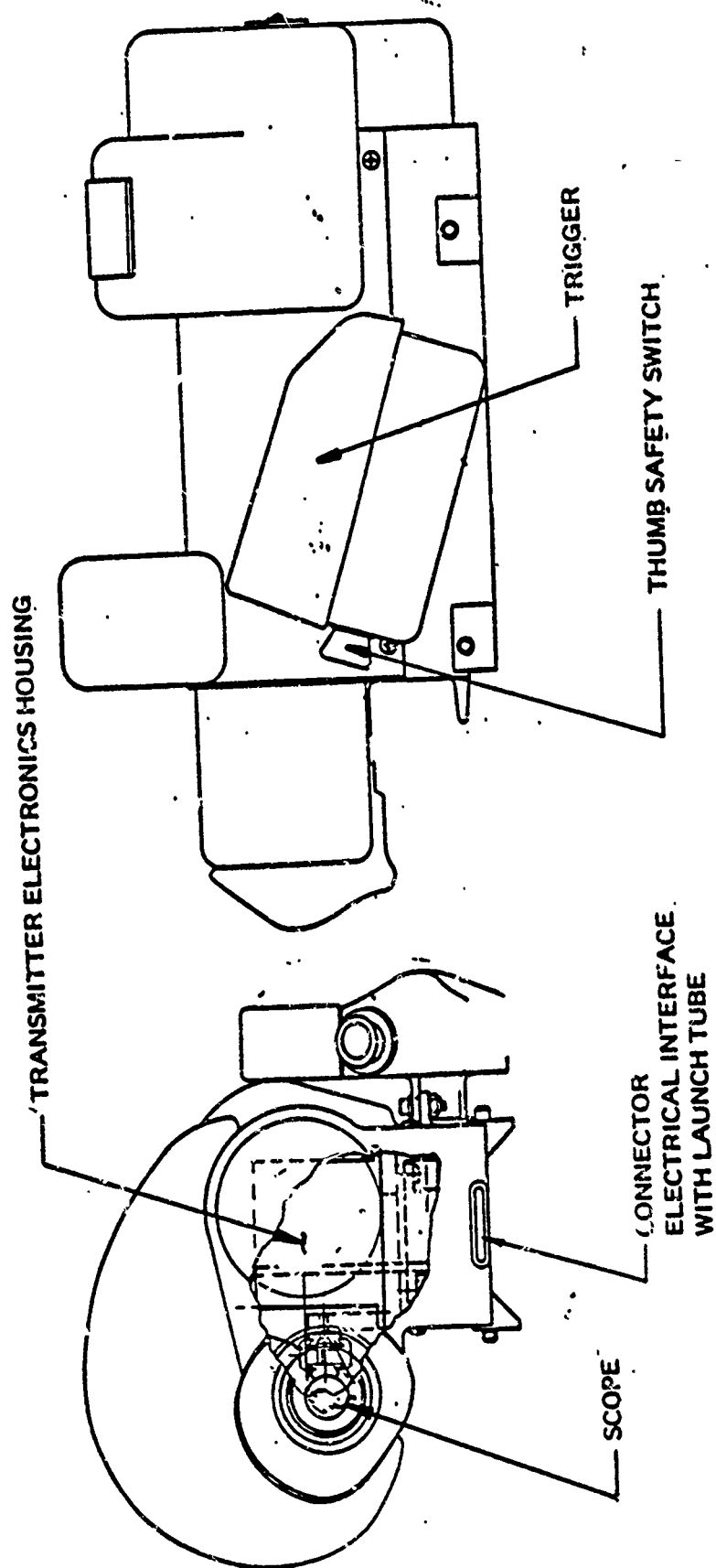


Figure 4-28, Dragon Laser Transmitter Outline Drawing



Figure 4-29. Dragon Laser Transmitter

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In either mode of operation, the rounds remaining can be checked. This is a feature on DRAGON that the previously described weapons do not have - that is, a rounds count display. By pressing a button, the rounds remaining are shown in the "DISPLAY" window (see figure 4-30).

#### 4.2.4 VIPER LASER TRANSMITTER

As with the DRAGON, the VIPER is similar in its functional design and is packaged in an assembly that simulates and replaces the LAW launch tube (see figure 4-31). The rear of the tube contains the ATWESS firing device.

The VIPER is turned to the "ON" position by the Controller in either Dry Fire or ATWESS mode and is supplied with a basic load of 4 rounds. Its firing rate is 6 RPM. There is no weapon key used in the VIPER for operation. The laser transmitter remains operable until the 4 rounds are expended. It must then be reset by a Controller. VIPER, like the DRAGON has the rounds remaining display.

The VIPER is a fire and forget weapon so there is no time delay or tracking requirement with this rocket simulator. When the trigger is depressed in Dry Fire mode, the laser fires. In the ATWESS mode, depressing the trigger fires the ATWESS and the transmitter simultaneously.

A special ring is provided in the LAW tube front sight (see figure 4-32). This ring is installed at the time of manufacture and is factory aligned with the laser transmitter. The ring is used for sighting since there is no simulation of elevation for trajectory. When ready to fire, the gunner must arm both the VIPER and the ATWESS. The laser will not fire unless a live ATWESS cartridge is chambered and the ATWESS Safe/Arm lever is in the ARM position.

#### 4.2.5 TOW LASER TRANSMITTER ASSEMBLY

The TOW transmitter assembly is designed as a replacement unit for the TOW tracker head. It clamps to the TOW traverse unit with the standard mechanical locking lever. The laser transmitter is located in the area normally occupied by the tracker and a commercial 15 power scope replaces the day sight. The main housing is a casting that closely resembles the actual TOW tracker casting except that six laser detectors for receiving kills or near misses are installed on the sides of the tracker head. The assembly configuration is depicted in figure 4-33. Mounting provision is made for the TOW night sight on the simulated TOW housing.

The laser is factory aligned to the 15X sighting scope so that there is no requirement for alignment or adjustment, other than focus, in the field.

Functionally, the TOW transmitter is similar to the DRAGON transmitter described in subsection 4.2.3. It is used with the ATWESS which is packaged in an expended TOW launch tube. Firing is performed in the normal manner for TOW with the exception that the ATWESS must be armed before the MILES TOW will fire. A system block diagram showing the relationship of the TOW transmitter to its associated system elements is shown in figure 4-14.

58125

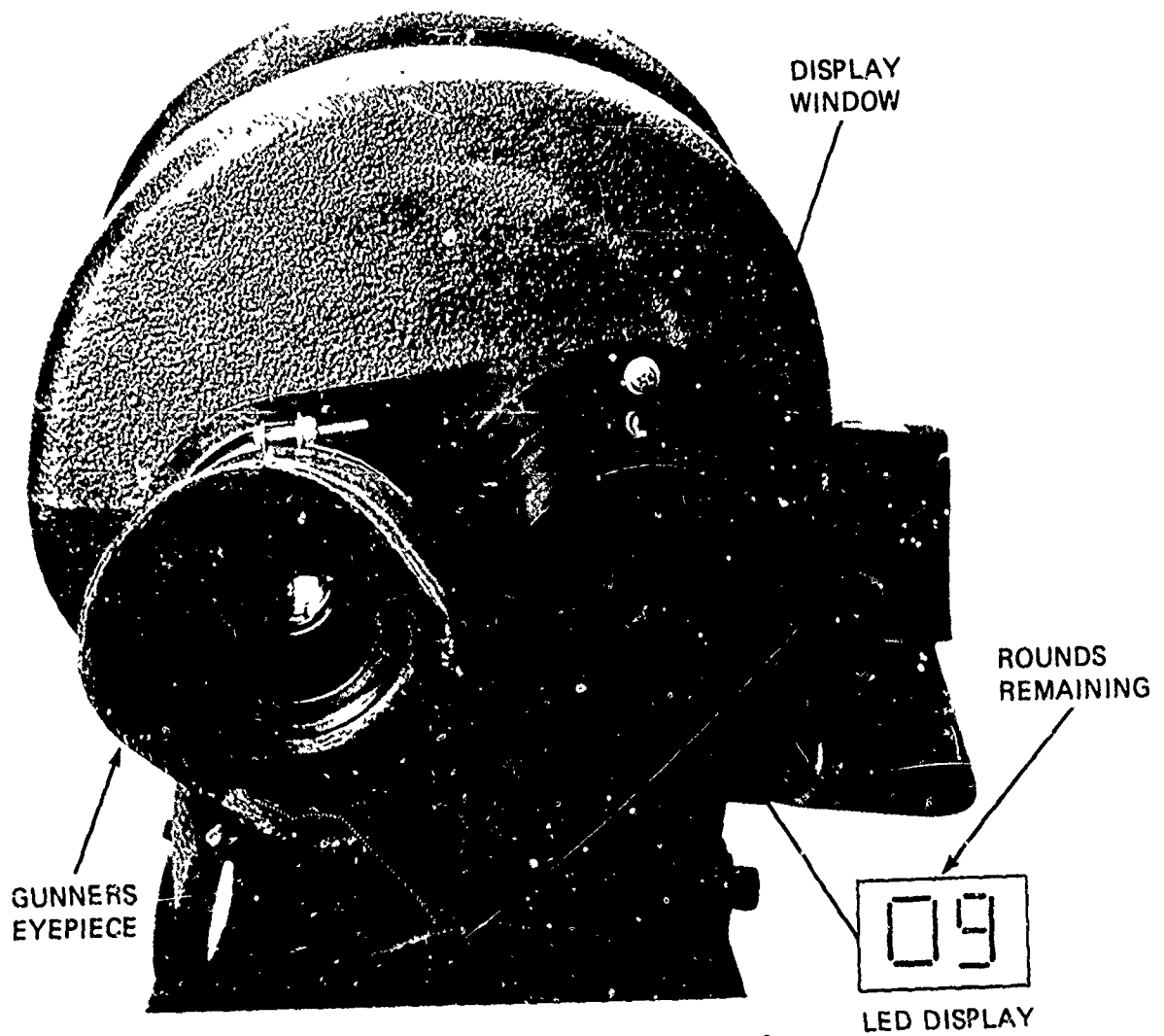


Figure 4-30. Dragon Rounds Count Display



Figure 4-31. Viper Laser Transmitter

12185

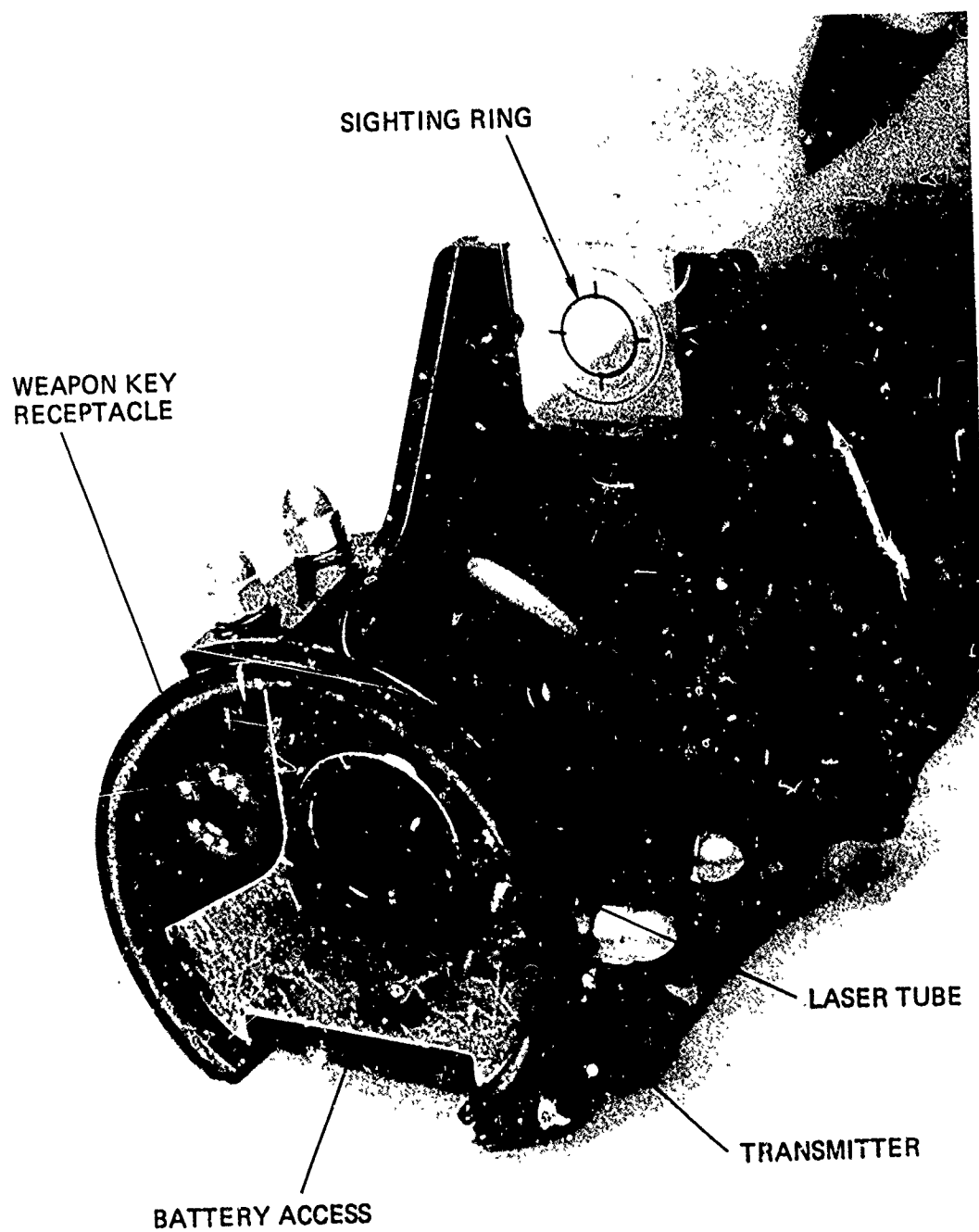


Figure 4-32. Viper Sighting System

8 58764

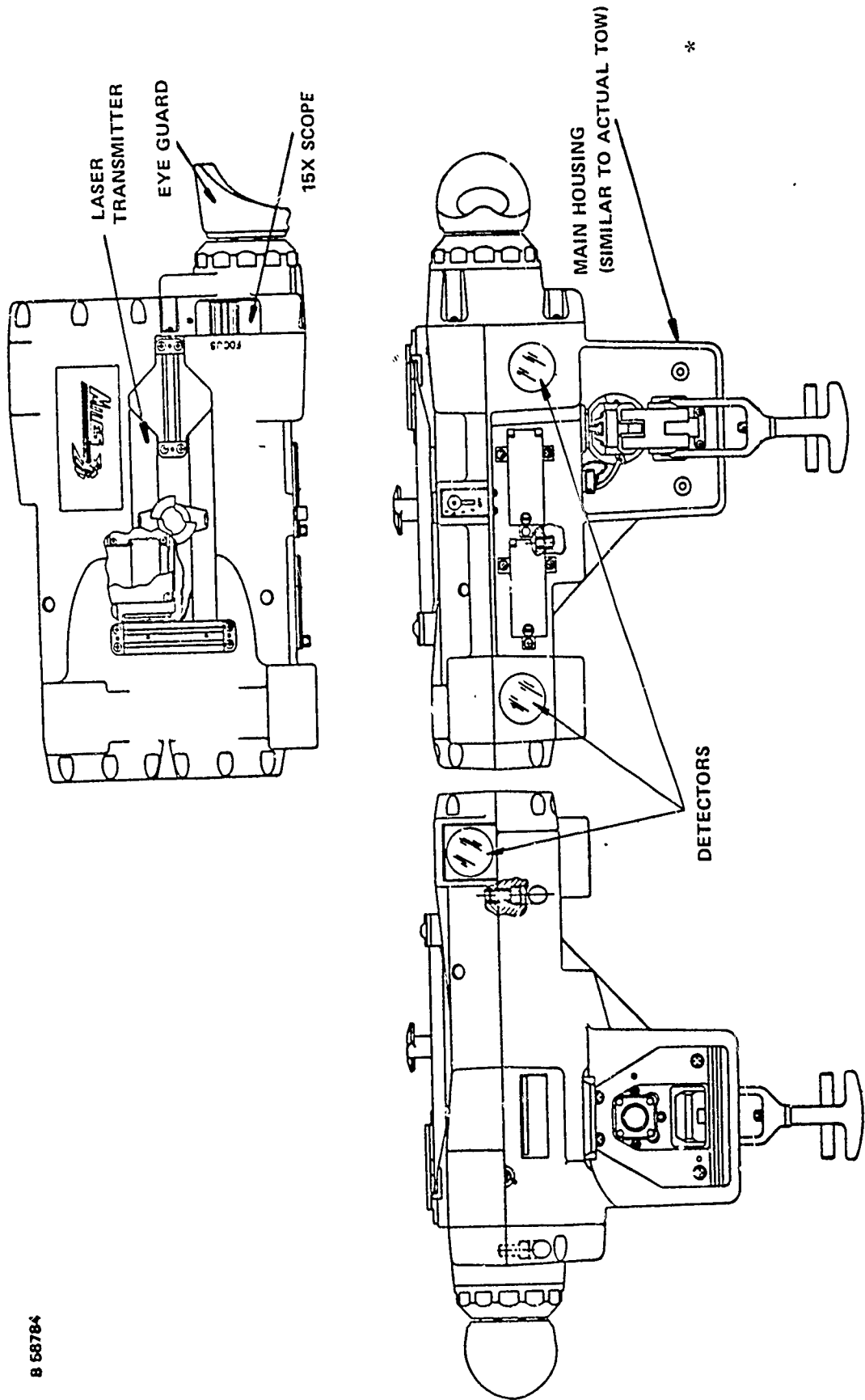


Figure 4-33. TOW Missile Laser Transmitter

On trigger depression the ATWESS fires immediately. There is then a 1 second delay before the MILES transmission begins. Since the TOW is a tracking missile, 10 seconds of target tracking time are required. The last 2 seconds are weighted equally with the first 2 seconds in determining a hit.

#### 4.3 DEPENDENT LASER TRANSMITTERS

Unlike the independent laser transmitters, the dependent laser transmitters require the Loader's Control Assembly (LCA), Combat Vehicle Kill Indicator (CVKI), battery box, and interconnecting cabling to operate as a part of the vehicle systems in which they are used. Power is supplied by the 12 volt battery pack and routed to the transmitters via the LCA. The LCA performs the complete logic control function for the dependent laser transmitters. This includes automatic weapon disablement when the vehicle is determined by the LCA to be "killed."

These transmitters are functionally similar to the ones previously described except that part of the electronics is located in the LCA and the batteries are in the battery box. This division of functions also causes a repackaging of each of the three dependent transmitters. Figure 4-34 shows the typical dependent transmitter in its relationship to the other components of a vehicle simulator system. Figure 4-35 is a block diagram typical of the dependent laser transmitters.

##### 4.3.1 105 mm/COAX LASER TRANSMITTER ASSEMBLY

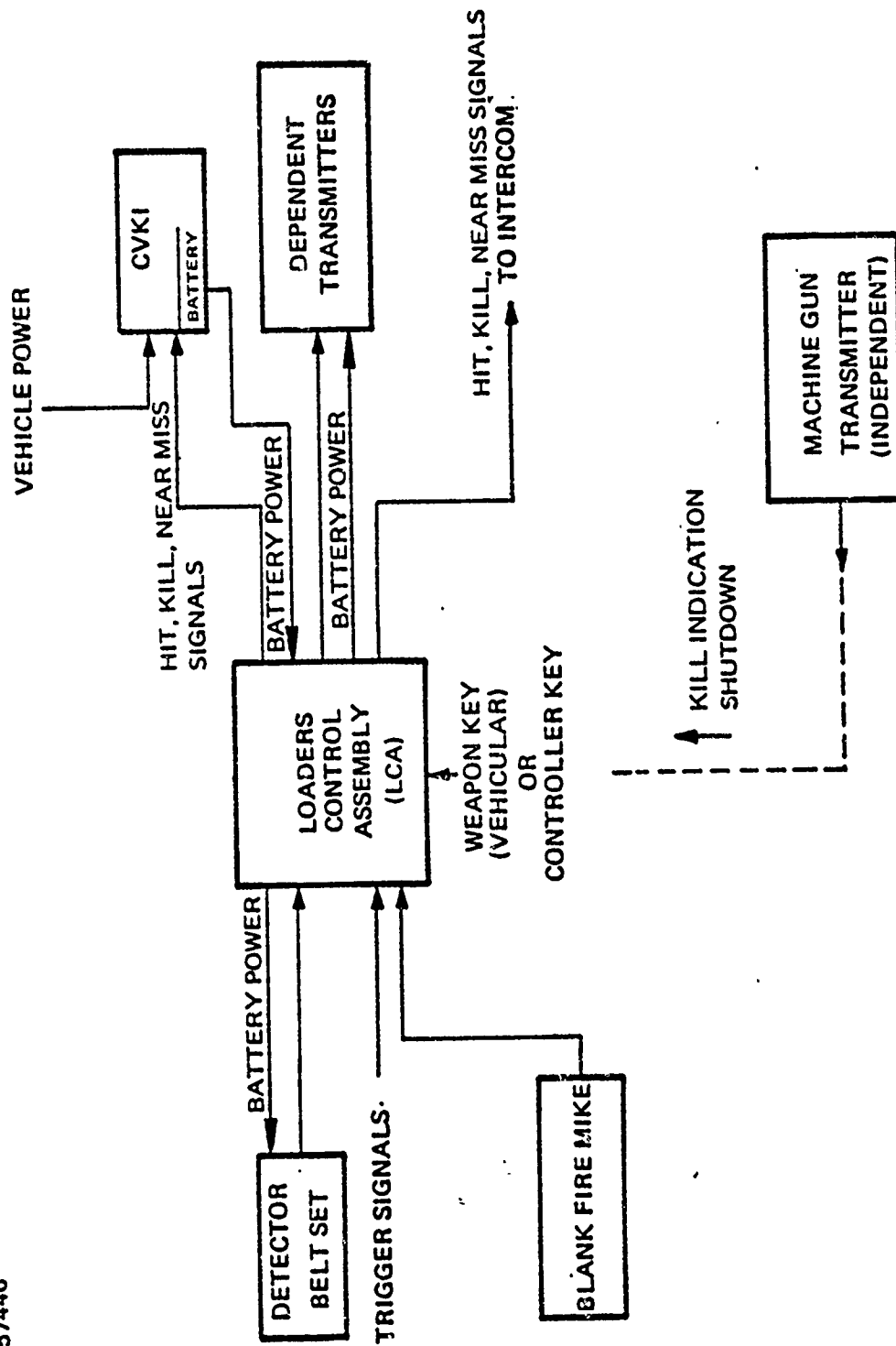
The 105 mm/Coax transmitter assembly is packaged to mount in the chamber of the 105 mm gun on the M60A1 and M60A3 tanks. The assembly contains two laser tube assemblies, one for the 105 mm main gun and one to simulate the 7.62 mm coaxial machine gun. A telescope is packaged as a part of the assembly and the two laser tubes and telescope are factory aligned to each other. Tolerances of alignment are:

- a. Coax to 105 mm =  $\pm 1.5$  mrad
- b. 105 mm to telescope =  $\pm 0.3$  mrad

The assembly is inserted in the gun chamber and locked in place with the mechanism shown in figures 4-36 through 4-39. Another assembly, also shown, is used to mechanically lock the breech in the open position.

##### Laser/Gun Tube Alignment

The laser and main gun alignment is accomplished in the field by the vehicle crew. A boresight target is selected at approximately 1200 meters or greater and the main gun is pointed until the telescope crosshairs in the laser transmitter assembly are aligned with the aiming point. The gun is then fixed at that point and the tank weapon sights are adjusted to match the telescope sights.



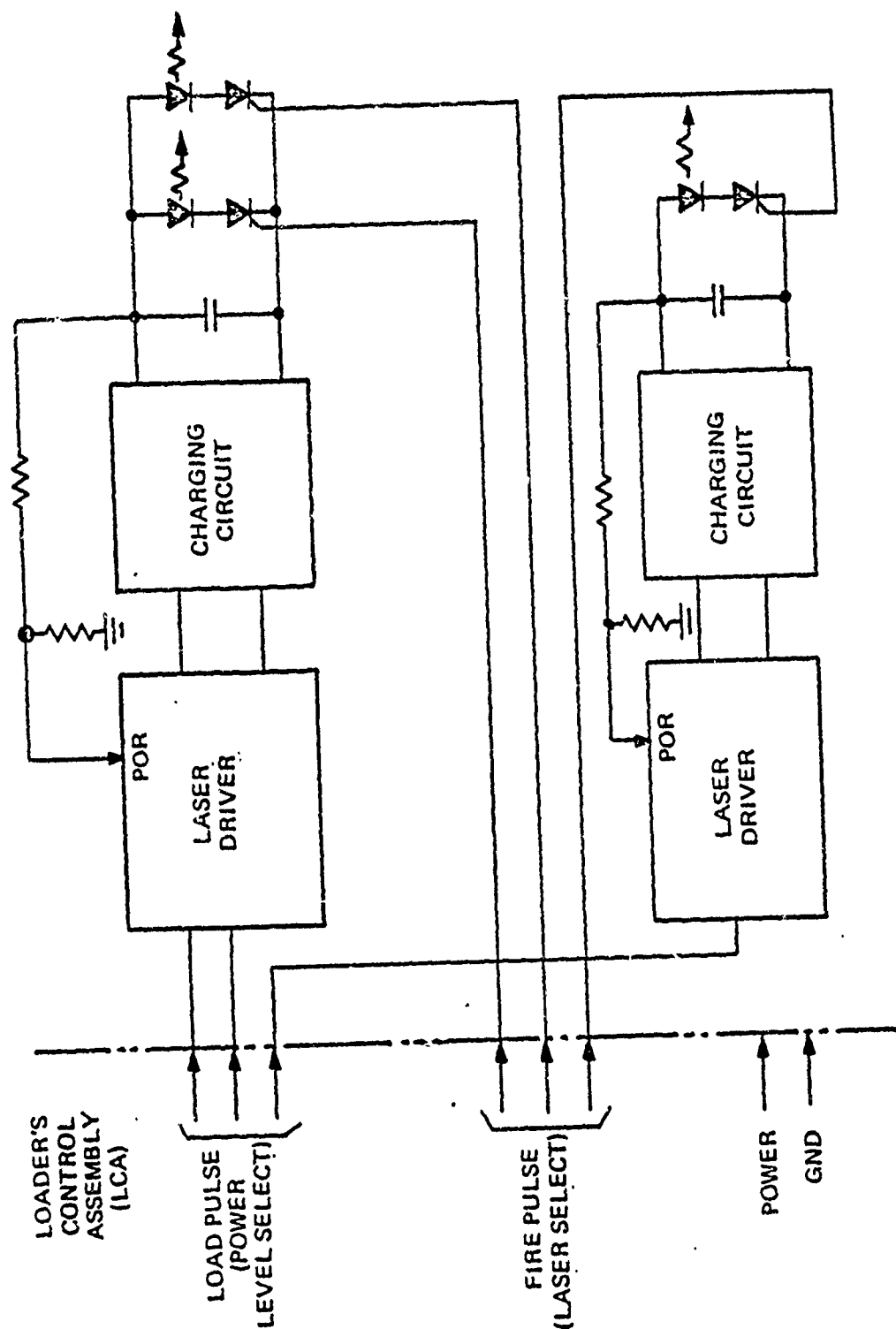


Figure 4-35. Dependent Laser Transmitter Functional Block Diagram



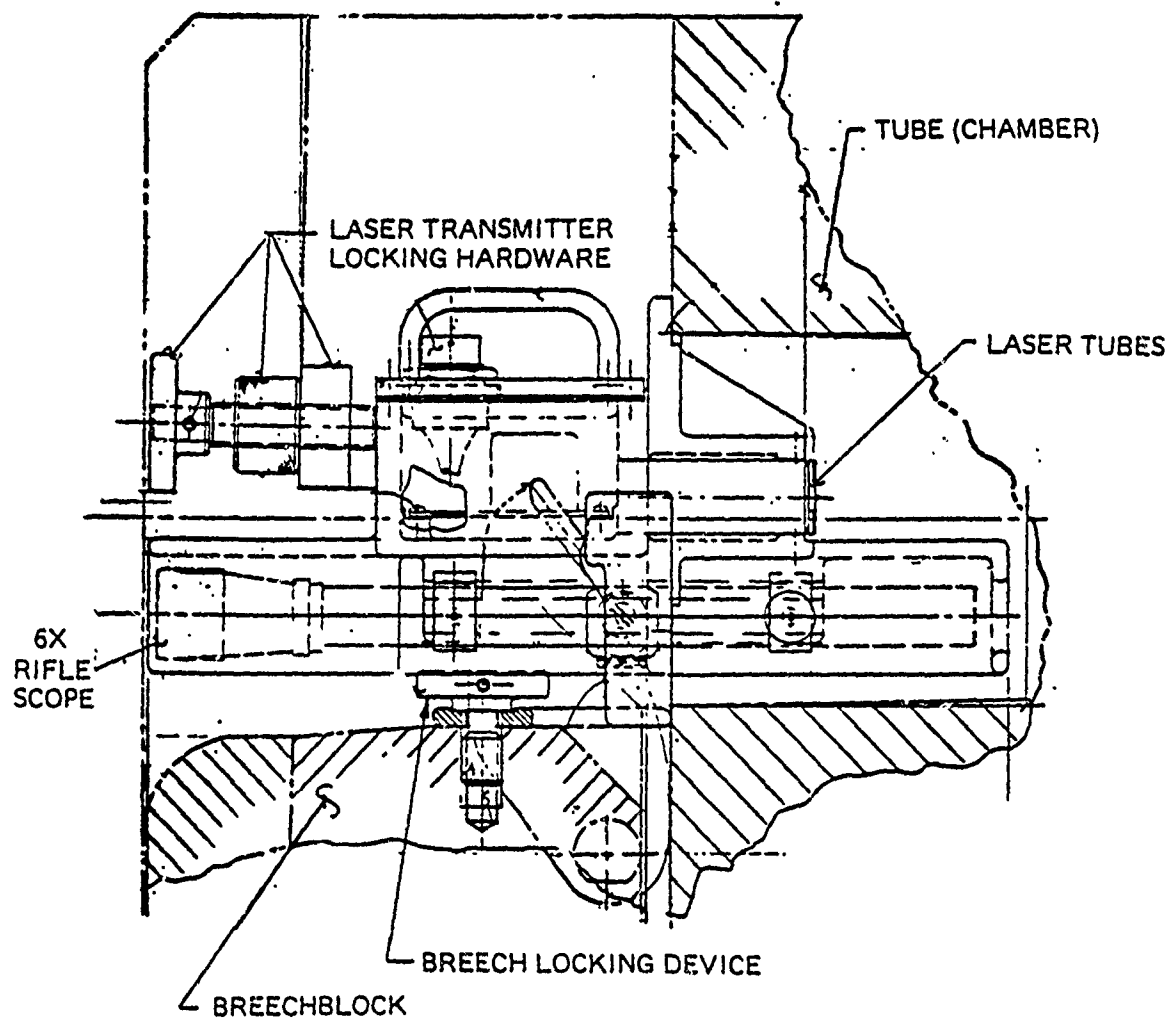


Figure 4-36. 105mm Laser Transmitter - Side View

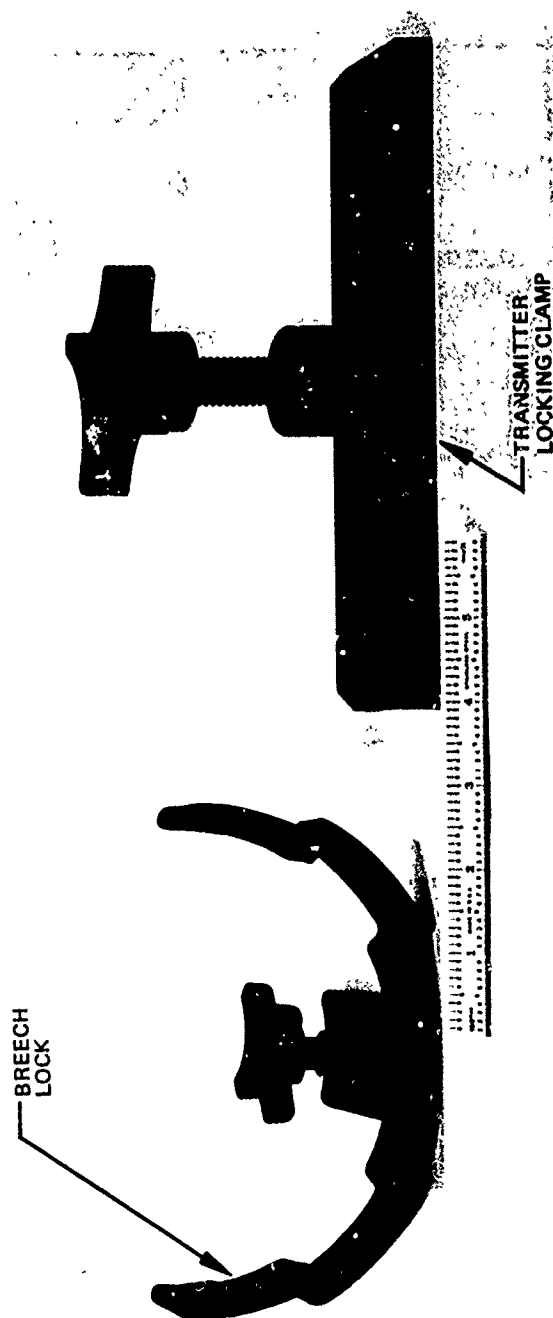


Figure 4-37. 105 mm Locking Mechanisms

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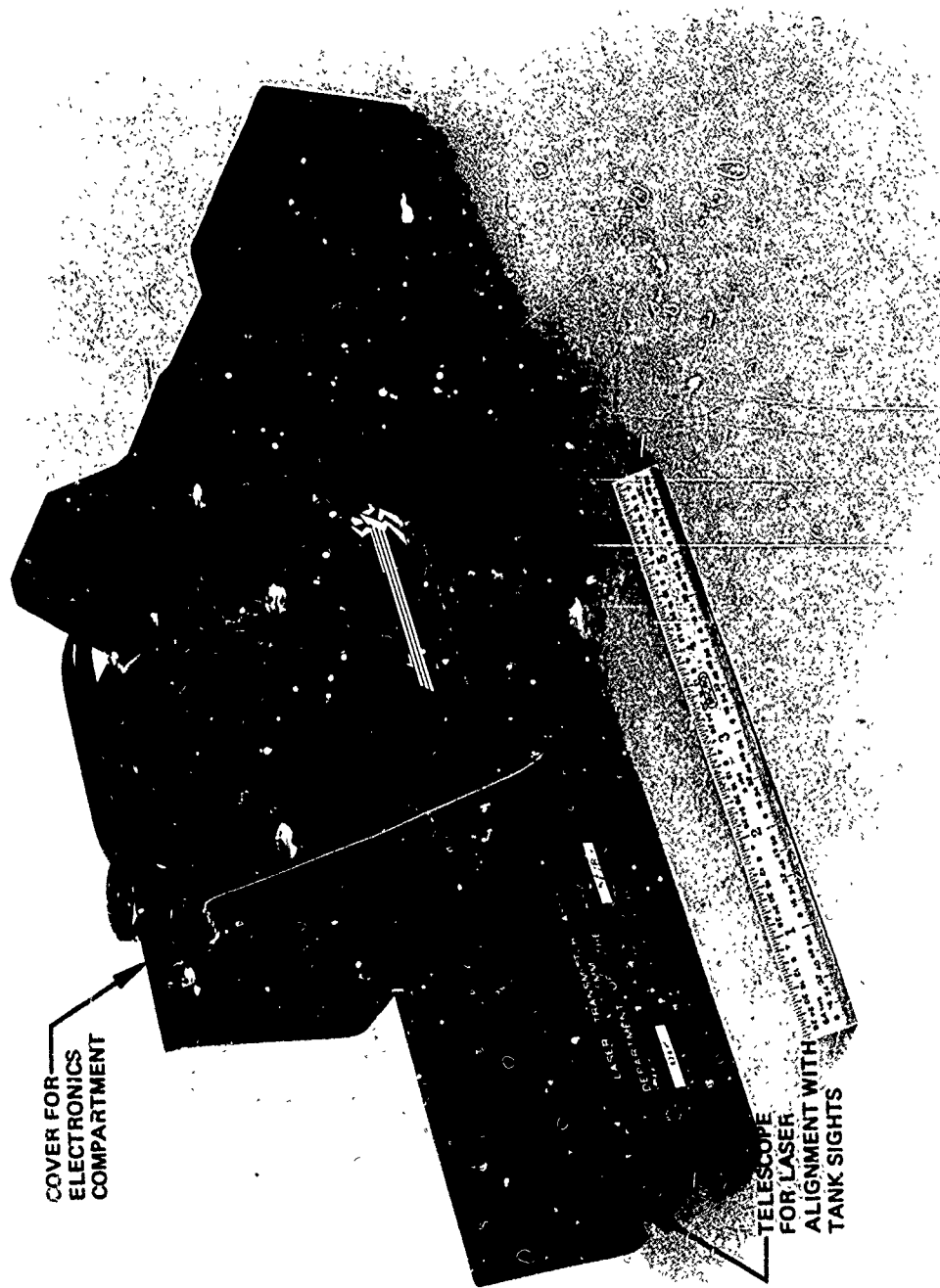


Figure 4-38. 105 mm Transmitter Assembly



Figure 4-39. 105 mm Transmitter Assembly

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#### 4.3.2 152 mm/COAX/SHILLELAGH LASER TRANSMITTER ASSEMBLY

The 152 mm/Coax/Shillelagh transmitter is packaged to fit into the main gun chamber on the M60A2 tank and the M551 AARV vehicle. The assembly contains three laser tube assemblies, one each for the 152 mm main gun, coax machine gun, and Shillelagh missile simulators. A 6x telescope is packaged as part of the assembly and the three laser tubes and telescopes are factory aligned to each other.

Tolerances of alignment are:

- a. Coax to Shillelagh =  $\pm 0.5$  milliradian
- b. 152 mm to Shillelagh =  $\pm 1.0$  milliradian
- c. Telescope to Shillelagh =  $\pm 0.3$  milliradian

The assembly is inserted in the gun chamber and locked in place as shown in figures 4-40 through 4-42.

##### Laser/Gun Tube Alignment

Laser/gun tube alignment is performed in the same manner as previously described for the 105 mm/Coax laser assembly.

In addition a Breech Adapter Plug, attached to the cable, is used to defeat the Shillelagh interlock so that the Shillelagh trigger circuitry may be used for MILES when the breech is open. A lanyard is attached to the adapter plug to prevent it from being inadvertently left in the vehicle.

\*

#### 4.4 DETECTORS/HIT INDICATORS

Encoded messages sent by the laser transmitters are received by detectors sensitive to the GaAs laser radiation. The received messages are amplified, decoded, and a hit, near miss or kill determination performed. An appropriate signal is then sent to the hit indicator(s) to activate the audio and visual alarms that signify the casualty status.

##### 4.4.1 MAN-WORN LASER DETECTOR (MWLD)

The man-worn laser detector provides detection of laser radiation, logic/decoding, and kill/near miss indication for high fidelity simulation of infantryman vulnerability to all anti-personnel weapon fire. A functional block diagram of the MWLD is shown in figure 4-43.

Since a man is vulnerable to both small and large weapon fire, his decoder allows kills from the complete MILES hierarchy of weapons, including the missiles.

The MWLD is designed to give unrestricted movement to the infantryman and is ruggedized to minimize vulnerability to damage during tactical combat exercises. Every precaution has been taken to reduce the potential for cheating by the infantryman. The man-worn laser detector, shown in figure 4-44, consists of two basic units:

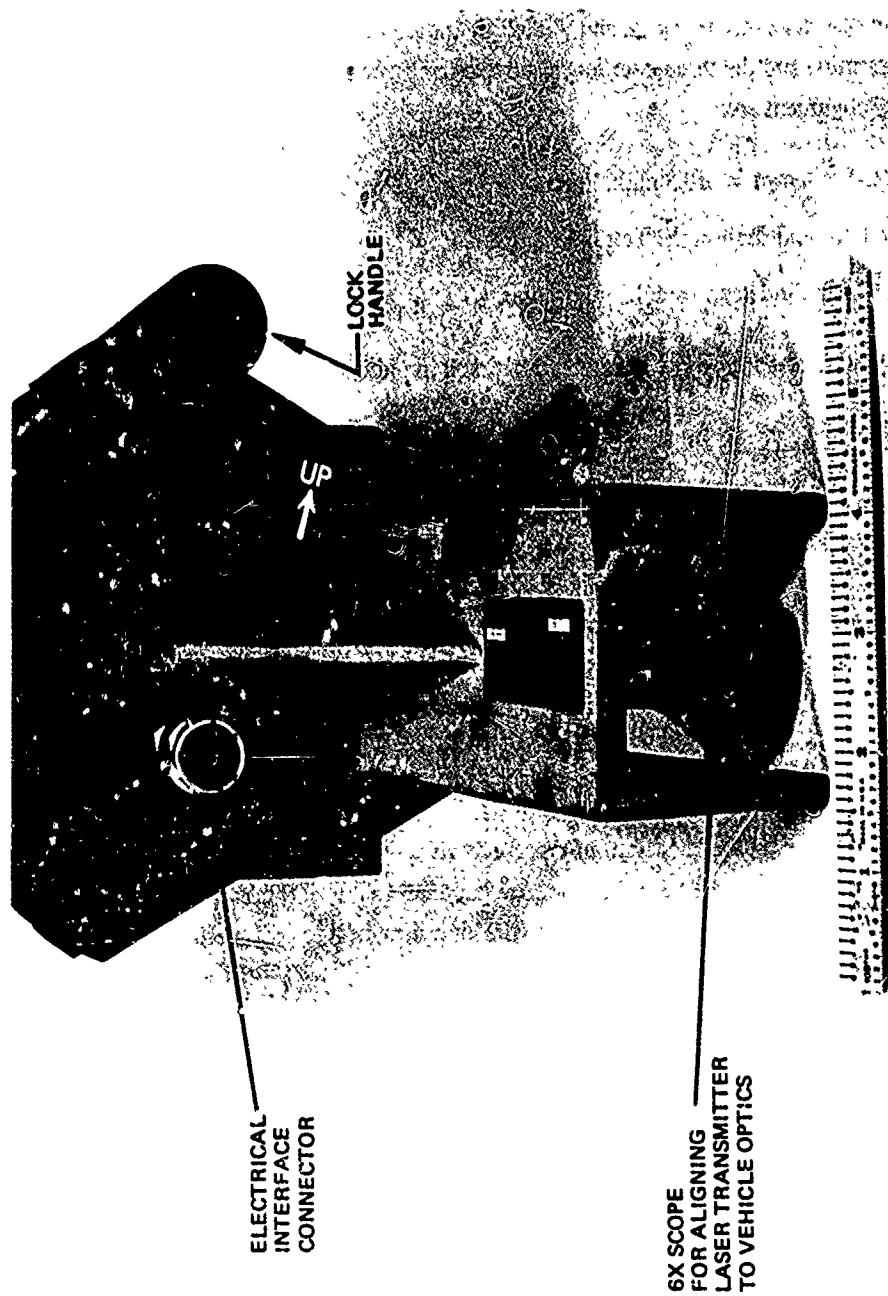


Figure 4-40. 152 mm Laser Transmitter

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Figure 4-41. 152 mm Laser Transmitter

8 782 94

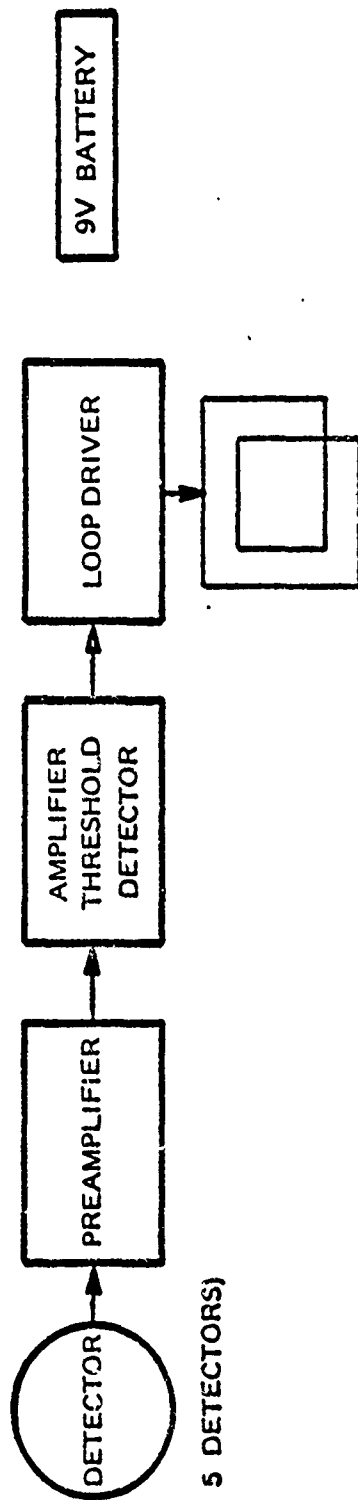
LASER TUBES FOR:  
152MM  
COAX M.G.  
SHILLELAGH



Figure 4-42. 152 mm Laser Transmitter

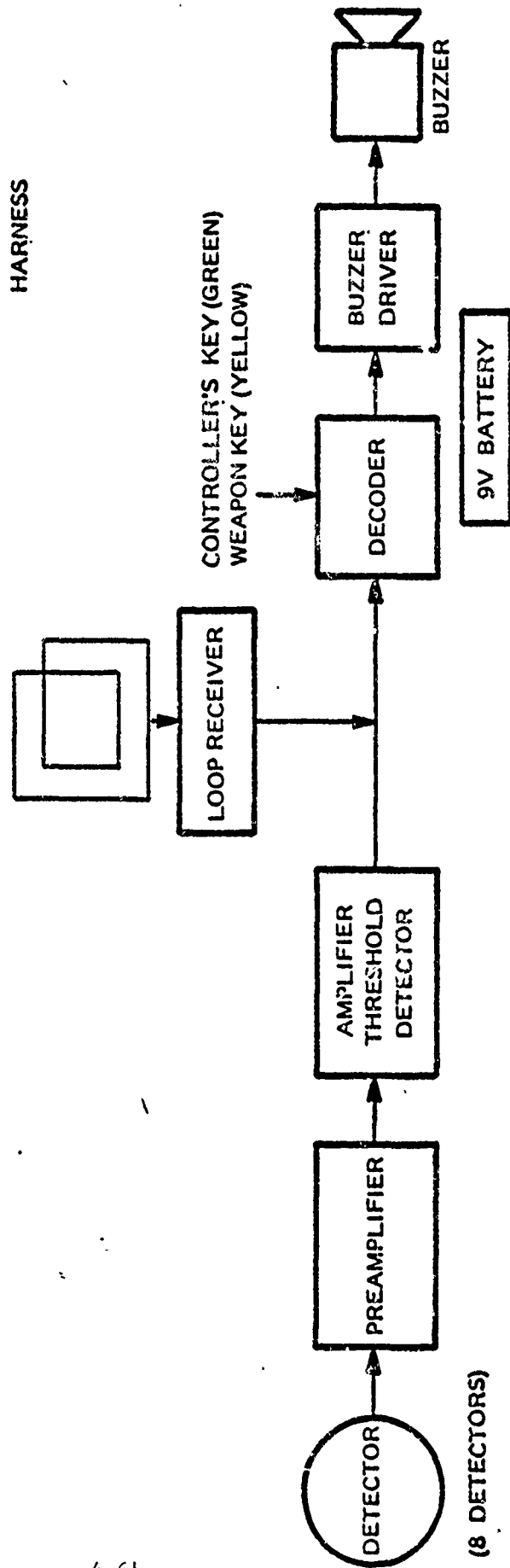


57284



HELMET

4-61



HARNESS

Figure 4-43. Man Worn Laser Detector Block Diagram



Figure 4-44. Man-Worn Laser Detector

58120

- a. Helmet detector assembly (5 detectors)
- b. Harness detector assembly (8 detectors)

#### 4.4.1.1 Helmet Detector Assembly

The helmet strap fits snugly on a standard issue steel helmet and can be used with or without the camouflage cover. The helmet strap assembly is shown in figure 4-45. Since the helmet strap assembly is olive drab in color, it is acceptable to merely install it on the helmet. If the camouflage cover is used, the helmet strap goes on the outside over the camouflage cover.

Five detectors provide 360 degree azimuth and  $\pm 50$  degree elevation coverage for susceptibility of the head to laser shots. Figure 4-46 shows the detector configuration common to all MILES detector assemblies. Molded plastic protective covers are installed over the glass windows of the detectors to prevent breakage. Typical detector and bare cell off-axis responses are shown in figure 4-47 from test data taken with the detector assemblies and with bare solar cells. The detector assemblies have RFI shielding and the plastic cover provides a smooth exterior surface that can easily be wiped clean. A metal grid, internal to the assembly, is used for RFI shielding.

\*

The helmet electronics are shown in figure 4-48. The total net weight for the helmet strap is approximately 24 ounces, including the electronics box.

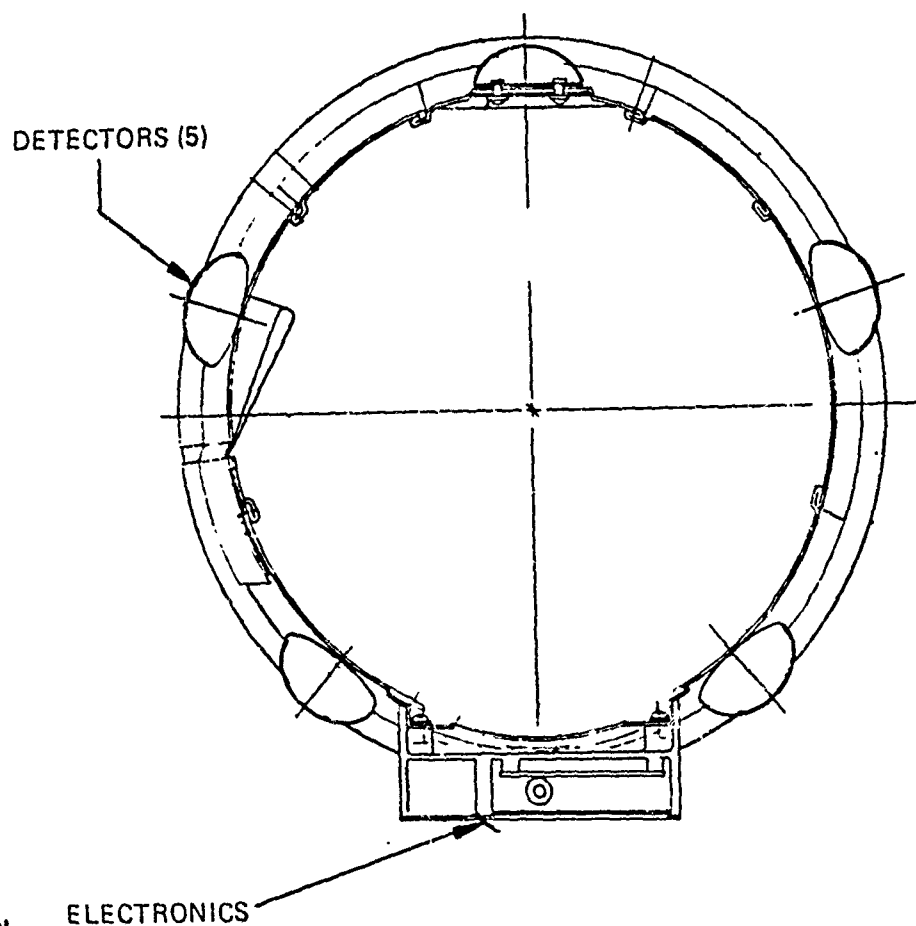
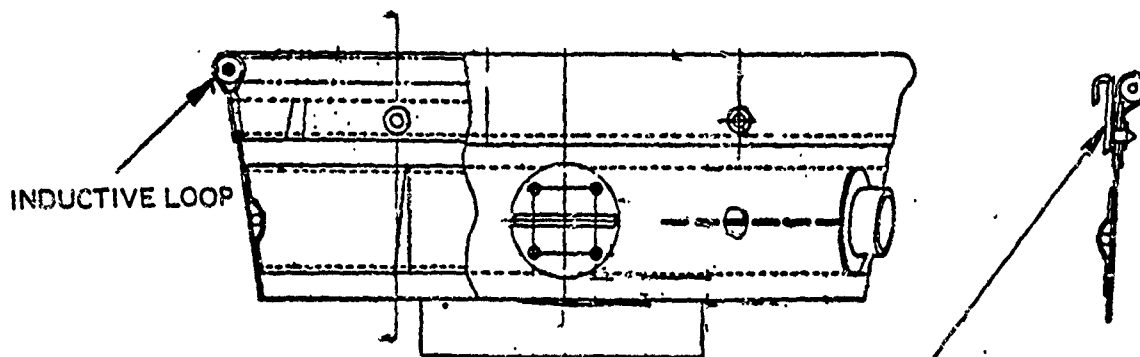
Laser messages received by the detectors are amplified in the helmet electronics package and then transmitted by the loop driver electronics to an inductive loop sewn into the lower rim of the helmet strap. This loop is inductively coupled to a similar loop in the man-worn harness. Receipt of the inductively coupled message by the electronics decoder box on the man-worn harness will initiate a kill or near-miss indication, depending upon the coded message.

#### 4.4.1.2 Harness Detector Assembly

The man-worn harness is similar to the Army's standard issue lift harness with the addition of laser detectors, decoder electronics, hit indicator, and wiring sewn into the harness (figure 4-49).

Signals received either from the inductive loop (helmet hits) or from the harness detectors (torso hits) are transmitted by wires to the decoder electronics assembly where they are amplified, decoded, and then used to activate a signal that triggers the hit indicator. The hit indicator is an audio alarm sewn into the harness and located on the shoulder below the left ear. The alarm frequency is  $2900 \pm 500$  Hz and its sound level is 64 to 78 dB at 12 inches distance.

The decoder, shown in figure 4-50, is located on the back of the harness between the shoulders as shown in figure 4-51. The decoder is attached by screws to the harness. Battery replacement can be performed by loosening a thumb screw and opening a battery door. The battery is then lifted out and a new battery inserted by pushing it into the battery cavity and resealing the battery door. The weapon key



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Figure 4-45. Harness Assembly, Helmet

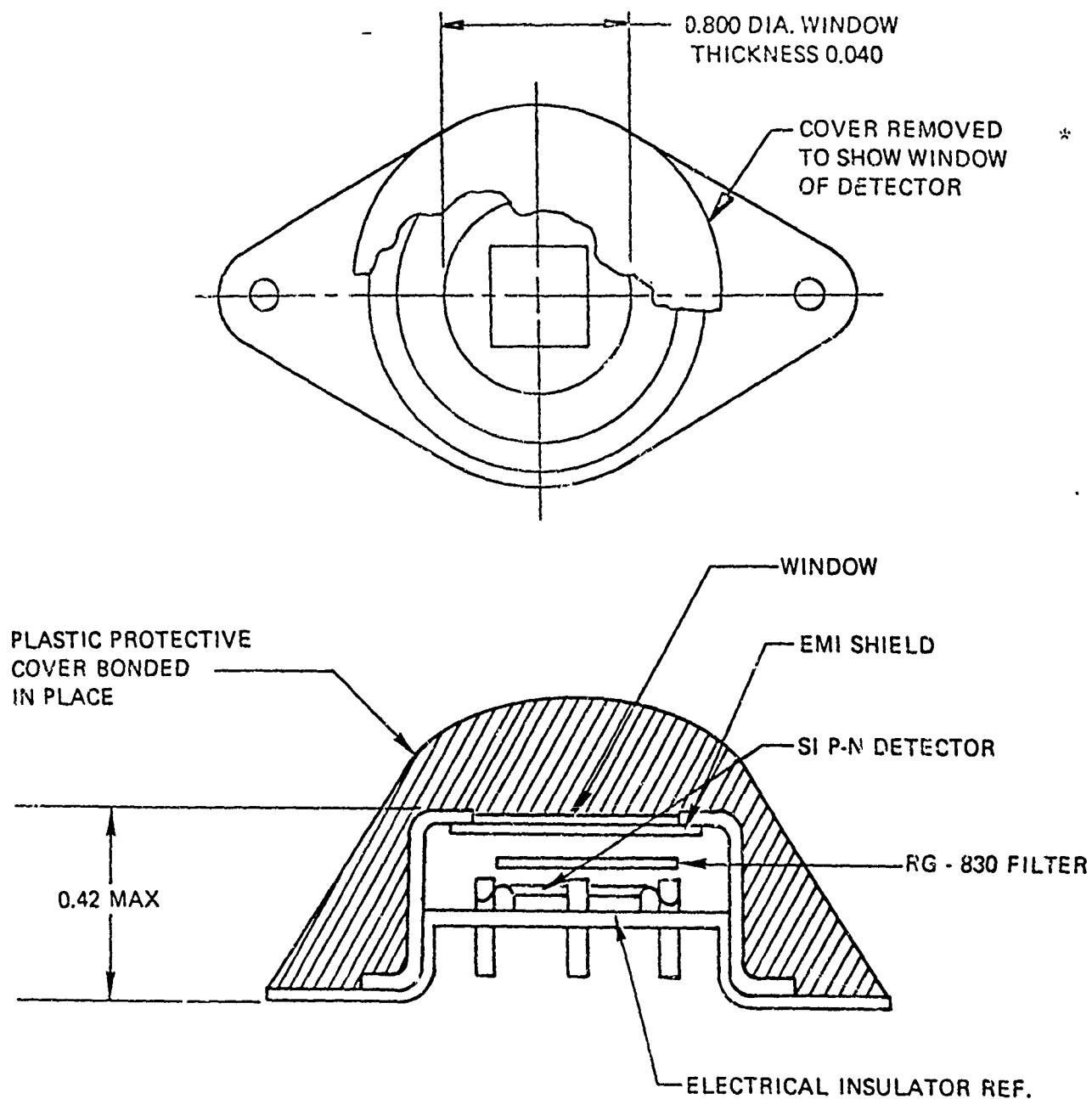


Figure 4-46. Detector Configuration

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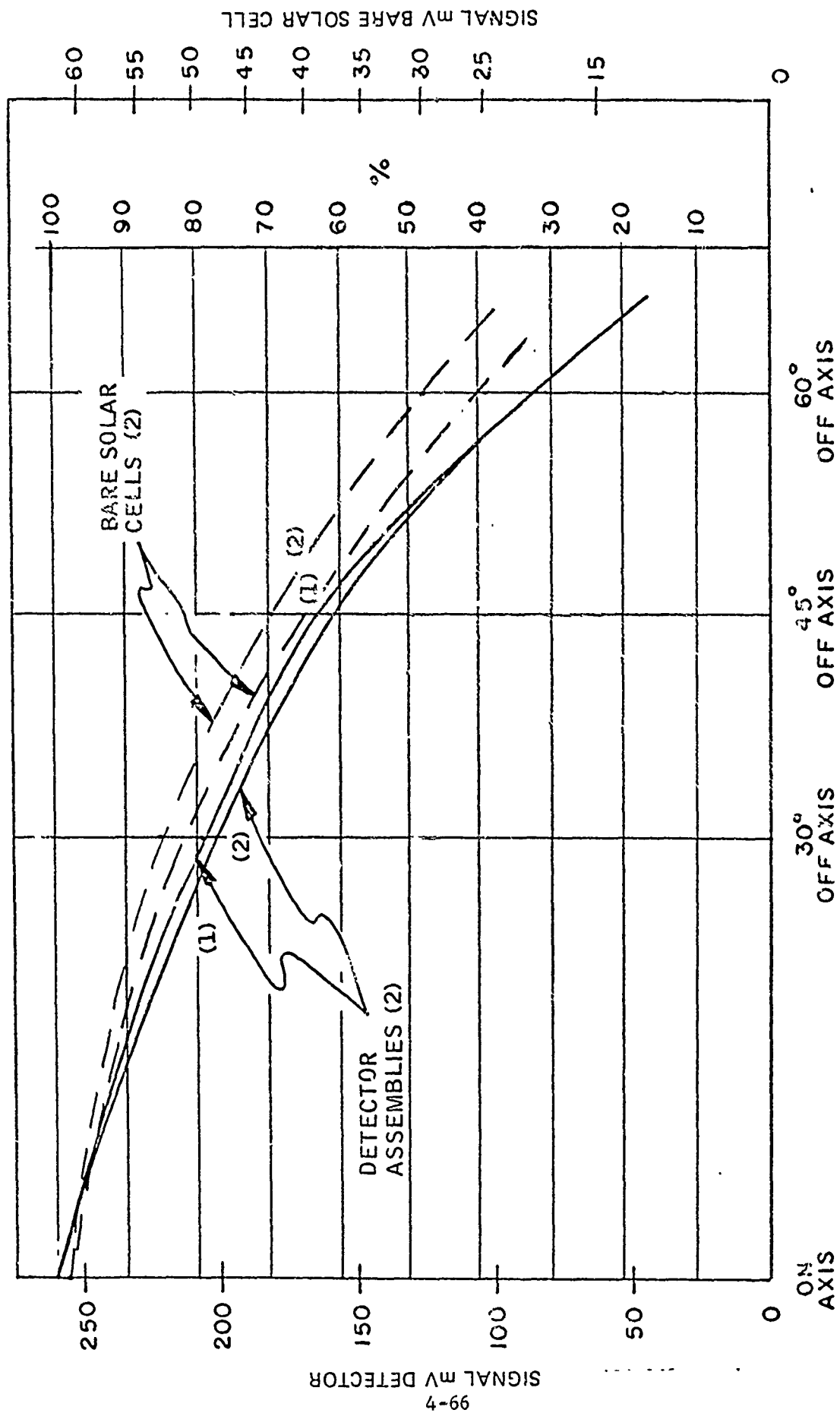


Figure 4-47. Detector Off-Axis Response

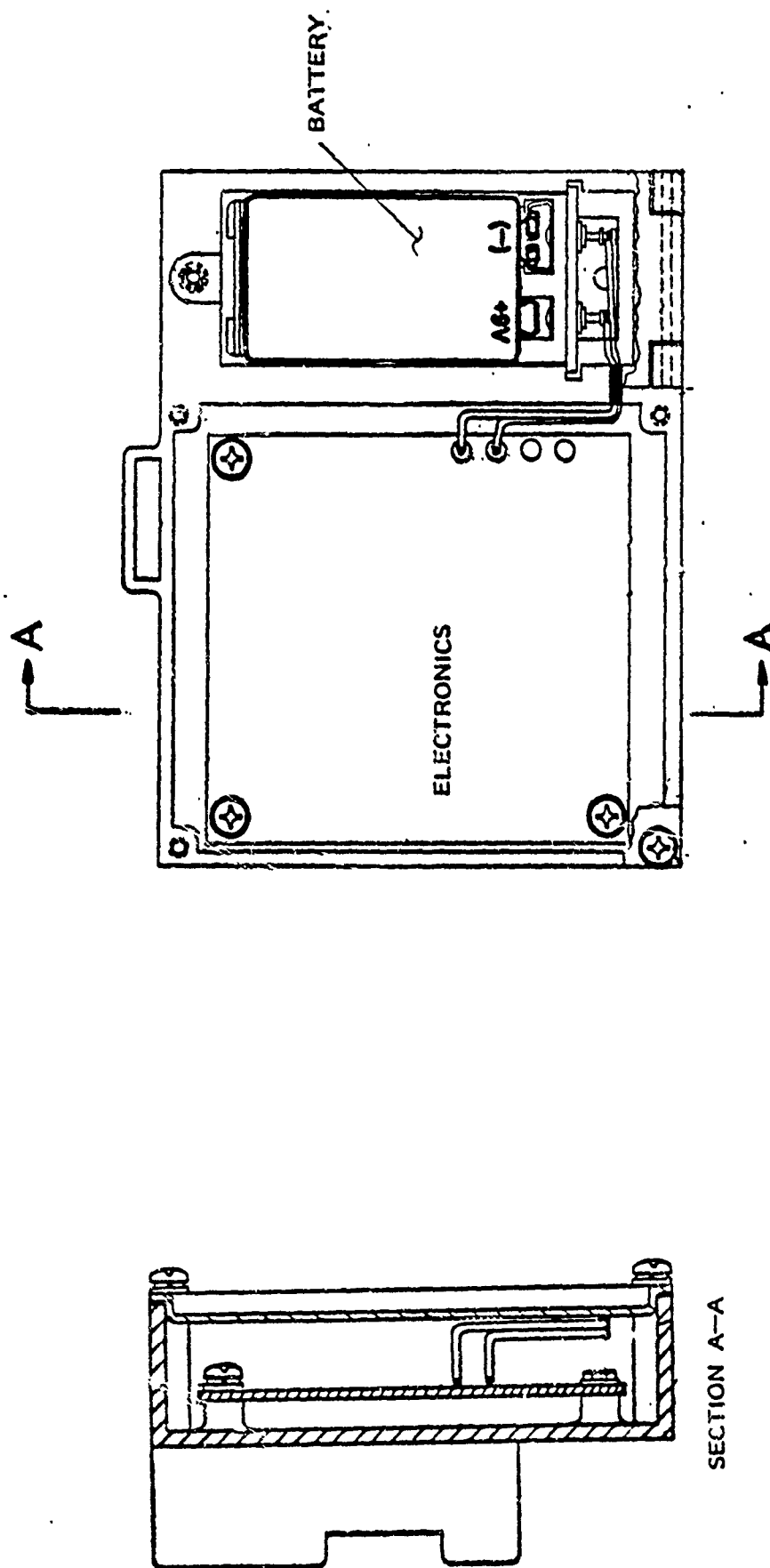


Figure 4-48. MWLD Helmet Electronics Assembly

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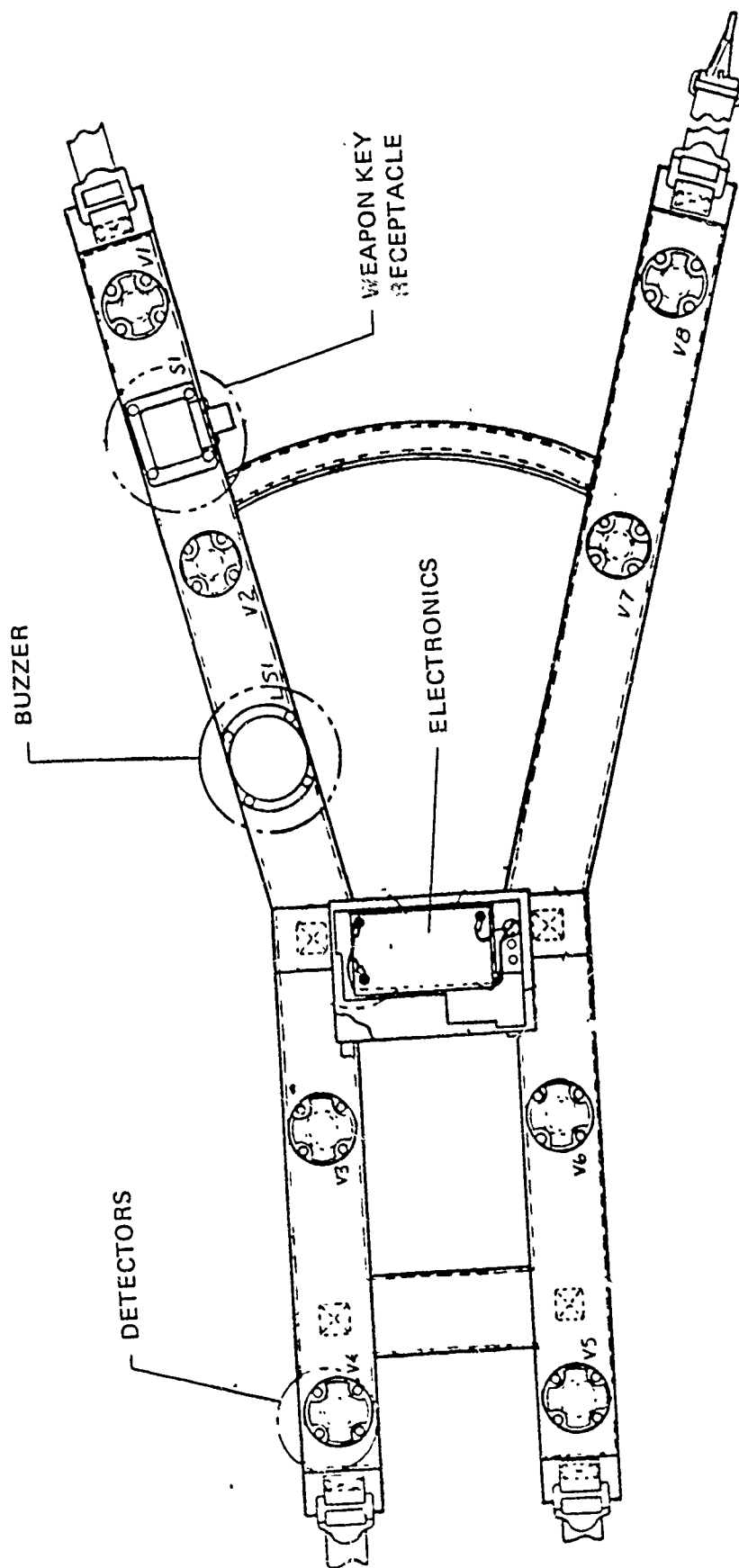


Figure 4-49. MWLD - Torso Harness Assembly



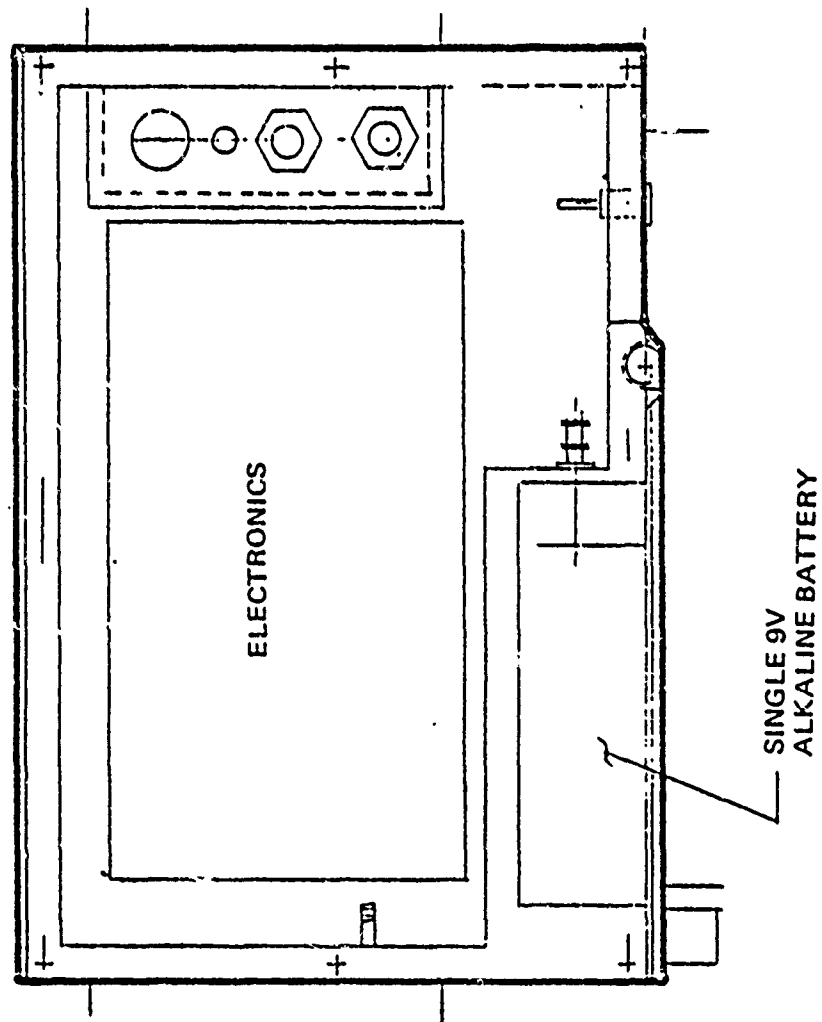


Figure 4-50. MWLD Torso Electronics Assembly

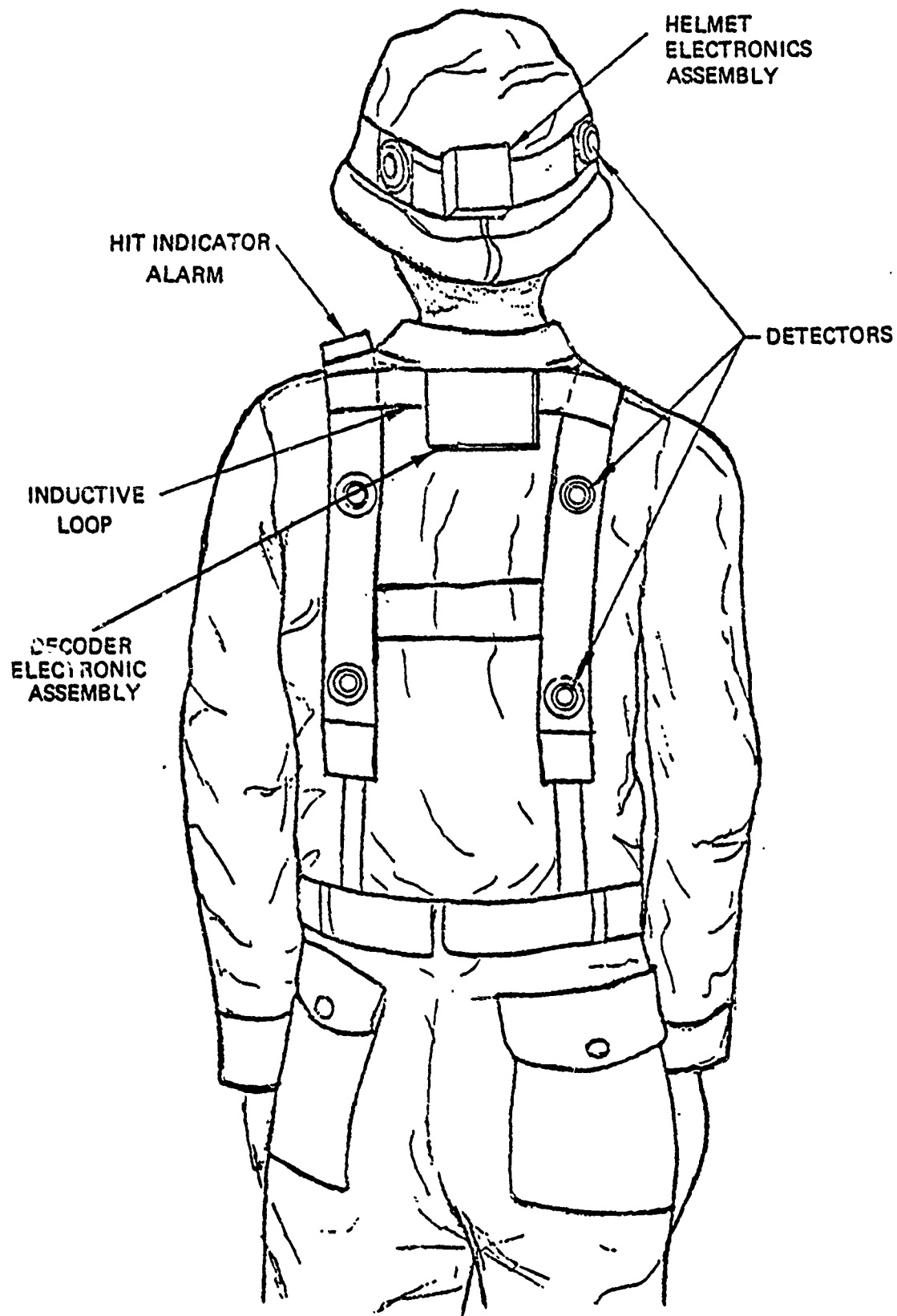


Figure 4-51. MWLD Harness, Rear View

22639

receptacle is located on the front left strap between the two detectors as shown in figure 4-52. This allows ready access for insertion of the yellow weapon key to shut down the alarm.

The harness is constructed from heavy nylon webbing. A light nylon web is sewn onto the basic harness to form a wire raceway. The detectors are soldered to the wire leads and riveted to the harness. The inductive loop is sewn into the harness around the neck. Two turns of the inductive loop are completed by the strap across the chest. \*

#### 4.4.1.3 Safety

The hit indicator, shown in figures 4-51 and 4-52 is located approx 6 inches from the soldier's left ear. At that distance, the sound pressure from the alarm is approximately 92 dB which is above the safety limit for continuous noise. It is important therefore, that the infantryman turn off his alarm when a "kill" occurs. Figure 4-53 is a sound pressure map of the MWLD alarm.

#### 4.4.2 COMBAT VEHICLE LASER DETECTOR (CVLD)

The CVLD is a common name for the elements that make up a vehicle detection system. The CVLD is similar in function to the MWLD described in subsection 4.4.1 but has added capabilities and complexity. The elements which comprise the CVLD are:

- a. Detector Belt Segment Assemblies
- b. Decoder Assemblies
  - Control Indicator Assembly (CIA) - Used only on the M113 APC Systems
  - Loaders Control Indicator (LCA) - Used on all other vehicle systems
- c. Combat Vehicle Kill Indicator (CVKI) Assembly

These modules are connected by cable assemblies which are a part of the vehicle adapter kits discussed in subsection 4.5.

##### 4.4.2.1 Detector Belt Assembly Segments

The Detector Belt Assembly segments, shown in figure 4-54, are designed for use in various combinations to make up detector belt sets for each of the vehicles in the MILES system. Each belt contains SiPn detector modules and an electronic threshold/detector preamplifier module. The detector modules are common throughout the MILES system. GaAs laser signals received by the detector modules are amplified and then routed to the vehicle decoder assembly by means of wiring sewn into the belt segments. The belt segments have fastener tape (pile-type) backing and attach to vehicles which have the mating hook-type fastener tape.

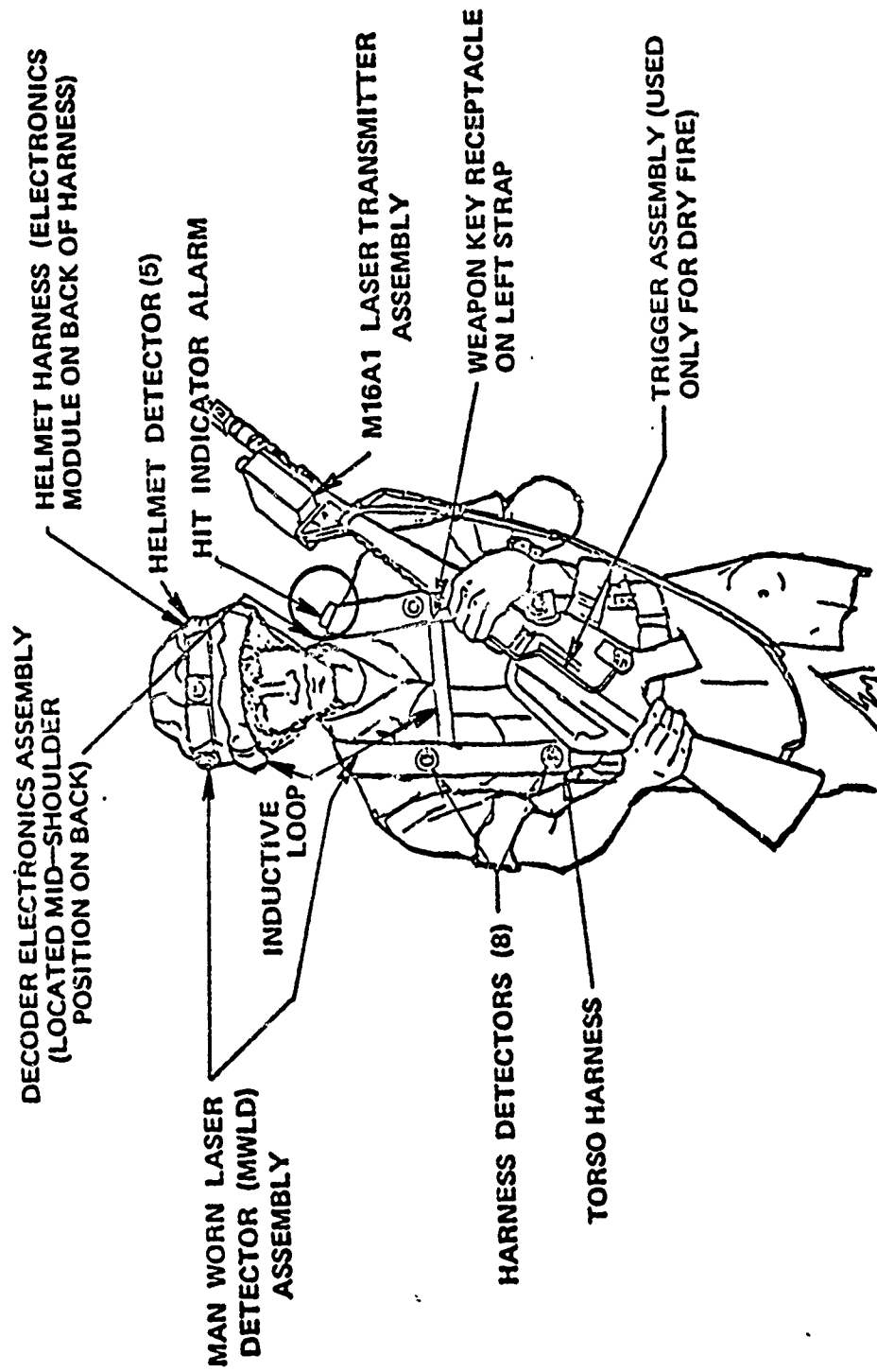
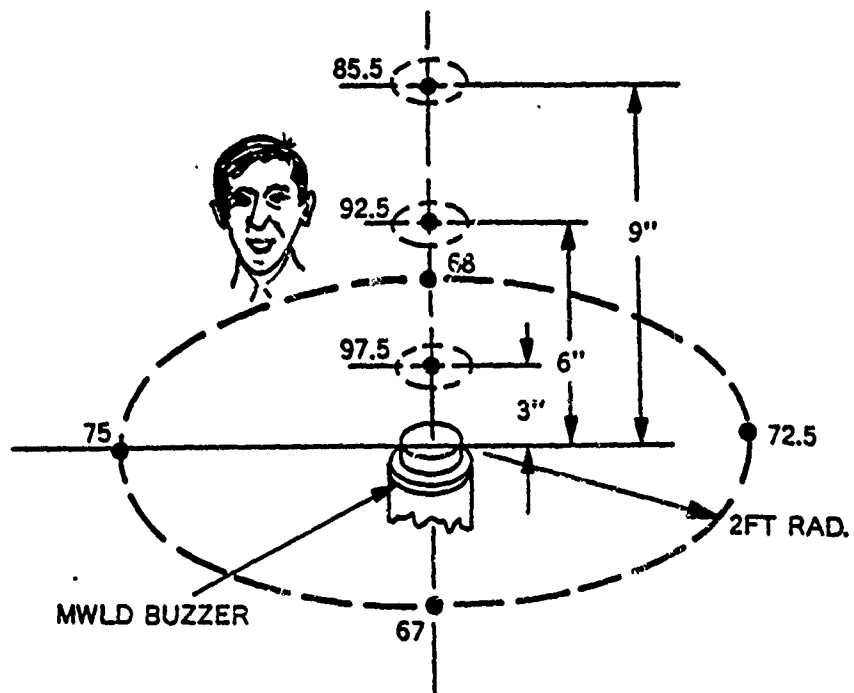


Figure 4-52. M16A1 Laser Transmitter Assembly Front View



AT 12" IN ANY DIRECTION FROM THE ALARM  
THE PRESSURE LEVEL IS LESS THAN 85 db

Figure 4-53. MWLD Alarm, Sound Pressure (dB) Map

61067

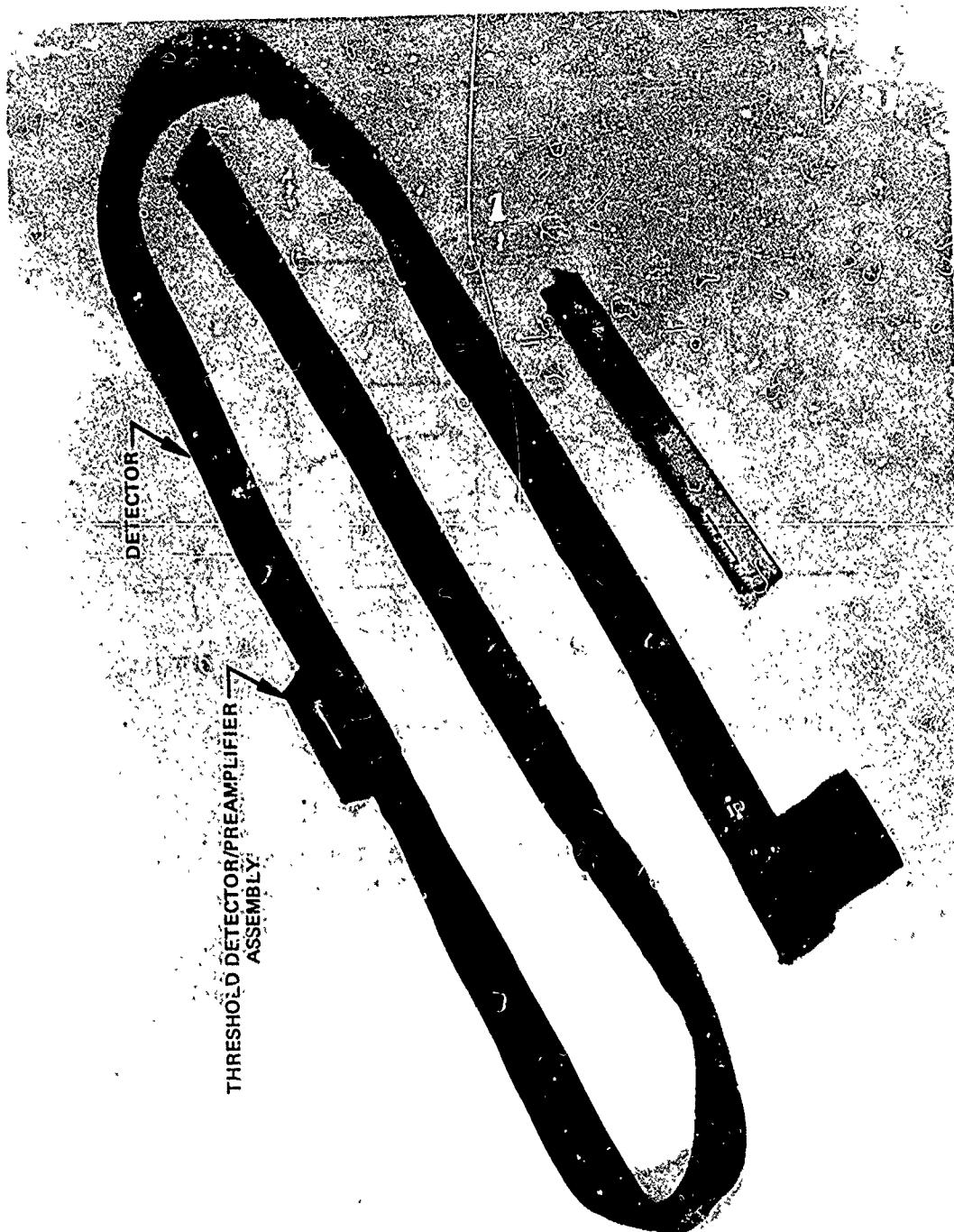


Figure 4-54. Detector Belt Assembly Segment

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Five different belt segment configurations in various combinations are used to make the vehicle belt sets as follows:

| M113 APC                      | <u>Length (in.)</u> | <u>No. of Detectors</u> |
|-------------------------------|---------------------|-------------------------|
| ● Belt Segment No. 1 (2 each) | 167                 | 6                       |
| ● Belt Segment No. 2 (2 each) | 83                  | 4                       |
| M60A1/A3 Tank                 |                     |                         |
| ● Belt Segment No. 3 (2 each) | 175                 | 8                       |
| ● Belt Segment No. 4 (1 each) | 149                 | 6                       |
| M60A2 Tank                    |                     |                         |
| ● Belt Segment No. 3 (2 each) | 175                 | 8                       |
| ● Belt Segment No. 5 (1 each) | 216                 | 7                       |
| M551 AARV                     |                     |                         |
| ● Belt Segment No. 3 (2 each) | 175                 | 8                       |
| ● Belt Segment No. 4 (1 each) | 149                 | 6                       |

\*

The belt segments differ primarily in length, detector quantity, and detector placement. The belts are constructed of heavy olive drab colored nylon webbing. Wiring is sewn into the belt segments. The segments are joined electrically by in-line connectors and mechanically by Velcro fastener tape. For sloping turrets, Velcro covered wedges (see figure 4-55), a part of the vehicle adapter kits, return the detectors to a plane parallel with the horizontal.

Interconnecting cabling, a part of the adapter kit, completes the hookup of the detection belts to the decoder assembly inside the vehicle.

#### 4.4.2.2 Decoders (LCA and CIA)

The Loader's Control Assembly (LCA), shown in figure 4-56, is used on all vehicles in the MILES except on the M113 APC where a similar unit, the Control Indicator Assembly (CIA), shown in figure 4-57, is substituted. The basic difference is that the CIA does not perform the function of firing dependent laser transmitters, and therefore does not have "ROUNDS REMAINING" positions on the front panel selector switch, nor does it perform an encoding function.

Figure 4-58 is a block diagram of the typical vehicle system showing the interrelationship of the LCA to the other assemblies within the system. This diagram applies to the CIA as well if the "Dependent Transmitter" block is removed.

56433 A

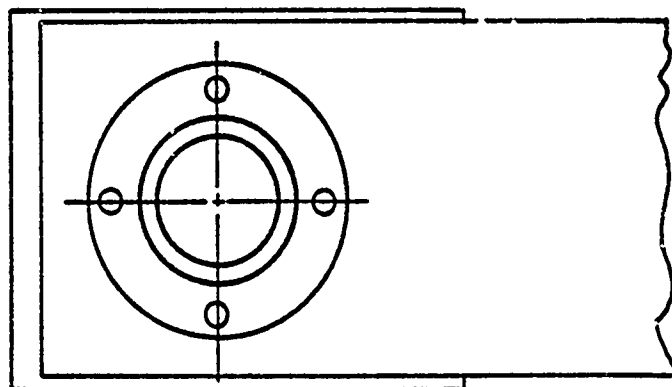
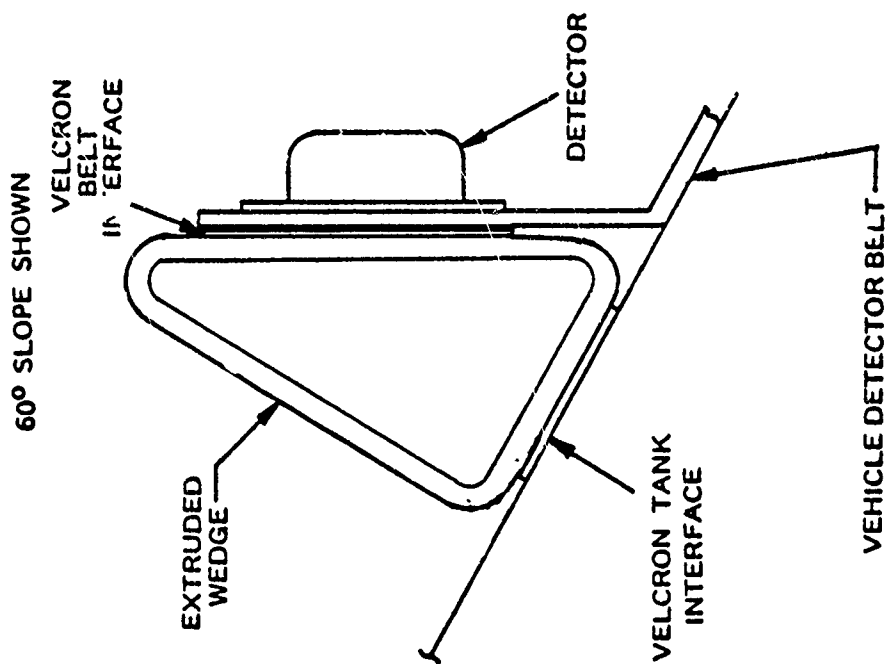
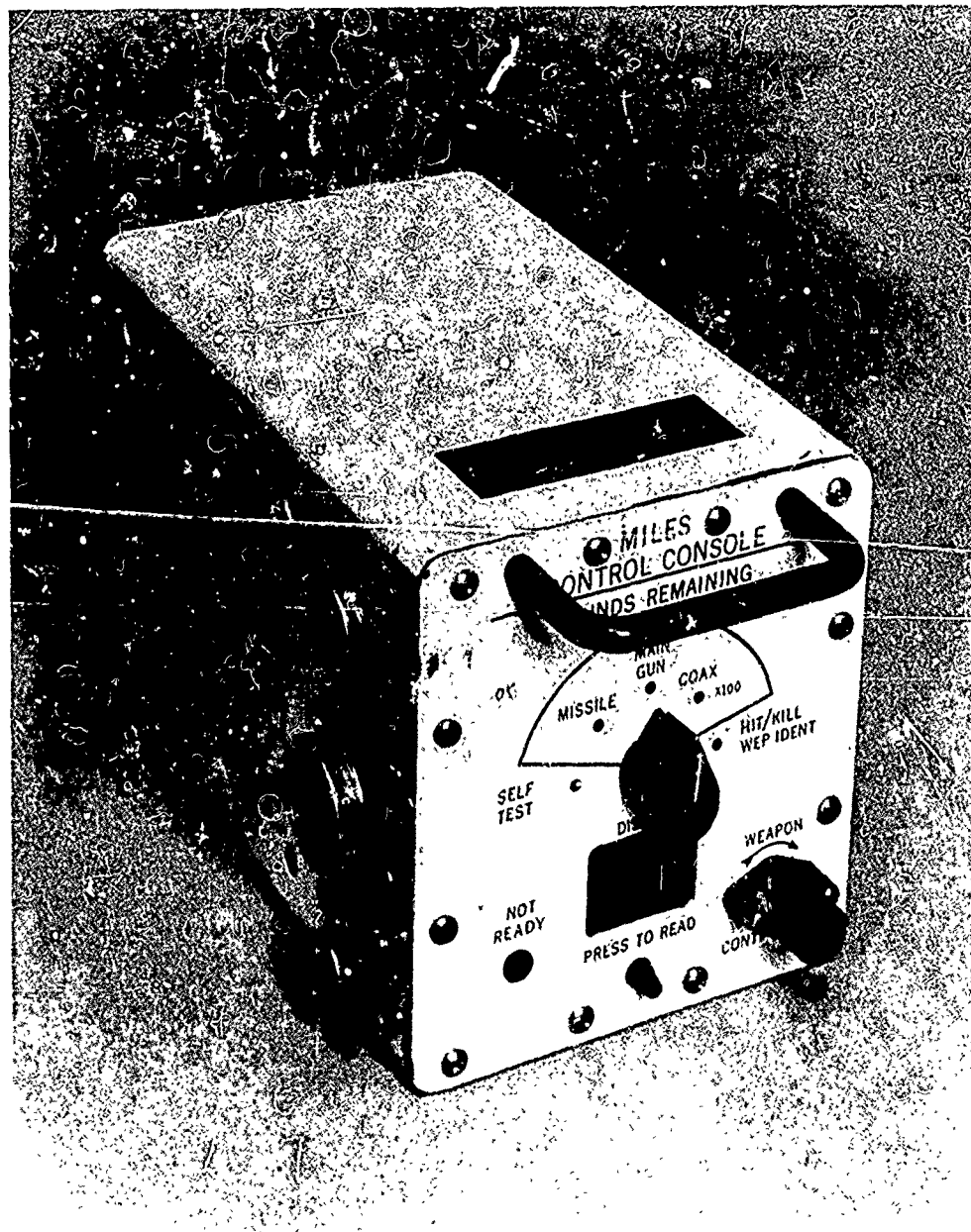


Figure 4-55. Wedge with Belt





97919

Figure 4-56. Control Console (LCA)

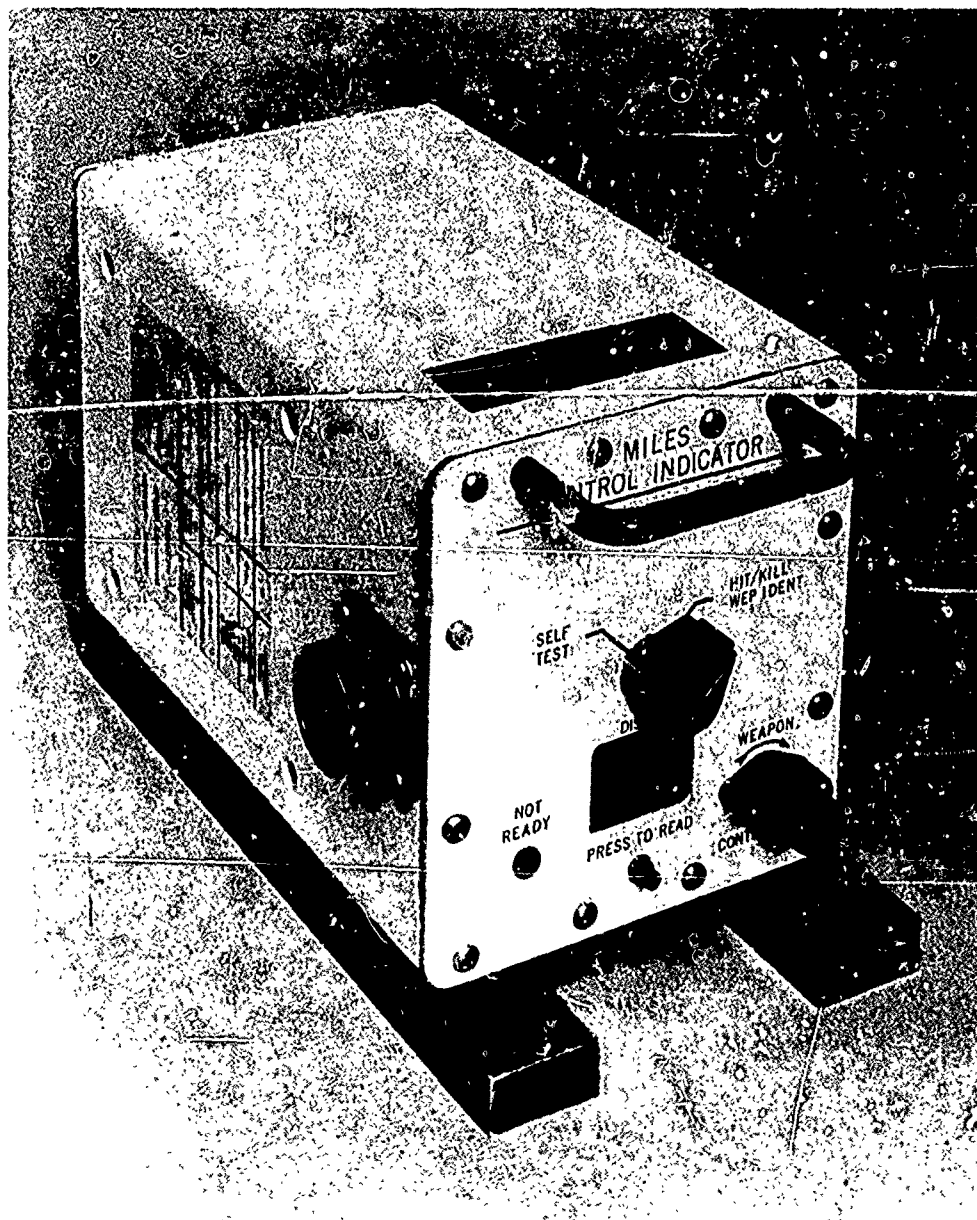
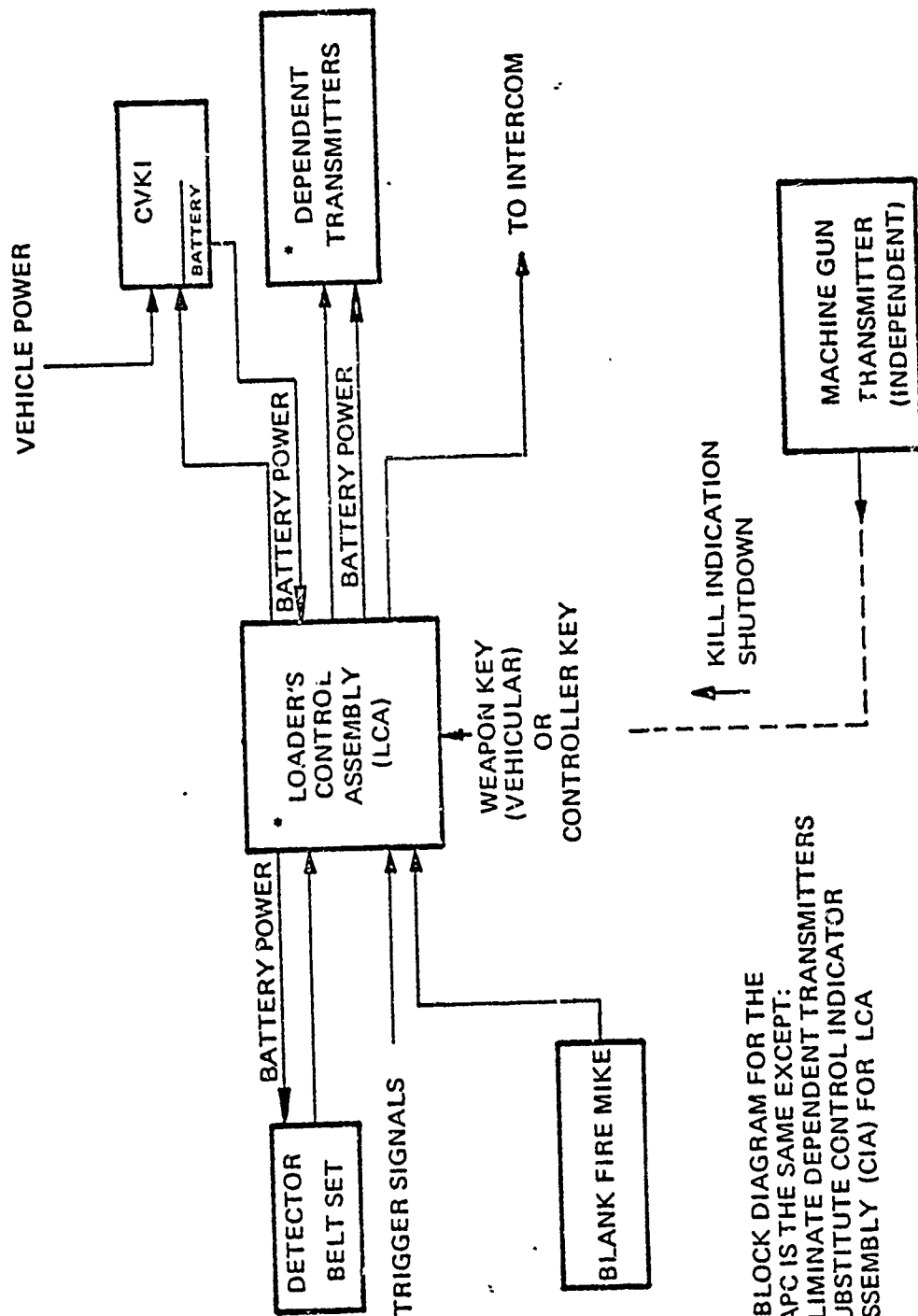


Figure 4-57. Control Indicator (CIA)

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- THE BLOCK DIAGRAM FOR THE M113 APC IS THE SAME EXCEPT:
- ELIMINATE DEPENDENT TRANSMITTERS
- SUBSTITUTE CONTROL INDICATOR ASSEMBLY (CIA) FOR LCA

Figure 4-58. Vehicle Systems - General Block Diagram

Power for the vehicle system is supplied from batteries located in a battery box. This battery power is supplied to the LCA/CIA. The LCA then supplies power to the dependent laser transmitters and to the detector belt set. The CIA supplies power only to the detector belt set.

### ENCODING

When firing the vehicle weapon simulators, the actual weapon triggers are used, and firing signals are routed to the LCA. The LCA takes these firing signals and uses them to trigger and fire the dependent laser transmitters. The laser transmission is encoded within the LCA for its weapon identification.

Figure 4-59 is a block diagram showing the dependent laser transmitter functions and the interface with the LCA. The dependent laser transmitters for ED MILES are:

- a. M60A1/A3 TANKS
  - 105 mm/Coax Laser Transmitter Assembly
- b. M60A2 TANK AND M551 AARV
  - 152 mm/Coax/SHILLELAGH Laser Transmitter Assembly

The coax machine gun, when used in the blank fire mode, is monitored by a microphone assembly. Output of the microphone is routed to the LCA where it is used to trigger the coax machine gun transmitter.

### DECODING

Incoming laser signals are received by the detector belt set, amplified, and routed to the LCA or CIA where they are decoded. Signals are evaluated to be:

- Nonsense code - no response
- Valid Hit
- Valid Kill
- Valid Near Miss

### CONTROL FUNCTIONS OF LCA/CIA

After decoding, a signal is used to activate the CVKI, intercom, and where applicable, the NOT READY light on the panel of the LCA/CIA. When the incoming signal results in a valid kill, the LCA automatically deactivates all dependent laser transmitters.

The target vehicle responses to near miss, hit and kill are detailed in figures 4-60 through 4-62 for both the LCA and the CIA, with the front panels of these assemblies shown for easy reference.

57780

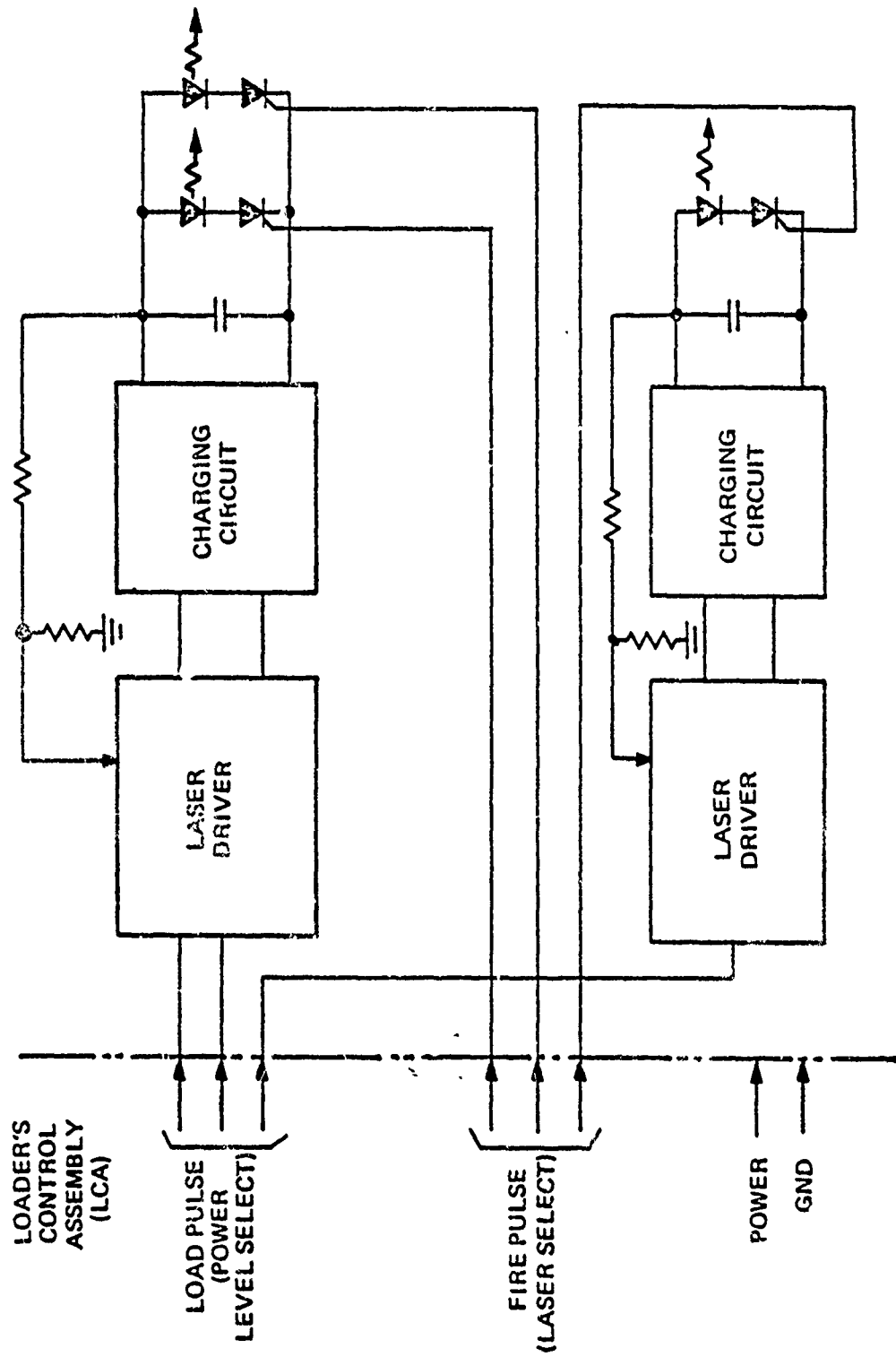


Figure 4-54. MILES Dependent Laser Transmitter Functional Block Diagram

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- CVKI - TWO FLASHES
- INTERCOM - TWO TONES
- NOT-READY (TO FIRE) INDICATOR - NO RESPONSE
- HIT / KILL INDICATOR - NO CHANGE
- FIRING CAPABILITY - NO EFFECT
- IN-PROCESS TRACKING - NO EFFECT

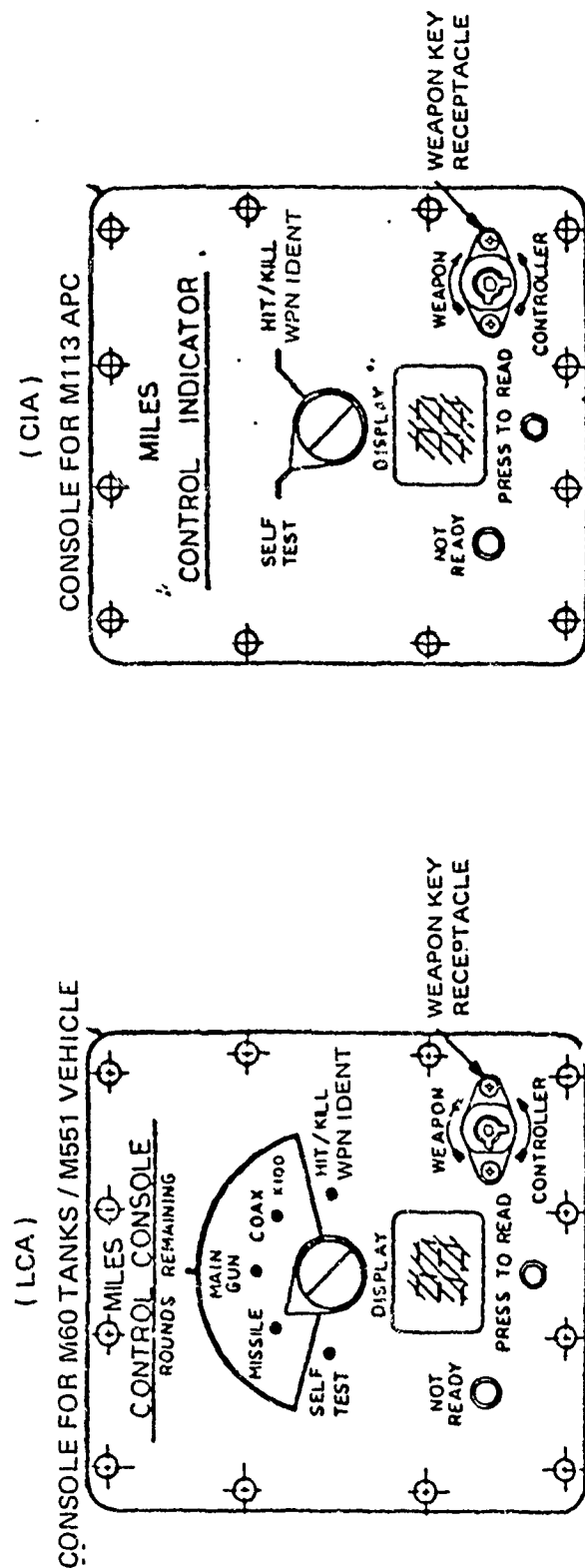


Figure 4-60. Target Vehicle Near-Miss Response

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- CVKI - FOUR FLASHES
- INTERCOM - FOUR TONES
- NOT-READY (TO FIRE) INDICATOR - NO RESPONSE
- HIT / KILL WEAPON IDENT. - DISPLAYS CODE NO. OF ATTACKING WEAPON WHEN PRESS-TO-READ BUTTON IS DEPRESSED
- FIRING CAPABILITY - NO EFFECT
- IN-PROCESS TRACKING - NO EFFECT

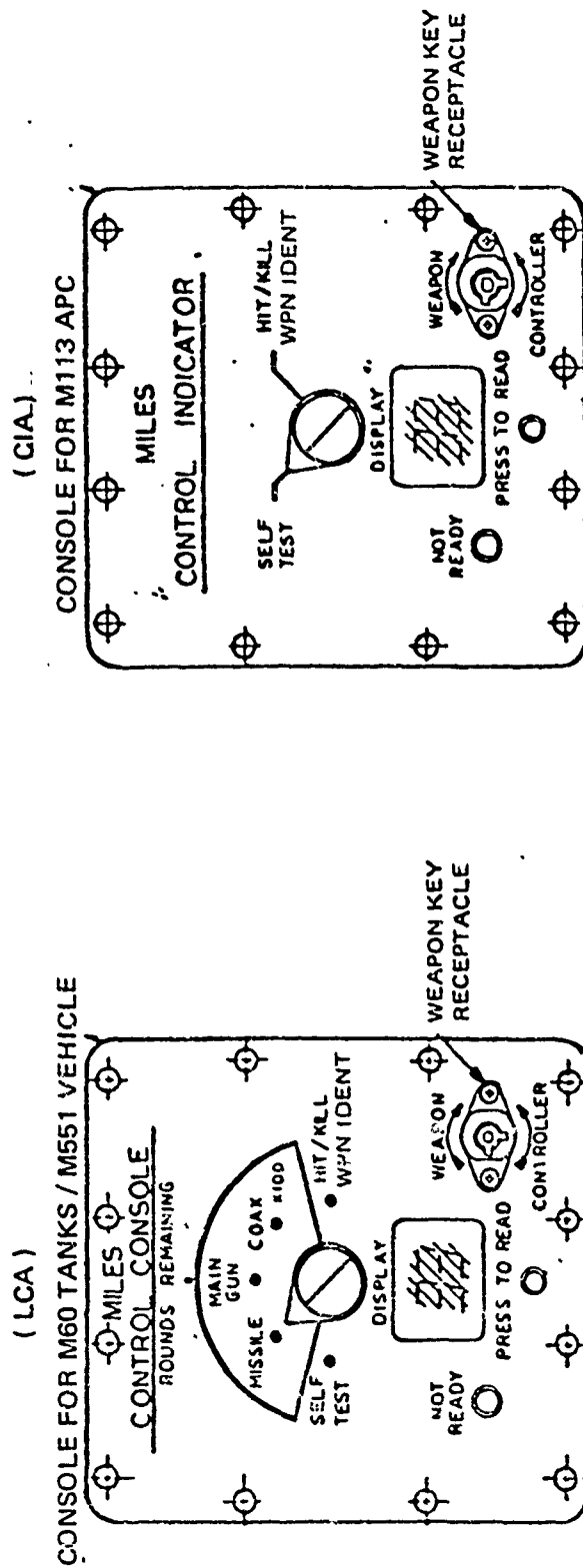


Figure 4-61. Target Vehicle Hit Response

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- CVKI - CONTINUOUS FLASHING UNTIL RESET BY CONTROLLER
- INTERCOM - CONTINUOUS TONE UNTIL DISABLED BY CUPOLA GUN WEAPON KEY IN WEAPON KEY RECEPTACLE
- NOT-READY (TO FIRE) INDICATOR - CONTINUOUSLY ILLUMINATED UNTIL DISABLED BY CUPOLA GUN WEAPON KEY IN WEAPON KEY RECEPTACLE.
- HIT / KILL WPN IDENT - DISPLAYS CODE NUMBER OF ATTACKING WEAPON WHEN PRESS-TO-READ BUTTON IS DEPRESSED.
- FIRING CAPABILITY - MAIN GUN MISSILE AND COAX AUTOMATICALLY DISABLED; CUPOLA GUN DISABLED BY REMOVAL OF WEAPON KEY.
- IN-PROCESS TRACKING - ABORTED INSTANTLY.

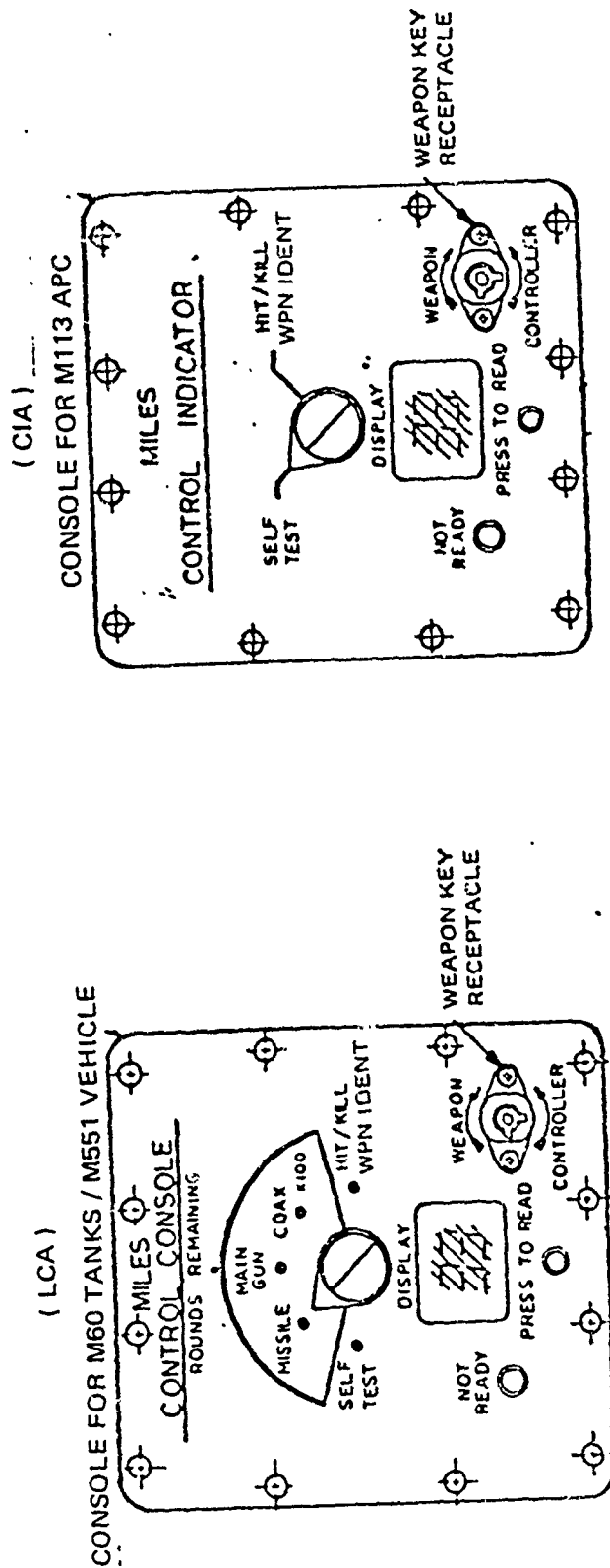


Figure 4-62. Target Vehicle Kill Response



When the vehicle is killed, the CVKI strobe light is activated and operates continuously. A continuous tone is also inserted into the vehicles intercom system. This noise can only be shut down by removing the weapon key from the cupola gun independent transmitter and by inserting it in the weapon key receptacle of the LCA/CIA to turn off the alarm. The independent transmitters are:

- a. M113 APC
  - M2 Machine Gun
- b. M60A1/A3 TANK
  - M85 Machine Gun
- c. M60A2 TANK
  - M85 Machine Gun
- d. M551 AARV
  - M2 Machine Gun

## DISPLAYS

### a. Casualty Assessment

After-action casualty assessment can be performed using the LCA/CIA. By rotating the selector switch to "HIT/KILL WEP IDENT" and pressing the "PRESS TO READ" button, a number is read out on the "DISPLAY." This is the identification number of the last weapon to hit or kill the vehicle. A Casualty Assessment card is supplied to the vehicle crew (see figure 4-63). This card cross-references weapons to their identification numbers.

### b. Rounds Remaining

The initial basic load of ammunition for the vehicle dependent laser transmitters is set at the time the controller enables the system by use of his Controller Key in the weapon key receptacle of the LCA. Basic ammunition loads are fixed and are:

- a. M60A1/A3 TANK
  - 105 mm Main Gun - 63 rounds
  - Coax Machine Gun - 1800 rounds

# CASUALTY ASSESSMENT

| HIT/KILL WEAPON CODE NO. | ATTACKING WEAPONS                         |
|--------------------------|-------------------------------------------|
| 00                       | Controller Gun                            |
| 01                       | Maverick                                  |
| 02                       | TOW, Shillelagh†                          |
| 03                       | Dragon†                                   |
| 04                       | Viper†                                    |
| 05                       | 152mm†                                    |
| 06                       | 105mm†                                    |
| 07                       | TOW, Shillelagh, Sagger, Helfire [ASH]    |
| 08                       | Dragon                                    |
| 09                       | M202 Flame                                |
| 10                       | M21 Antitank                              |
| 11                       | Claymore M81A1 and M16                    |
| 12                       | 105mm                                     |
| 13                       | 152mm, 155mm, 8 inch Rocker, 105 Howitzer |
| 14                       | 2.75 inch Rocker                          |
| 15                       | Viper                                     |
| 16                       | 120mm                                     |
| 17                       | 90mm                                      |
| 18                       | 75mm and 73mm [Russian APC]               |
| 19                       | Grenade [40mm]                            |
| 20                       | Rockeye [Cluster Bomb]                    |
| 21                       | GAU-8, AH [30mm]                          |
| 22                       | Bushmaster [25mm], ZU23-4 [23mm]          |
| 23                       | Vulcan [20mm]                             |
| 24                       | M2, M85 Machine Gun                       |
| 25                       | Roland II, Chaparral                      |
| 26                       | Stinger                                   |
| 27                       | M16 Rifle, M60 MG, Coax Mg                |

† Special 100% Kill Codes

Figure 4-63. Casualty Assessment Card

b. M60A2 TANK

- 152 mm Main Gun - 33 rounds
- Coax Machine Gun - 1800 rounds
- SHILLELAGH Missile - 13 rounds

c. M551 AARV

- 152 mm Main gun - 20 rounds
- Coax Machine Gun - 1800 rounds
- SHILLELAGH Missile - 9 rounds

The rounds remaining are checked by rotating the selector switch to "ROUNDS REMAINING" and the weapon in question. By pressing the "PRESS TO READ" button, the rounds remaining indication is then read out on the "DISPLAY." A "00" display indicates all rounds have been expended.

c. Other Switch and Display Functions

Figures 4-64 and 4-65 depict decals that are applied to the housings of the LCA and CIA. These decals list the switch positions, the possible display readings, and the meaning of the numbers that appear on the display for the various switch positions.

4.4.2.3 Battery Box

The battery box, shown in figure 4-66, houses two 6-volt lantern-type batteries. These batteries are used to power the following dependent transmitters:

a. M60A1/A3 Tank

- 105mm Main Gun
- Coax Machine Gun

b. M60A2 Tank

- 152mm Main Gun
- Coax Machine Gun
- Shillelagh Missile

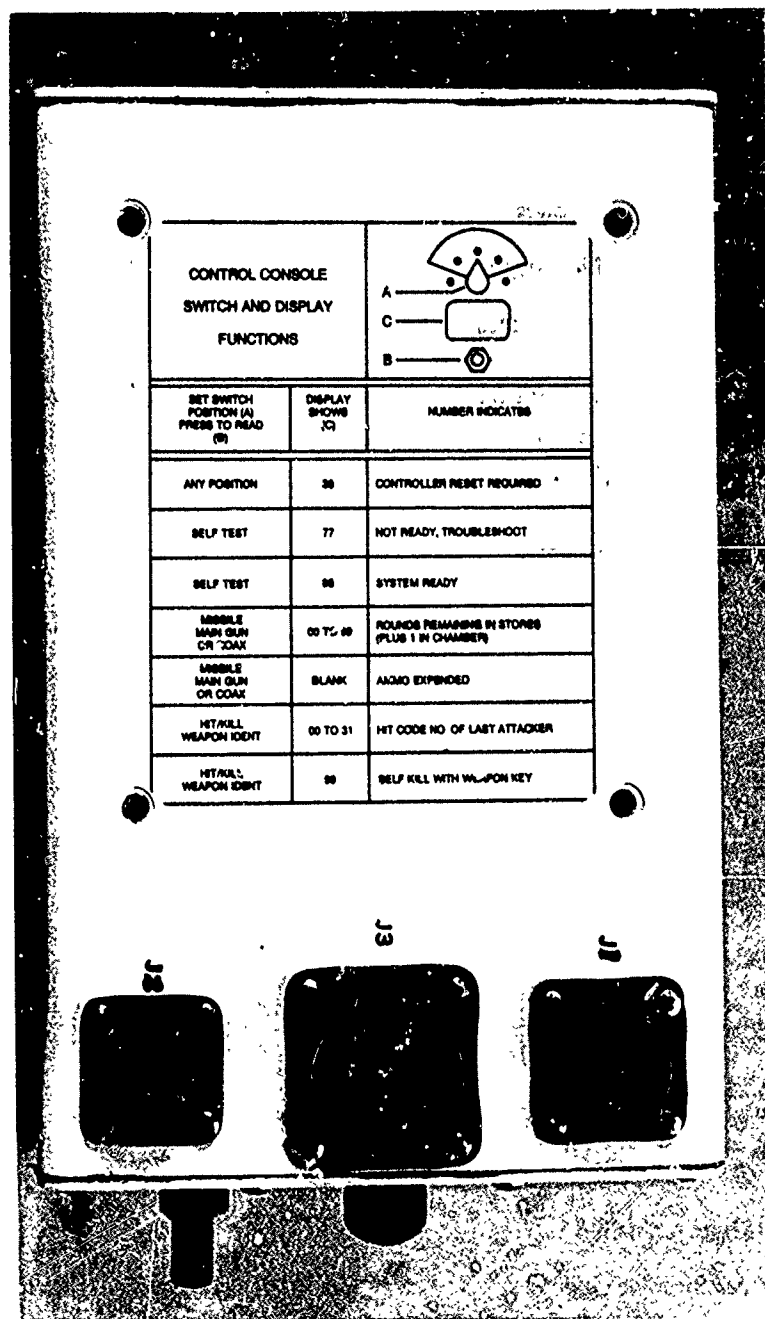


Figure 4-64. Control Console (LCA) Display Functions

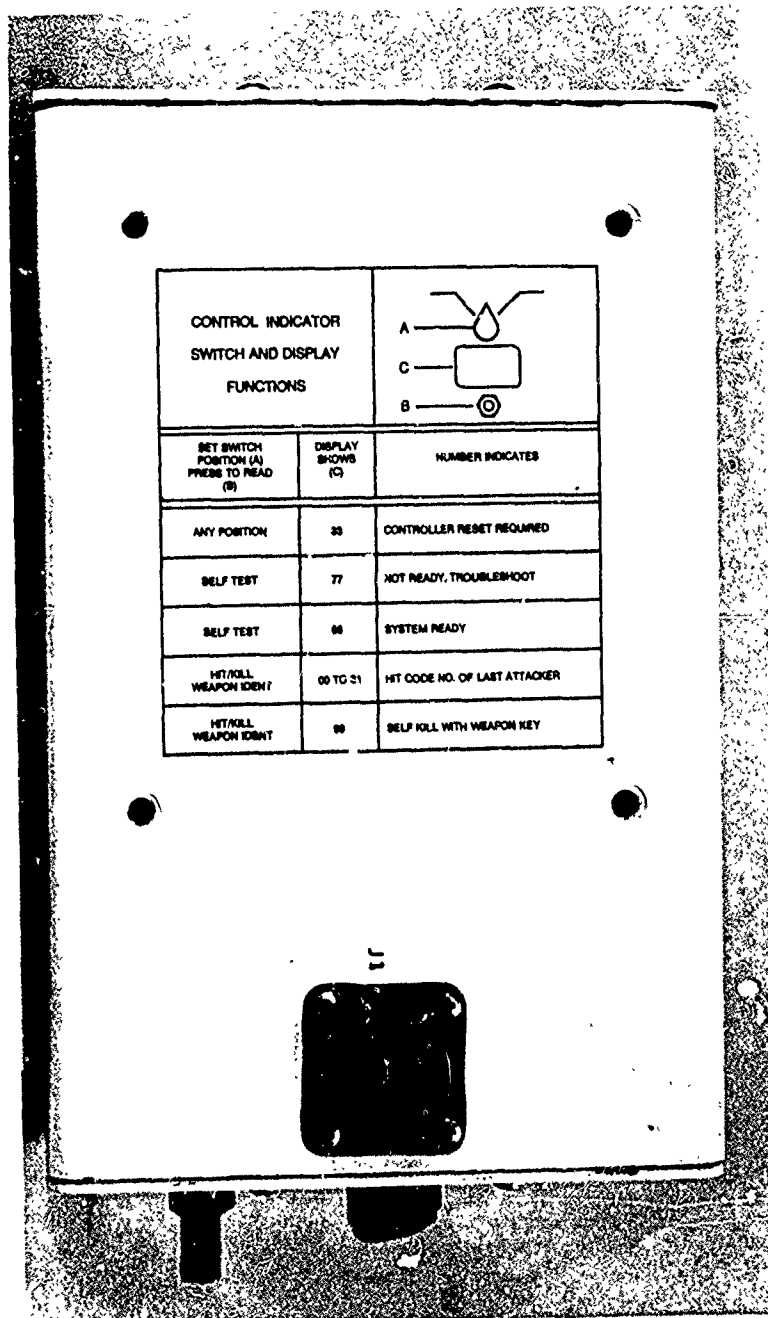
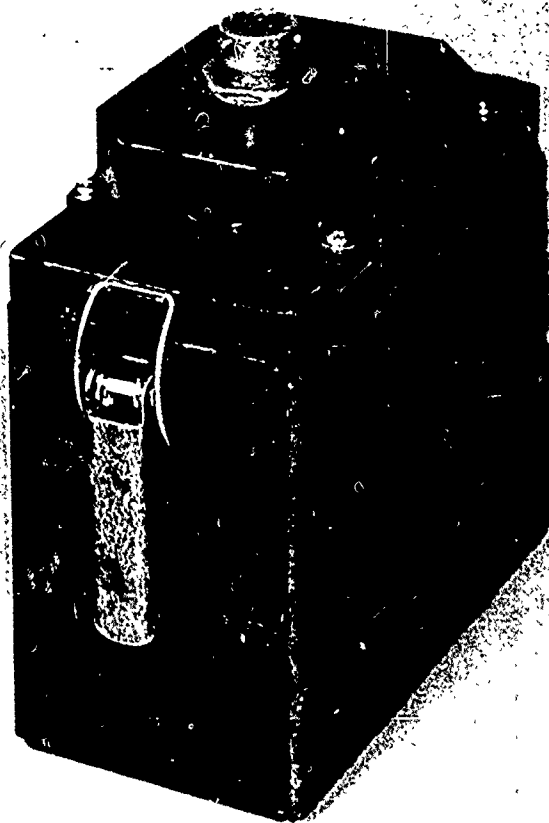
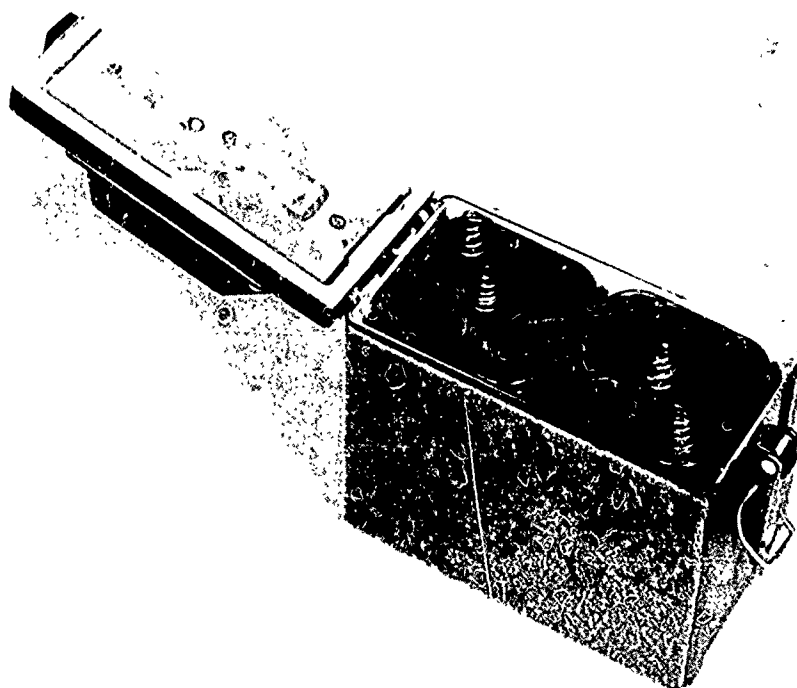


Figure 4-65. Control Indicator (CIA) Display Functions



97914

(a) Cover Closed and Locked



97913

(b) Cover Open

Figure 4-66. Battery Box  
4-90

c. M551 AARV

- 152mm Main Gun
- Coax Machine Gun
- Shillelagh Missile

The batteries also provide power for operating the LCA and CIA and the vehicle detector belt electronics.

The battery box is located inside the vehicles and is connected to the LCA or CIA by the battery cable. The box is secured to the vehicle by mounting with a Velcro pad. The batteries are inserted into the box with their power clips out so that they contact the printed circuit board which is installed in the battery box door. Battery power is applied when the battery box door is closed.

**4.4.2.4 Combat Vehicle Kill Indicator Description and Function**

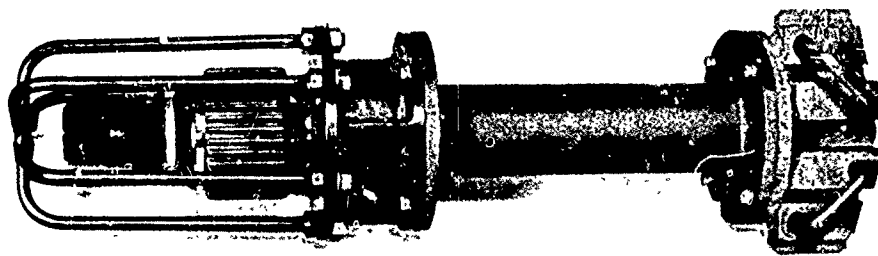
The Combat Vehicle Kill Indicator (CVKI) is a strobe light that mounts on the outside of MILES-equipped vehicles. The CVKI bolts to various pedestals depending on which vehicle the CVKI is to be installed. Figures 4-67a and 4-67b show the CVKI mounted on an M113 APC pedestal and on an M60A1/A3 tank pedestal, respectively. The pedestals are of various heights in order to raise the CVKI above portions of the vehicles which may interfere with ground troops' ability to observe the CVKI strobe light from every angle. The pedestals are designed to be mounted to one of the lifting eyes on the vehicles.

The electronics for operating the CVKI is contained in the base of the light. Power to the CVKI is supplied by a cable which attaches to a connector also at the base. Figure 4-67b shows the connector at the rear of the CVKI. The power for operating the CVKI is not dependent on the MILES batteries, but is supplied by the vehicle's 24 vdc battery supply. This arrangement is used because if the MILES batteries were used, the electrical load on the strobe light would limit the total hours of the MILES batteries to less than the specified 100 hours per field exercise.

**4.5 ADAPTER KITS**

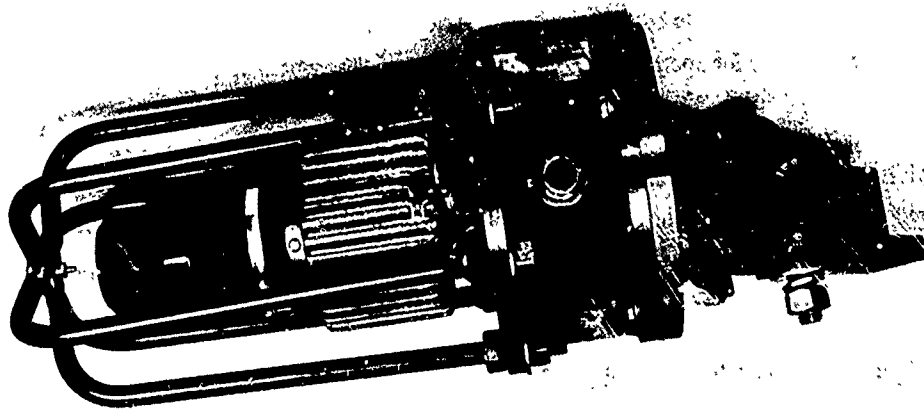
The adapter kits for vehicle systems consist of the necessary cabling to interconnect the laser transmitters, CVKI, belt set, control console and vehicle triggers (see figures 4-68 and 4-69). The interconnecting cabling also interfaces with the GFE Hoffman device and picks up 24Vdc vehicle power for use with the CVKI. A breech interlock connector plug is provided to allow use of the SHILLELAGH and main gun triggers when the breech is open. Mechanical locking mechanisms are provided to assure that the tank main gun breech is positively locked in the open position.

Wedge blocks are supplied for use with the belt sets. The wedge blocks are used under the detectors on belts to return the detectors to a position normal to the horizontal when the belts are on sloping turrets.



9676

(a) CVKI Mounted on M60A1/A3 Pedestal



6646

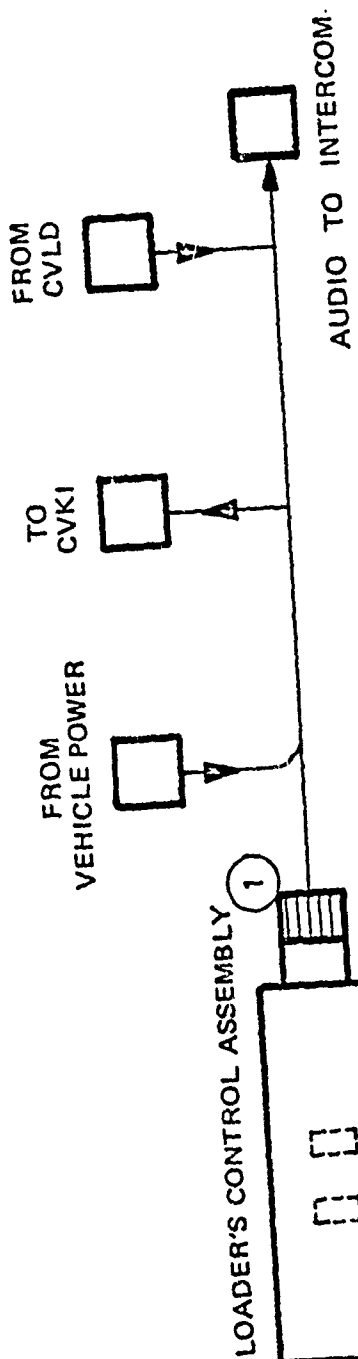
(b) CVKI Mounted on M113 APC Pedestal

Figure 4-67. Combat Vehicle Kill Indicator



57655

TO  
TRANSMITTER(S)



FROM  
COAX MG  
(MICROPHONE)

TO  
TRANSMITTER(S)

TO VEHICLE  
CHASSIS

LOADER'S BOX BRACKET

WEDGE BLOCKS

WEAPON KEYS

BREECH  
INTERLOCK  
CONNECTOR  
(M551 AND  
M60A2 ONLY)

(1) M113 (ONLY REQUIRED CABLE)

Figure 4-68. Vehicle Adapter Kits

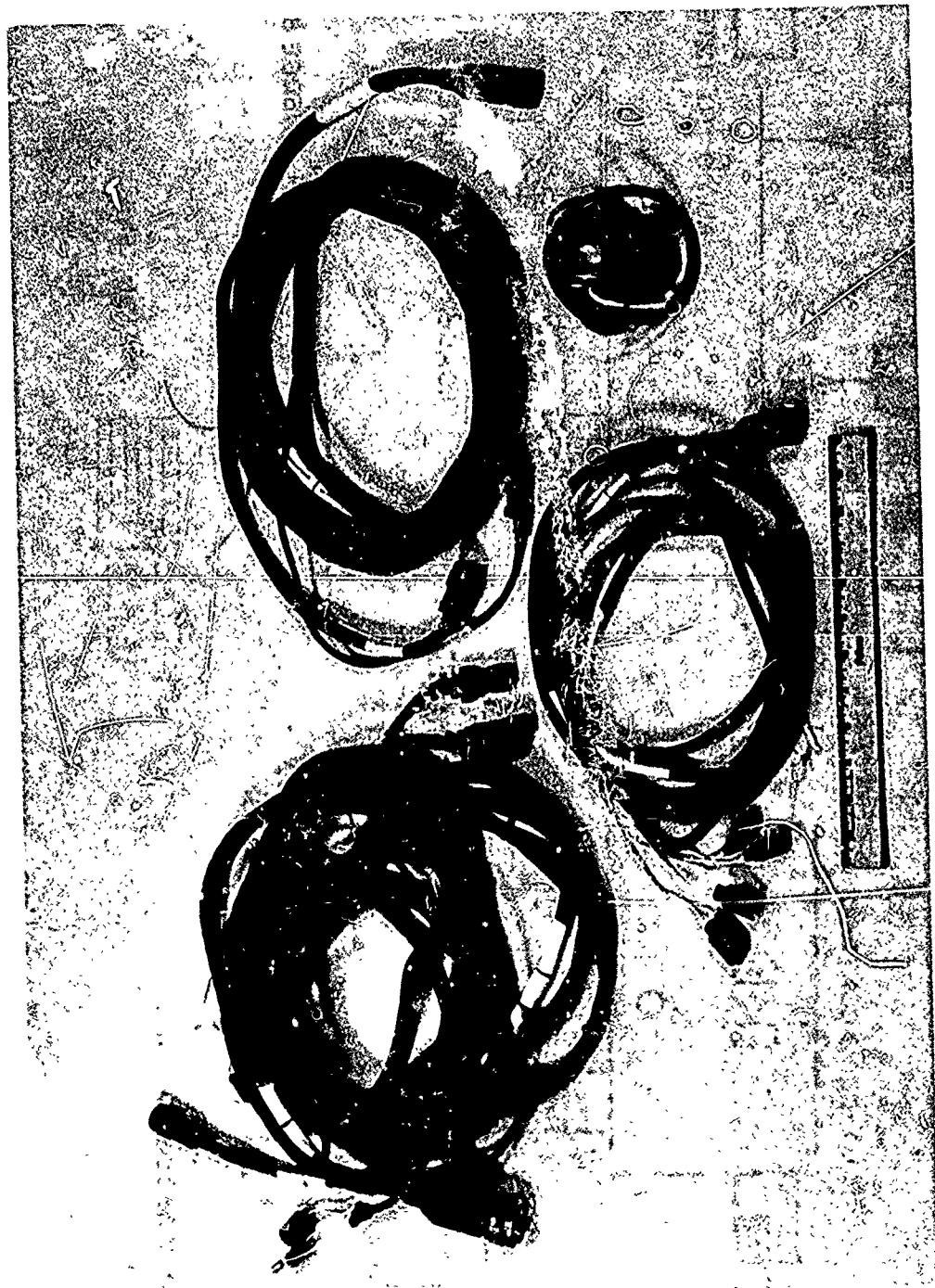


Figure 4-69. Interconnecting Cabling, Adapter Kit

87830

Three spare yellow weapon keys are supplied for use by the Tank Commander, gunner, and loader (of tanks) who wear MWI.Ds. \*

The microphone assembly for sensing of the coax machine gun blank firing is included in the kits for tanks. Miscellaneous mechanical parts are supplied to provide interface between the vehicle and the MILES assemblies. A grounding strap assures that the LCA is properly grounded to the vehicle.

A unique feature of the vehicle interconnecting cabling is that the cable for any specific vehicle tells (by means of jumpers in the mating connector) the control console (LCA or CIA) in just what vehicle the LCA or CIA has been installed. The LCA and CIA need this information to perform the functions of kill probability determination and, for the LCA, the weapon complement that it must control. Although the adapter kits are similar and many components are common, the adapter kit for each vehicle is unique and not usable on any other vehicle. \*

#### 4.6 ANTITANK WEAPONS EFFECTS SIGNATURE SIMULATOR (ATWESS)

The ATWESS has been developed by XEOS as a part of the MILES program. It was designed to provide TOW, DRAGON and VIPER antitank weapons with a device, for use with MILES, that provides a credible simulation of audio and visual effects of actual weapon firing. Use of ATWESS thus enhances the tactical training scenario.

The ATWESS is comprised of a common universal firing device, a common pyrotechnic cartridge, and unique adapters for each of the weapons to be simulated.

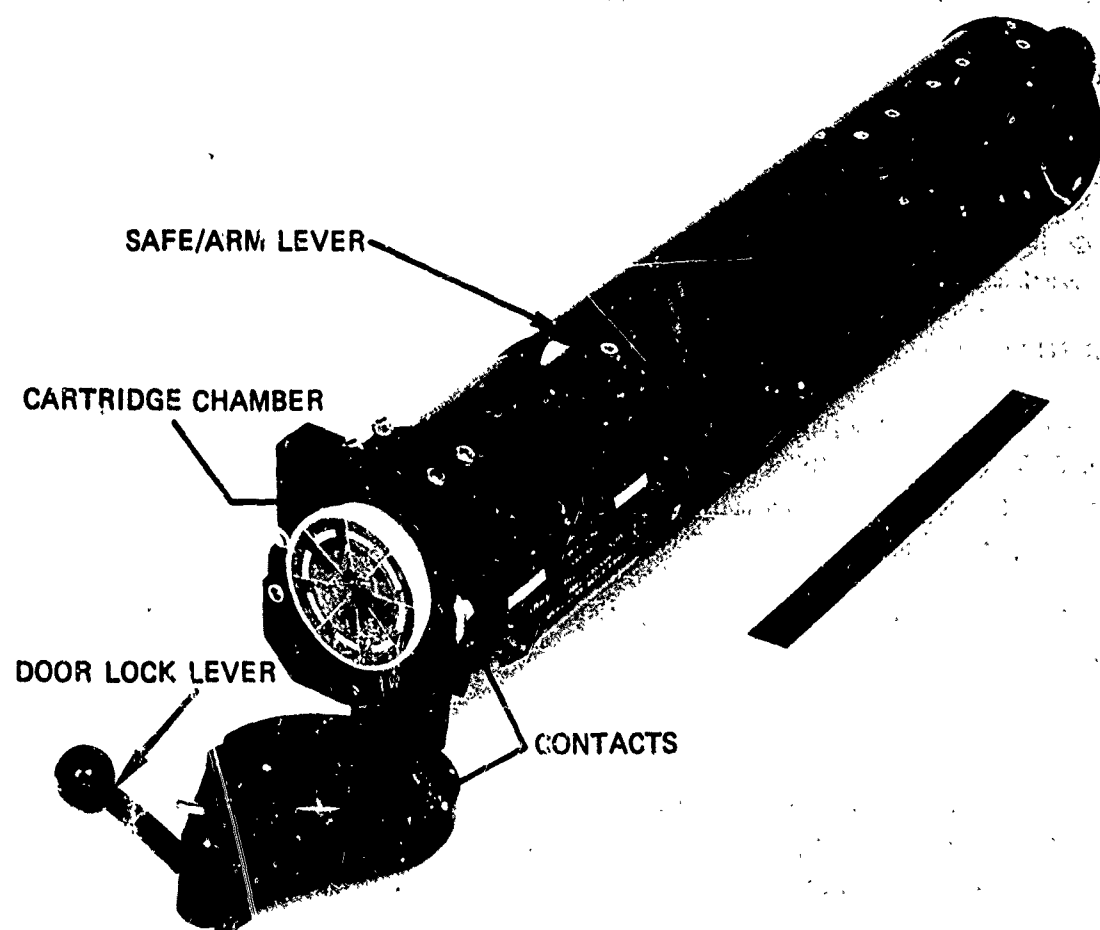
##### 4.6.1 FIRING DEVICE

The housing of the firing device, shown in figure 4-70, is cylindrical and sized to fit the LAW/VIPER launch tube, where it is attached by screws through the launch tube wall and into the housing of the firing device. For TOW and DRAGON launch tubes, adapter rings are used to interface the firing device and accommodate the larger launch tube diameters. The ATWESS firing device mounts in the rear of each of the launch tubes.

A firing chamber is sized to accommodate the ATWESS cartridge which looks very much like a large shotgun shell with a flange on the end opposite the primer. A hinged breech block door opens to allow insertion of the cartridge. Opening of the door performs the following functions:

- a. Ejects the spent cartridge far enough for easy removal by hand
- b. Cocks the firing mechanism
- c. Places the safe/arm lever in the safety position

Set in the back of the breech block door are two contact springs, insulated from the door. When the door is closed the springs complete an electrical circuit which uses the cartridge face as a conductive



77919

Figure 4-70. ATWESS Firing Device

path from one contact spring to the other. This circuit path must be complete for the MILES laser transmitter to fire. The plastic cartridge has a small printed circuit contact disc on its face which before the cartridge is fired provides the electrical path. When the cartridge is fired, the center of the contact disc is blown out and the circuit path is broken. Thus, the MILES will not fire again until a new ATWESS cartridge is inserted.

\*

The ATWESS is fired when MILES is triggered. It must first be loaded and cocked as described above. The arming lever must then be pulled out into the arm position. This arming action accomplishes two things:

- a. Withdraws a safety plate that in the safe position traps the firing pin
- b. Closes a microswitch that is in series with a part of the MILES firing circuit

A simplified block diagram of the MILES/ATWESS firing circuit is shown in figure 4-71.

Actual firing of ATWESS is accomplished by a signal from the MILES transmitter. The ATWESS electronics charge a capacitor and keep it in a fully charged state. The capacitor discharge is used to operate a solenoid which releases the sear and trips the firing pin hammer. MILES battery power, 9 vdc, is used to charge the capacitor. The capacitor charges in 10 seconds or less and is thus ready for the next ATWESS firing. This is less than the normal reload time of the weapons being simulated. The ATWESS draws approximately 50 mA of current for each cartridge firing.

Maintenance of the ATWESS firing device is similar to that of a weapon. Carbon deposits from the cartridge firing collect on the breech block door and door handle and around the breech opening. The device should be cleaned at a minimum after each field operation, and ideally should be done daily if the device has been fired numerous times. The door hinge and door handle pivot are exposed to weather and to the carbon particles from the blast. They should be given a light coat of gun oil occasionally to prevent galling or binding of the mechanisms.

\*

#### 4.6.2 CARTRIDGE

The cartridge, shown in figure 4-72, is a three piece injection molded unit consisting of a cylindrical housing with a flange on one end, a snap-in primer plate, and a snap-in closure disc for the flanged end of the cartridge. The primer plate has a hole in its center to accept a standard MIL-Spec primer. This primer is M42C1 per MIL-P-20444. The closure disc has a circular relief groove which shears when the cartridge is fired. This disc is the containment for the pyrotechnic composition which produces the audible report.

Loaded into the aft end of the cartridge, prior to installation of the primer plate, is a preformed pyrotechnic pellet of magnesium teflon composition. It is contained within a cardboard tube. This cylindrical pellet is coated with a first fire composition which acts as a catalyst to accelerate the ignition of the pellet. The pellet provides the flash and smoke of the weapons effect signature.

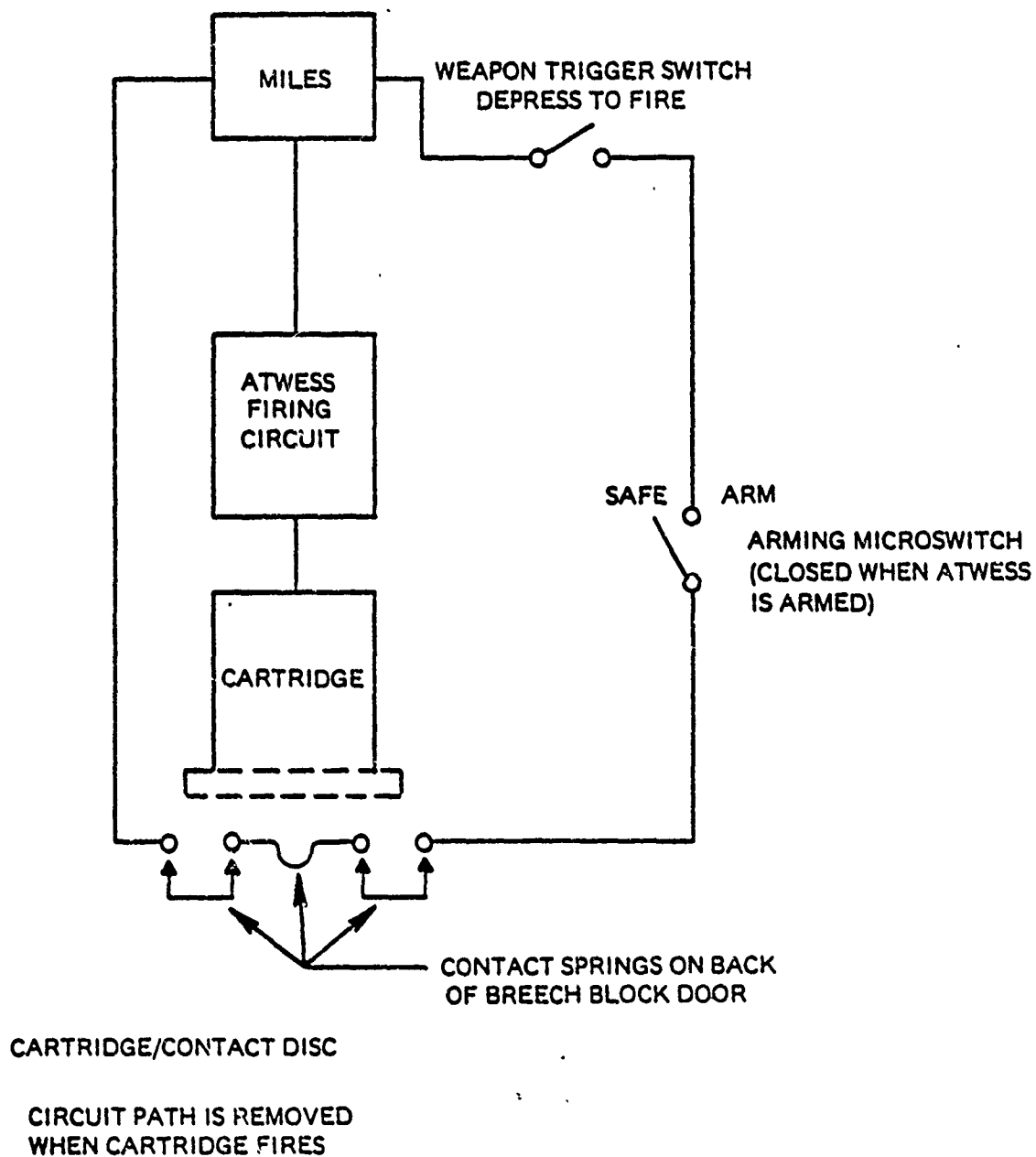


Figure 4-71. MILES/ATWESS Firing Circuit

60013

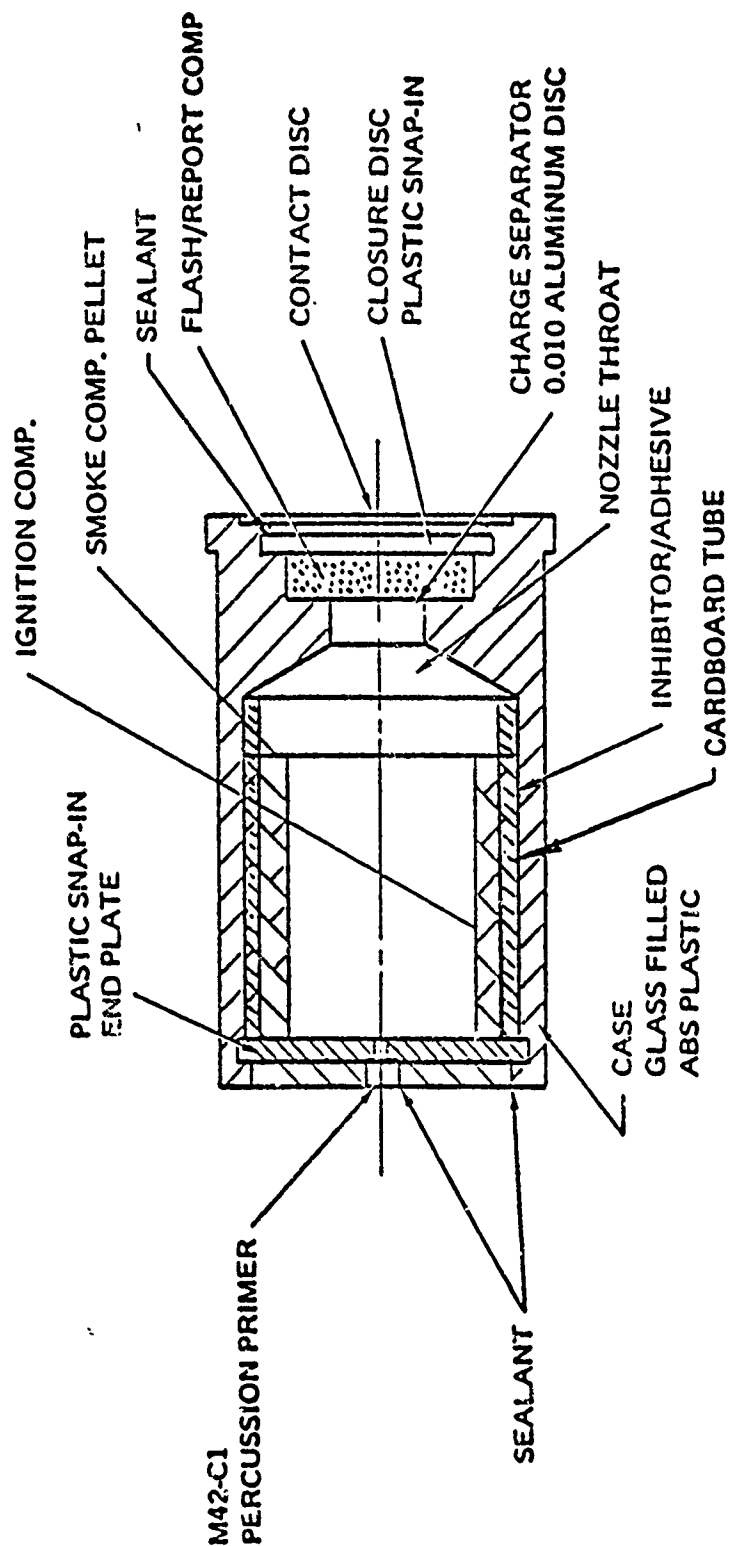
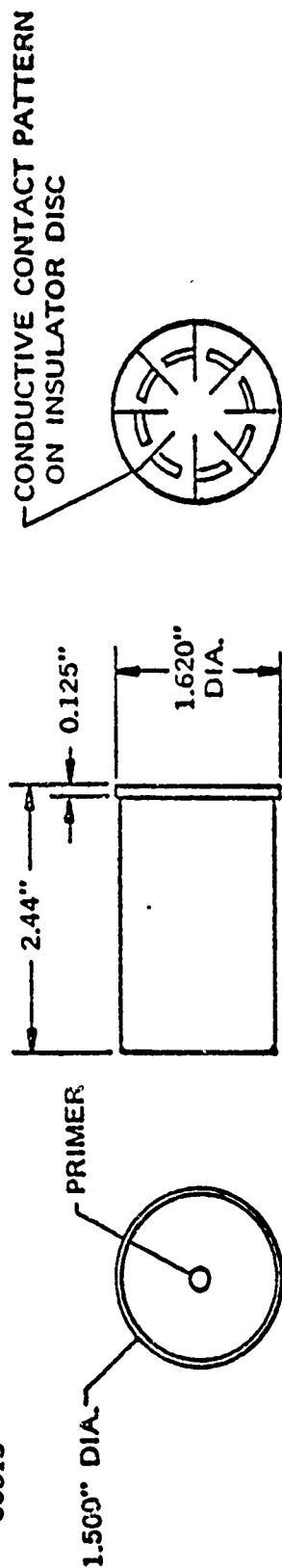


Figure 4-72. Weapons Effect Simulator Expendable Cartridge

An adhesive backed aluminum disc is placed at the cavity bottom on the other end of the cartridge as a separator wall between the pyrotechnic pellet and the bang composition chamber. Sixty milligrams of loose magnesium teflon mixture are loaded into the bang composition chamber and then the closure disc is snapped into place. All interfaces of the three plastic parts and the primer are made water tight with a sealant. Finally, the contact closure disc is bonded in place at the flanged end. The cartridge is complete except for identification. The finished cartridge is 1.5 inches in diameter by 2.44 inches long and weighs 1.9 grams.

#### 4.6.3 ATWESS SIGNATURE

Firing of the ATWESS results in the following sequential events:

- a. Report or Bang
- b. Flash
- c. Smoke

The report has a rise and decay time of approximately 2 milliseconds. Its maximum sound level is approximately 165 to 170 dB at one foot, which is typical of the distance from the ATWESS to the VIPER firer's ear. Figure 4-73 compares ATWESS with the DRAGON.

The flash when viewed in daylight appears to be 1 to 2 feet in diameter and approximately 7 feet in length (figure 4-74) and is visible even on a bright sunny day. The flash color varies with time from bright white to light orange. Total flash duration is 400 milliseconds. Figure 4-75 compares ATWESS with TOW and DRAGON.

Smoke is produced in abundance and is white in color. It rises and dissipates fairly rapidly. Figure 4-76 shows the ATWESS smoke at 1.5 seconds after firing.

#### 4.6.4 SAFETY

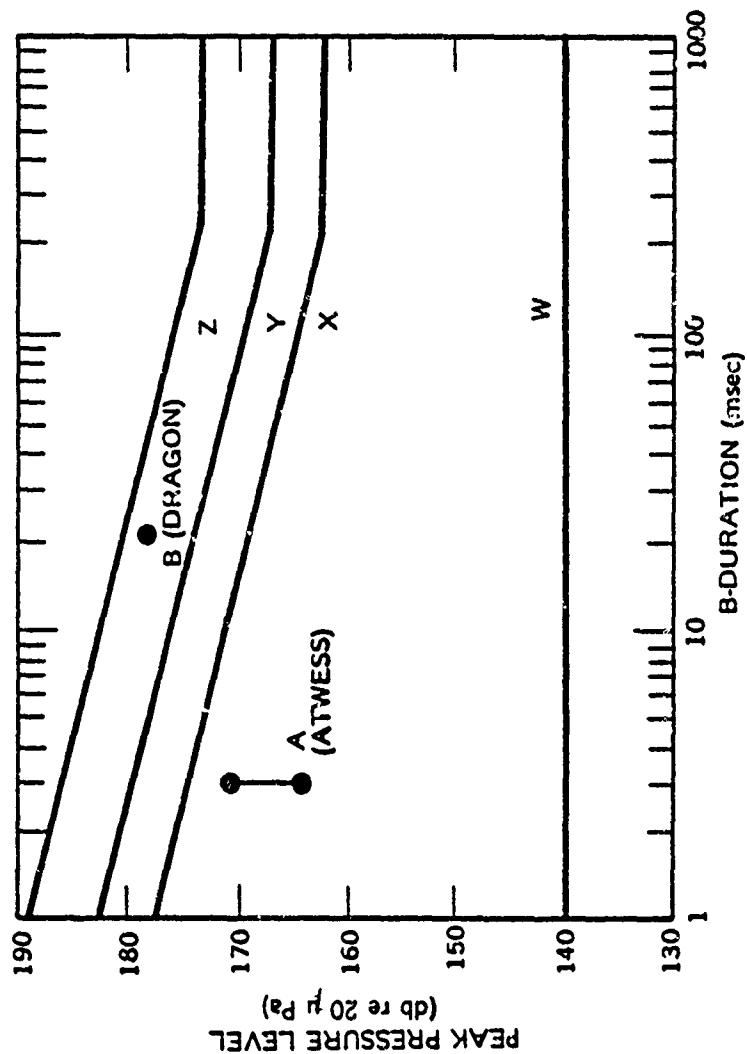
To avoid countertraining, personnel using the ATWESS should observe the same backblast and ear safety precautions that they do when using the actual weapons even though ATWESS is attenuated somewhat from the actual weapon signatures. Backblast areas for TOW, DRAGON and VIPER are shown in figures 4-77 through 4-79. Figure 4-80 is a plot of the ATWESS safe area test results. Ear plugs or muffs should be worn when firing ATWESS. A sound pressure map for ATWESS is shown in figure 4-81.

The ATWESS when fired shoots a flash to the rear 7 to 8 feet long and 1 to 2 feet in diameter. This flash is extremely hot (approximately 4000°F) and is the primary danger from the ATWESS. The plastic containment disc is severed, fractured, and potentially burned in the signature. However, parts of it could be expelled in the backblast area. By observing the actual weapon backblast areas a wide



- REQUIREMENT IS  $\geq 140$  db AND BELOW THE Y LINE OF FIG. 5 OF MIL-STD-1474A AT THE FIRER'S EAR

A = ATWESS  
B = DRAGON

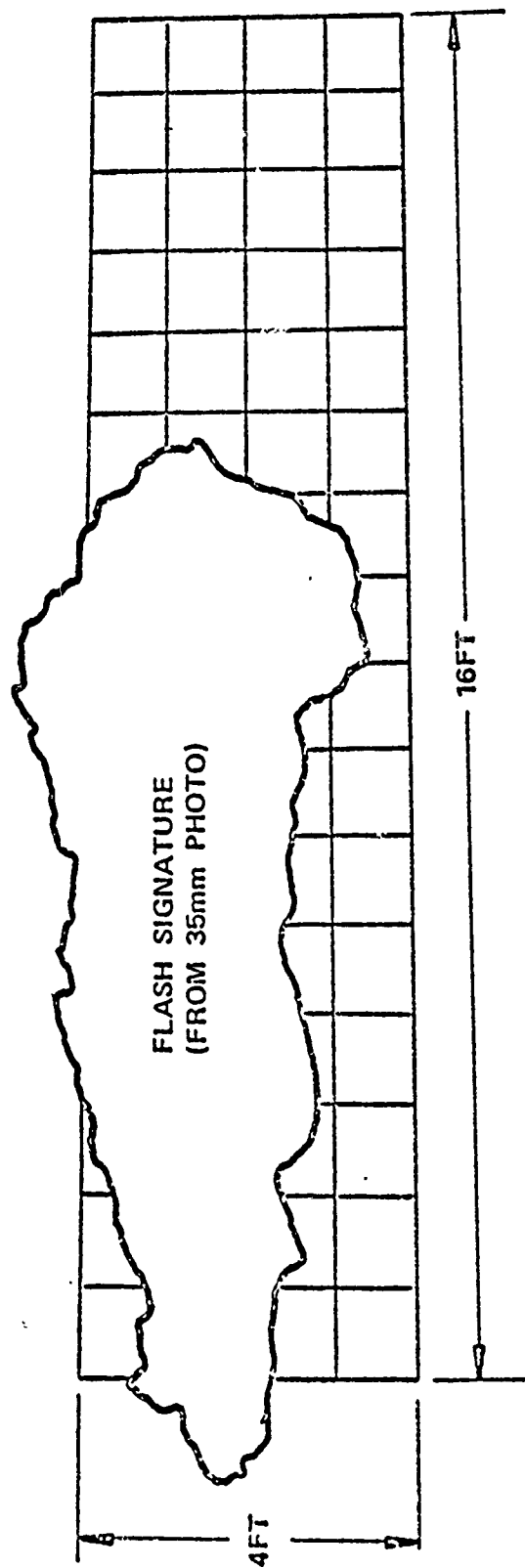


PEAK PRESSURE LEVEL AND B-DURATION LIMITS FOR IMPULSE NOISE  
(SEE TABLE 5 TO SELECT CURVE FOR USE. NOTE: USE OF LEVELS IN EXCESS OF LIMIT W  
REQUIRES MANDATORY HEARING PROTECTION PER 13 MED 251.)

Figure 4-73. ATWESS Audio Signature

59458

- FLASH, 5 -10 FT. LONG X 2-4 FT. DIA. MAXIMUM  
DURATION APPROX. 400 msec  
MAX. FLASH AT APPROX. 140 msec
- SMOKE, 14-16 FT. LONG X 4-6 FT. DIA.  
SMOKE PERSISTS FOR SEVERAL SECONDS  
COLOR, WHITE



4-102

Figure 4-74. ATWESS Visual Signature



Figure 4-75. ATWESS Smoke Signature at  $t = 1.5$  Seconds

622.11

117722



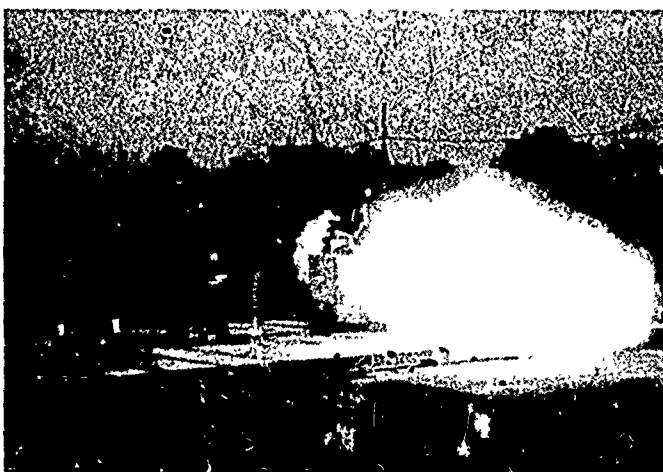
TOW

117724



ATWESS

117721



DRAGON

Figure 4-76. Flash Signatures - TOW, ATWESS, and DRAGON

007681

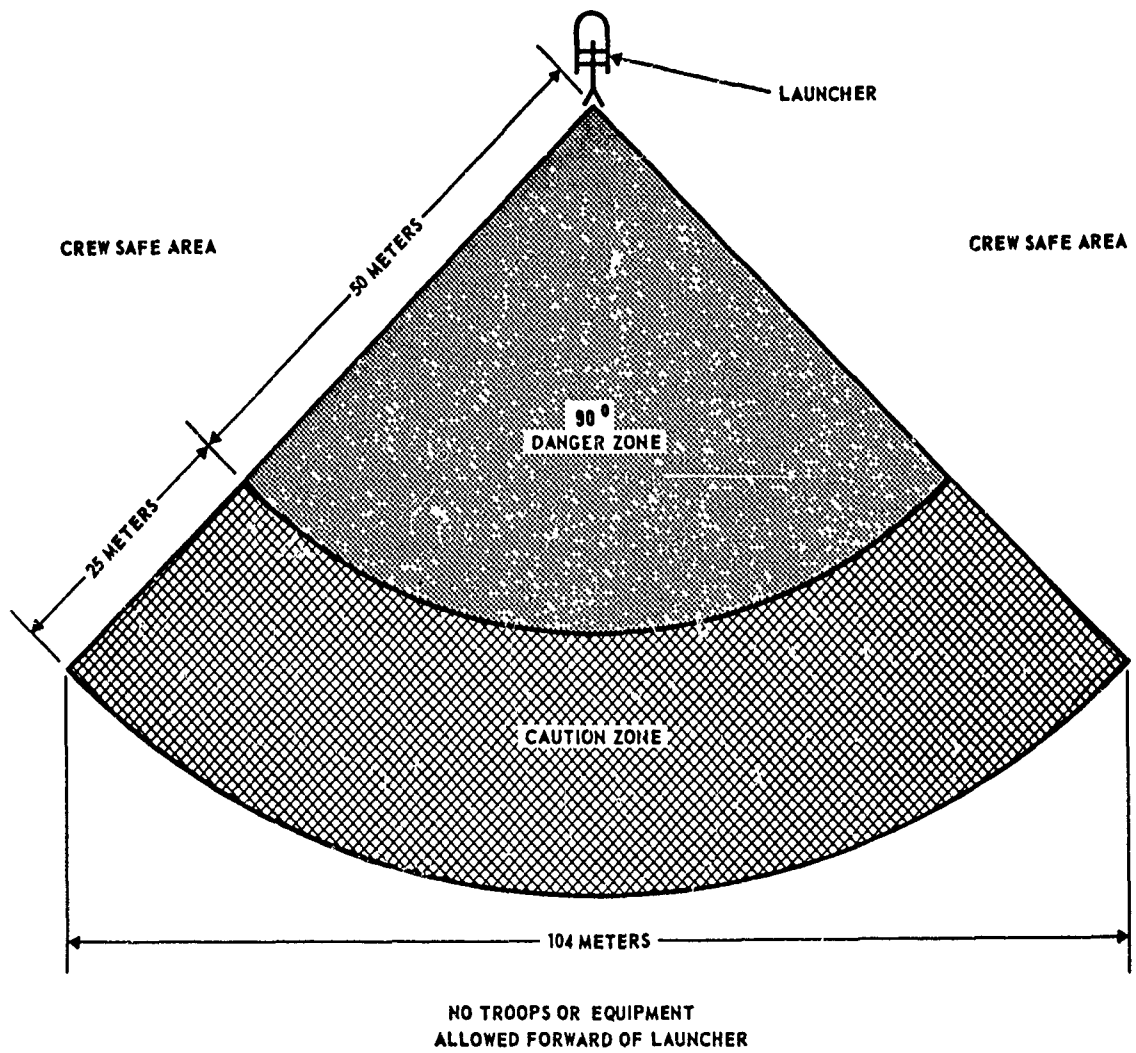
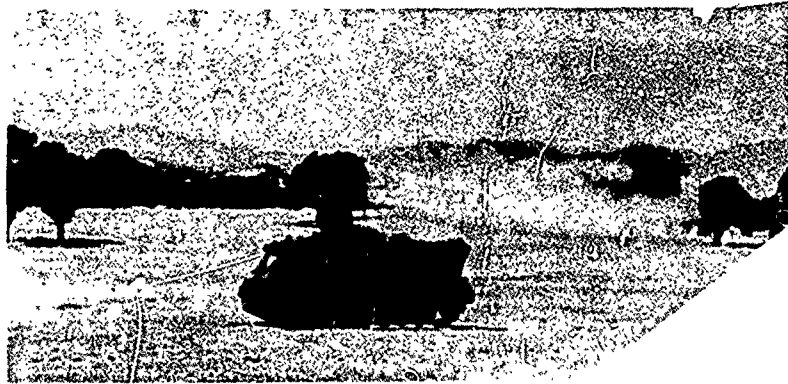


Figure 4-77. TOW (Actual) Missile Backblast Area

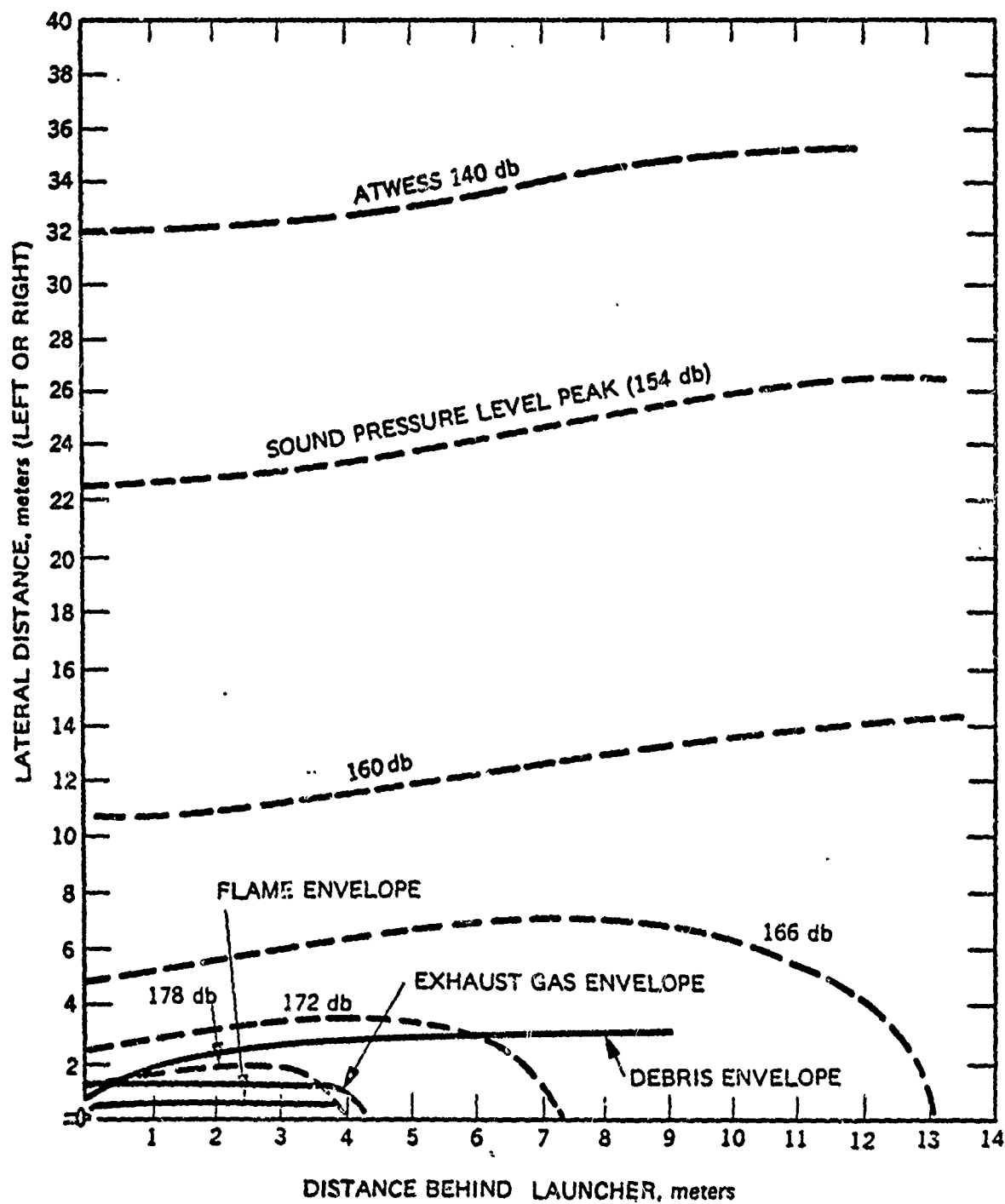


Figure 4-78. Dragon Sound Pressure Map

61061

61013

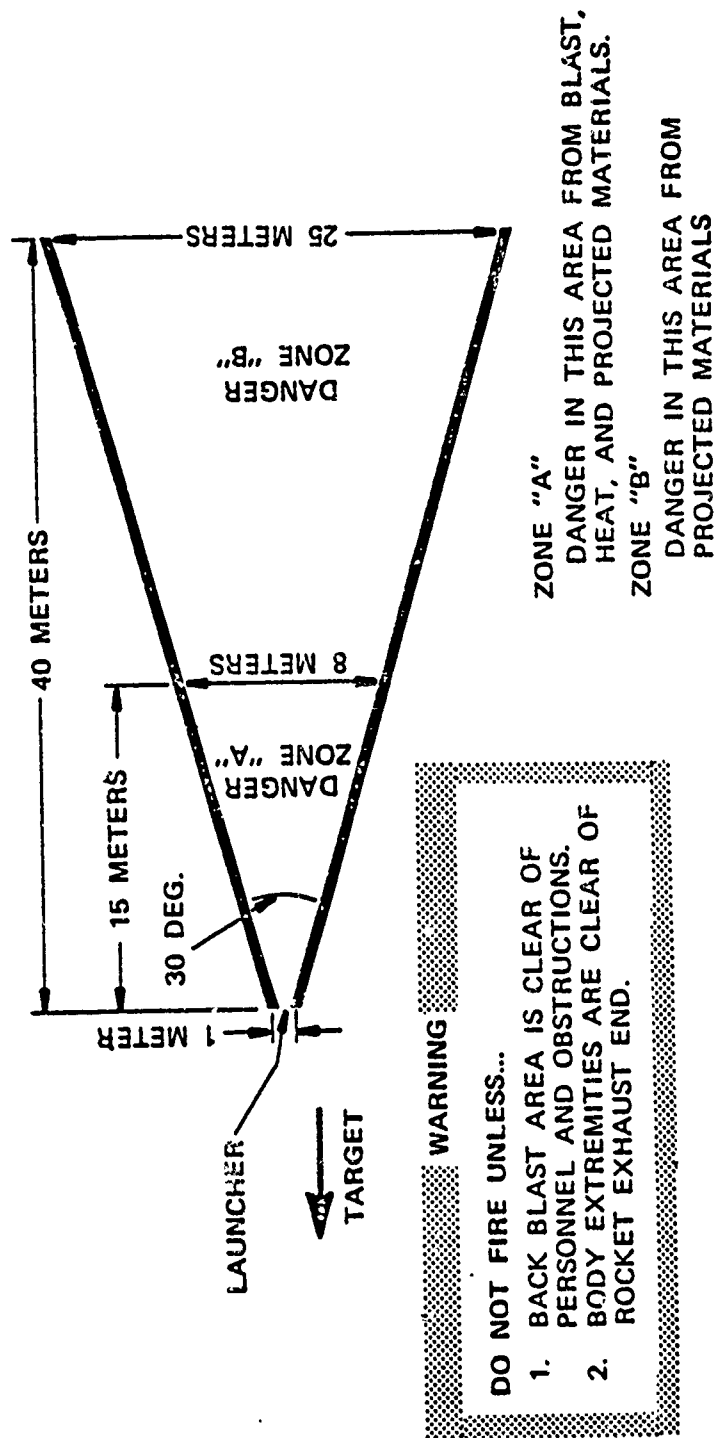
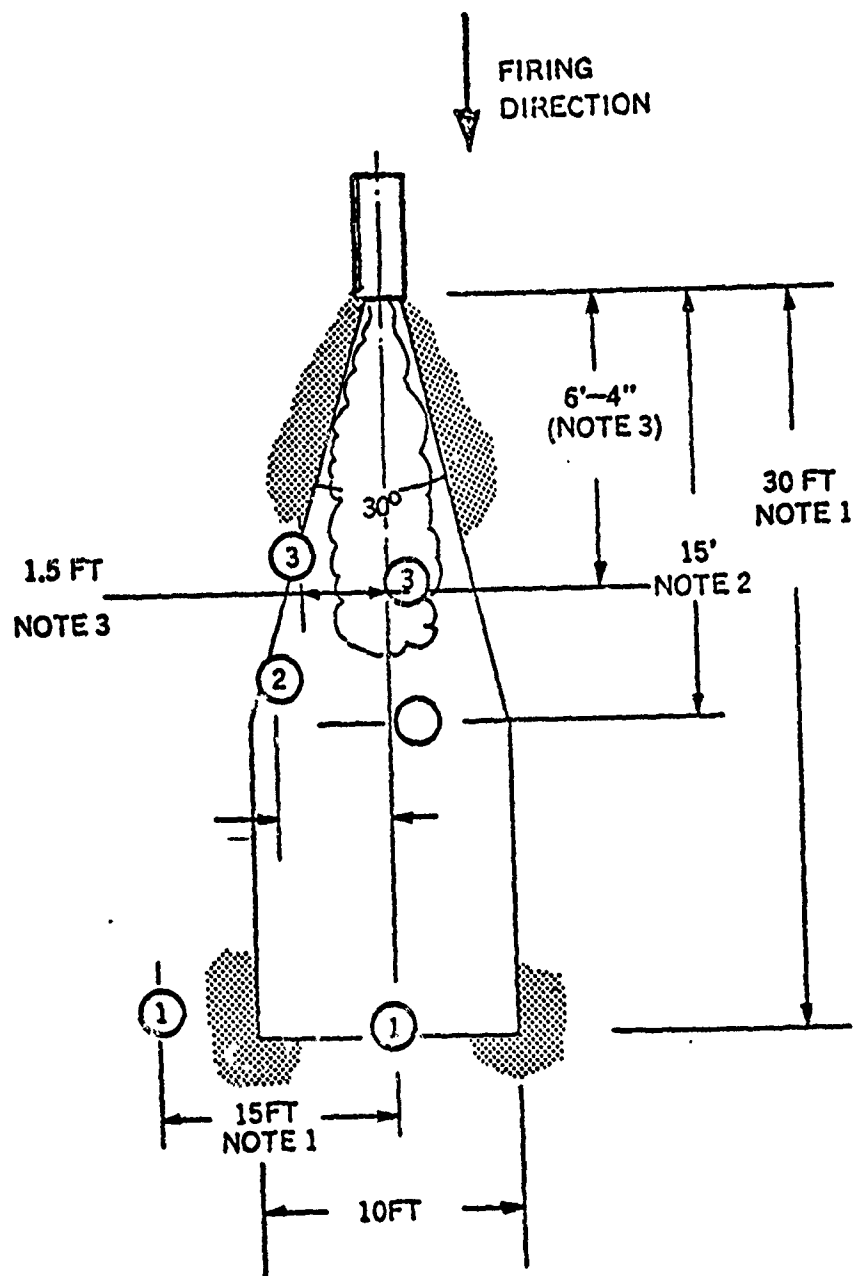


Figure 4-79. Viper Back Blast Danger Zones



**NOTES:**

1. 8X8 TEST WITNESS SCREENS SHOWED NO EFFECTS AT POSITION (1) ON EITHER SCREEN
2. WITNESS SCREENS SHOWED A SINGLE SCORCH ON THE IN-LINE SCREEN LOCATED 15FT FROM THE FIRING NO EFFECT ON THE SIDE SCREENS.
3. WITNESS SCREENS SHOWED A SPECKLED PATTERN ON THE IN-LINE SCREEN. NO EFFECT ON THE SIDE SCREEN.

Figure 4-80. ATWESS Safe Area Test Results

62447



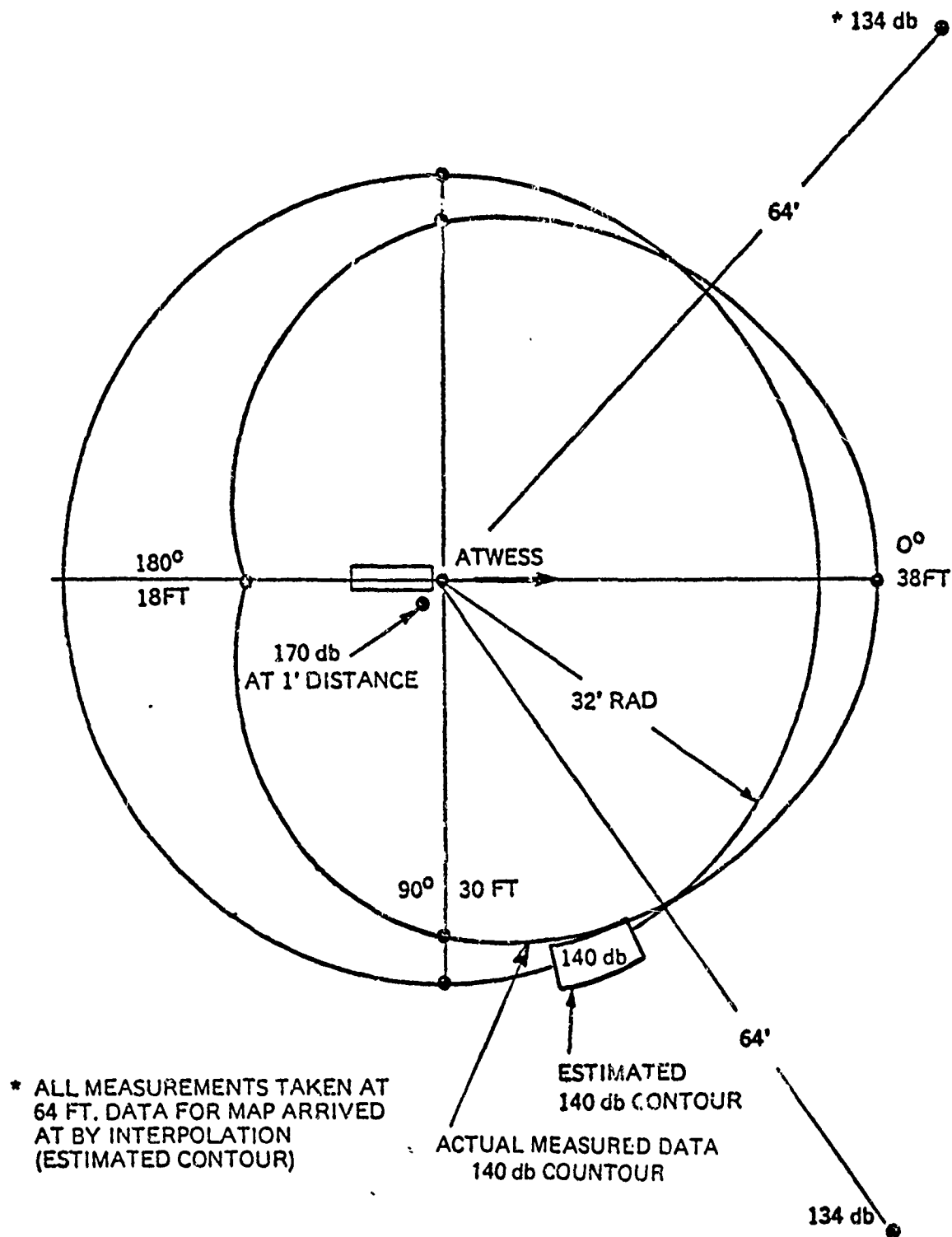


Figure 4-81. ATWESS Sound Pressure Map

62458

margin of safety will be imposed. The chemical components of the ATWESS cartridge are listed in table 4-2.

The smoke and by products of ATWESS firing are harmless. Analysis of the products of combustion is shown in table 4-3. The basic pyrotechnic mixture is used extensively in I.R. flares by the U.S. Air Force.

The ATWESS, as with any loaded weapon, should be kept in the SAFE condition and only ARMED when ready to fire at a target. Abusive handling or dropping the ATWESS in the armed condition could trip the hammer and cause ATWESS to fire.

ATWESS cartridges should be handled as with any live ammunition - with care. The cartridge case is a rugged glass filled plastic, but the primer cap must not be allowed to strike a sharp object.

#### 4.6.5 PACKAGING AND SHIPPING

##### 4.6.5.1 Cartridge

The basic requirement is to package the cartridge in cartons of 10 each. The XEOS approach to the cartridge packaging and shipping is shown in figures 4-82 and 4-83. The 10 cartridge carton weight is approximately 1.2 pounds and the 24 carton box weight is approximately 35 to 40 pounds. The shipping box is a standard 18 inches long by 12 inches wide by 12 inches deep, 200 pound burst strength cardboard box.

##### 4.6.5.2 Firing Device

The firing devices will be mounted in their respective launch tubes and packaged and shipped as final launch tube assemblies.

#### 4.6.6 MILES/ATWESS INTERFACE

##### 4.6.6.1 Electrical/Electromechanical Interface

The electrical interface between the ATWESS and MILES for DRAGON and VIPER is shown in schematic block diagram form as figure 4-84.

\*

The electromechanical interface for VIPER is a cable and connector from the MILES transmitter to the ATWESS. The electromechanical interface for DRAGON is the connector that mates the DRAGON launch tube with the MILES simulated DRAGON sight. The electromechanical interface for the TOW is accomplished by means of the TOW bridge clamp connector which mates to the connector on the expended TOW launch tube. The wiring from the tube interior is properly mated by a connector to the ATWESS interface connector.

\*

**TABLE 4-2**  
**ATWESS CHEMICAL COMPONENTS**

Part Name: Practice Cartridge, Cartridge Simulator

Part Number: 11749380

Chemical Components:

1. Pressed Smoke Composition - 14 Grams
  - 75% Magnesium
  - 15% Teflon
  - 10% Viton A [binder]
2. Ignition Composition - 0.5 gram
  - 25% Boron
  - 30% Potassium Perchlorate
  - 25% Barium Chromate
  - 10% Magnesium
  - 10% Viton A [binder]
3. Report Composition - 0.6 gram
  - 58% Magnesium
  - 38% Teflon
  - 4% Viton A [binder]
4. Primer
  - 1 each M42C-1

\*

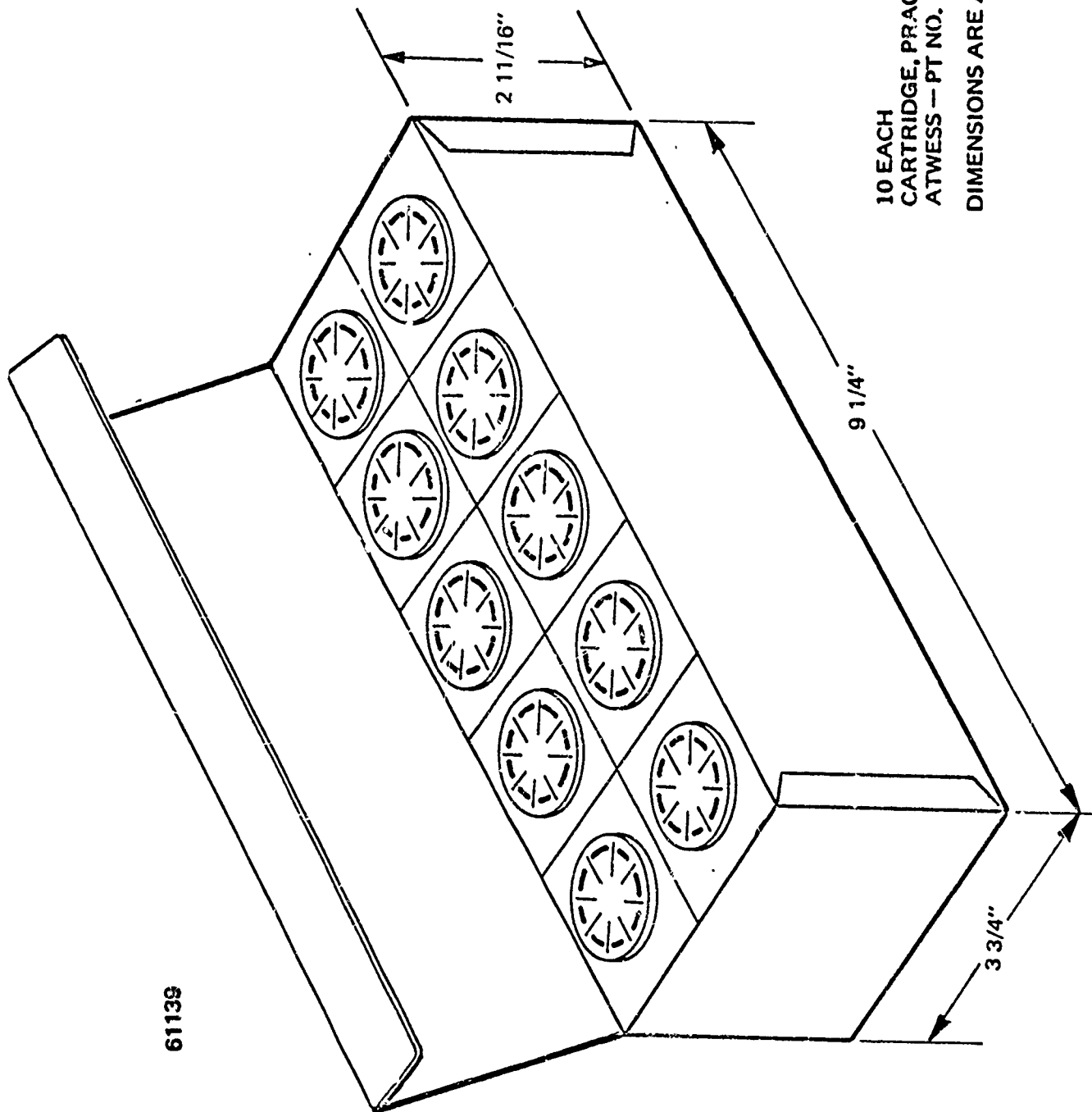
**TABLE 4-3**  
**CHEMICAL RESIDUE EXPECTED FROM ATWESS CARTRIDGE FIRING**

|                    |   |                  |
|--------------------|---|------------------|
| Magnesium Oxide    | - | 6.4 grams Solid  |
| Magnesium Fluoride | - | 6.4 grams Solid  |
| Carbon             | - | 2.16 grams Solid |
| Boron Oxide        | - | 0.01 gram Solid  |
| Potassium Oxide    | - | 0.01 gram Solid  |
| Barium Oxide       | - | 0.01 gram        |
| Cromium Oxide      | - | 0.02 gram        |

Plus less than 0.005 gram quantities of Zirconium Oxide, Iron Oxide, Silicon dioxide, and Nitrogen Gas.

Total Approx. 15 grams

This prediction is based on analysis of the same pyrotechnic used in another application.



10 EACH  
 CARTRIDGE, PRACTICE  
 ATWESS - PT NO. 11749380

DIMENSIONS ARE APPROXIMATE

\*

61140

MATERIAL: 200 LB. BURST STRENGTH  
CARDBOARD

LOADED:  
WEIGHT APPROX. 35-40 LBS.

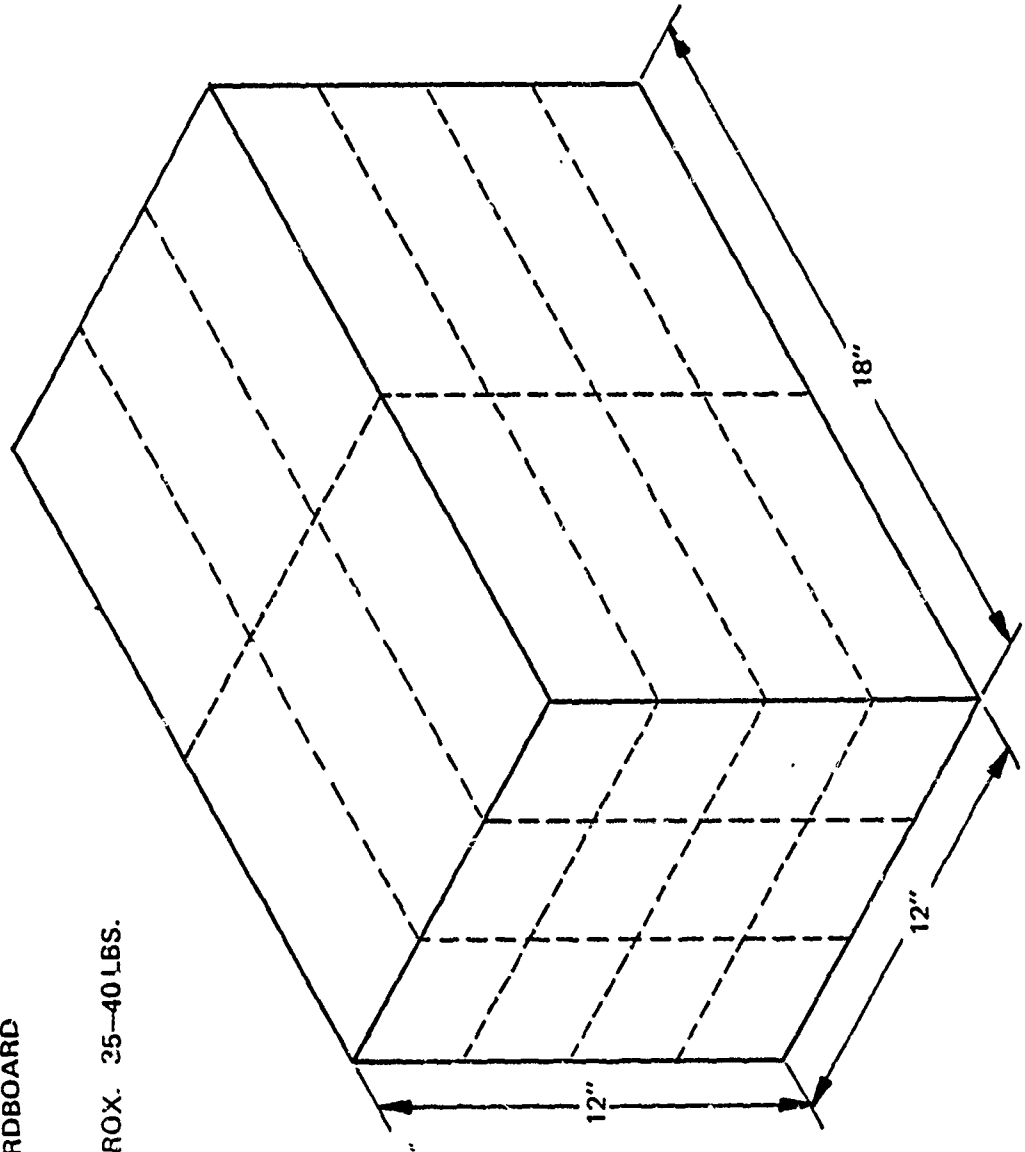
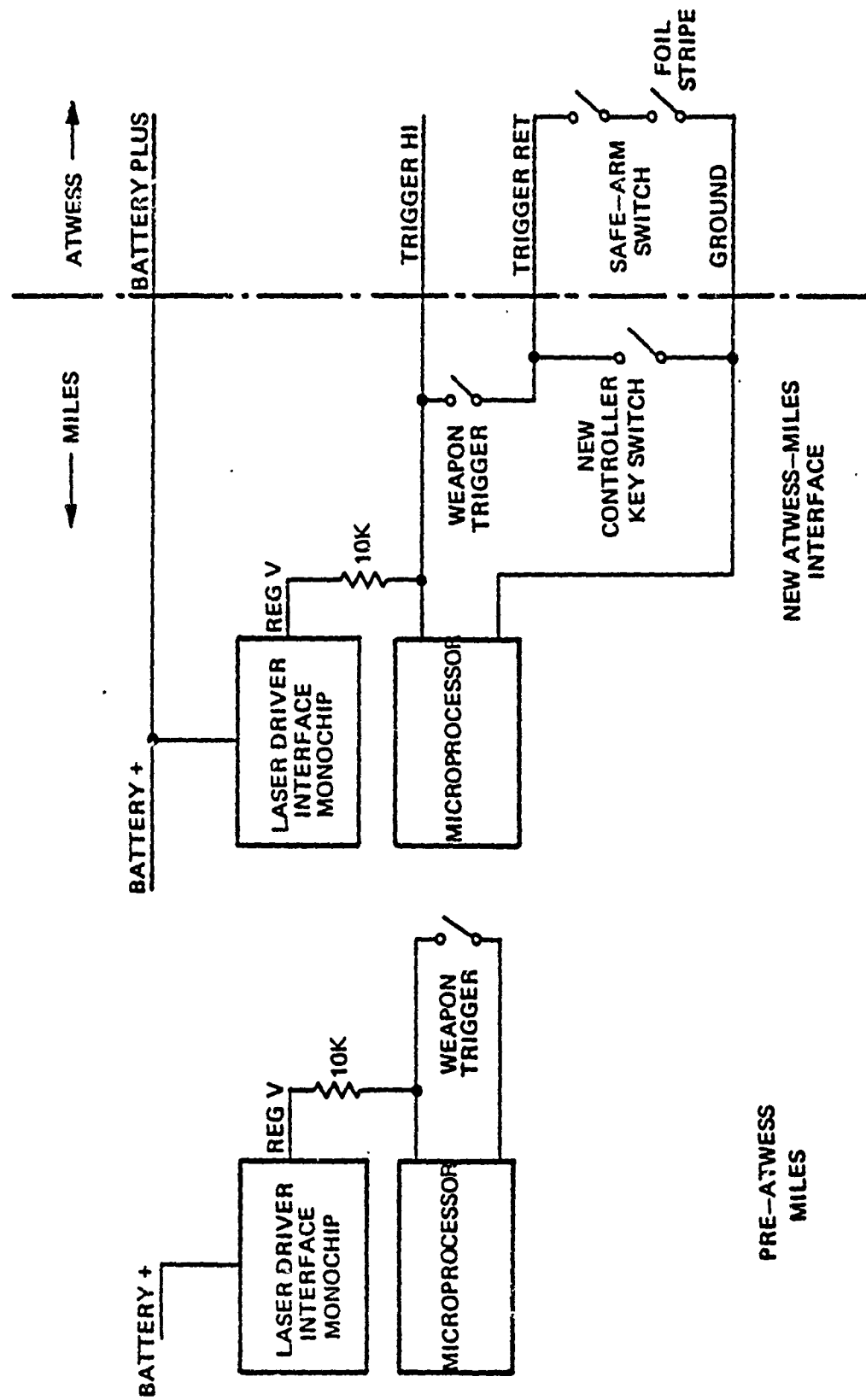


Figure 4-83. ATWESS Cartridge Shipping Container

61212



4-114

Figure 4-84. Dragon - Viper Electrical Interface

MILES has a capability for dry fire (i.e., firing without ATWESS). This capability can only be set by a controller who exercises the option with his controller key in the weapon key receptacle of the DRAGON or VIPER laser transmitter assembly. Dry fire for the TOW is accomplished by the controller setting a switch in the TOW MGS simulator to the dry fire position. This can only be done with the controller key. This switching function is shown schematically in figure 4-85.

#### 4.6.7 SYSTEM APPLICATIONS

ATWESS is intended to be used with MILES for simulation of DRAGON, VIPER, and TOW antitank weapons. The system functional descriptions follow.

##### 4.6.7.1 DRAGON

To fire the DRAGON simulator, the MILES laser transmitter (simulated DRAGON sight) must be mated to the ATWESS launch tube assembly. This is done in the normal manner used for attaching the actual DRAGON sight.

Firing is accomplished in the same manner as the normal DRAGON weapon except that the ATWESS must be armed before the MILES/DRAGON simulator will fire. When the DRAGON trigger is squeezed, ATWESS will fire immediately. One second later the MILES begins its laser transmission; The gunner must track the target for 6 seconds of laser transmission - 7 seconds from triggering. The expended ATWESS cartridge must be replaced before MILES or ATWESS will again fire. Figure 4-86 shows the DRAGON/ATWESS with the ATWESS breech open.

\*

##### 4.6.7.2 VIPER

Since the Viper is designed to be used once and then discarded, it was found that an expended Viper launch tube was not sufficiently rugged to withstand the rigors of repeated use. Therefore, a new Viper tube, which simulates the external configuration and operational use, was developed. The simulated tube differs from the real Viper in that the simulated tube is solid and does not telescope.

\*

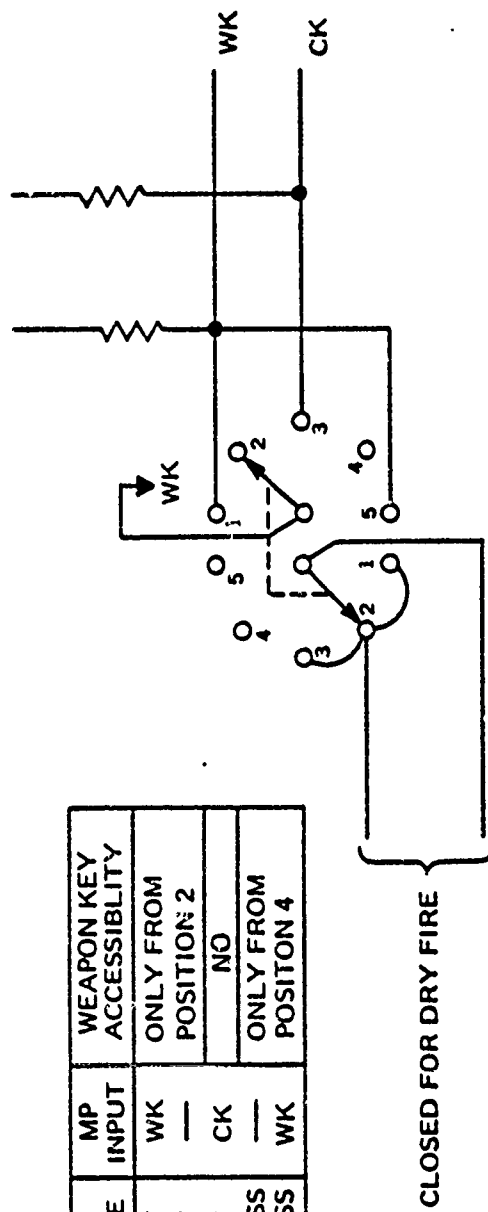
Firing is accomplished by loading an ATWESS cartridge into the rear of the Viper tube, pulling out the ATWESS safety lever to the armed position, aiming, and firing. The ATWESS and MILES both fire immediately when the trigger is depressed; no tracking is required. The expended ATWESS cartridge must be replaced before the Viper transmitter or the ATWESS will again fire. Figure 4-87 shows the Viper/ATWESS with a cartridge installed and the ATWESS breech closed and locked.

\*

##### 4.6.7.3 TOW

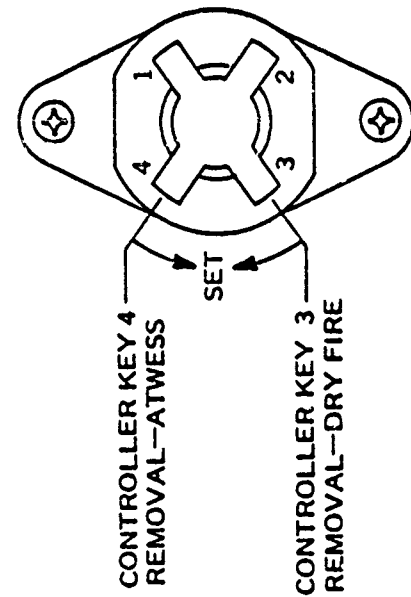
The ATWESS firing device is mounted into an expended TOW launch tube by means of two cylindrical adapter rings. Electrical interface wiring completes the TOW ATWESS assembly. This assembly is then placed in the TOW firing platform and left for the duration of the training or firing exercise. ATWESS cartridges are loaded into the firing device and ejected after firing.

61212



4-116

WEAPON KEY  
OPERATIONAL POSITION



WEAPON KEY  
OPERATIONAL POSITION

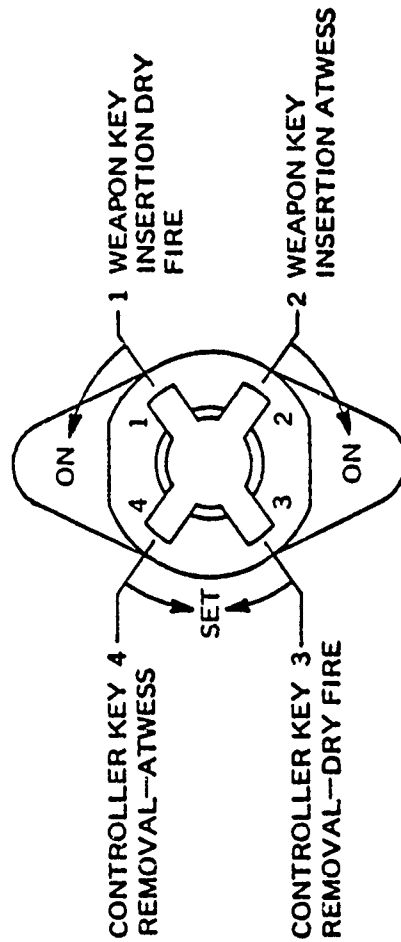
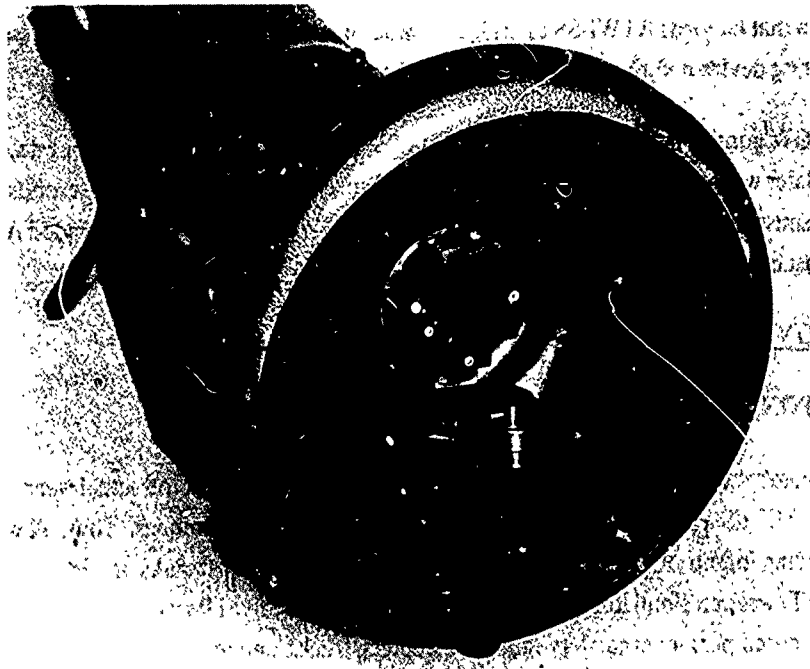


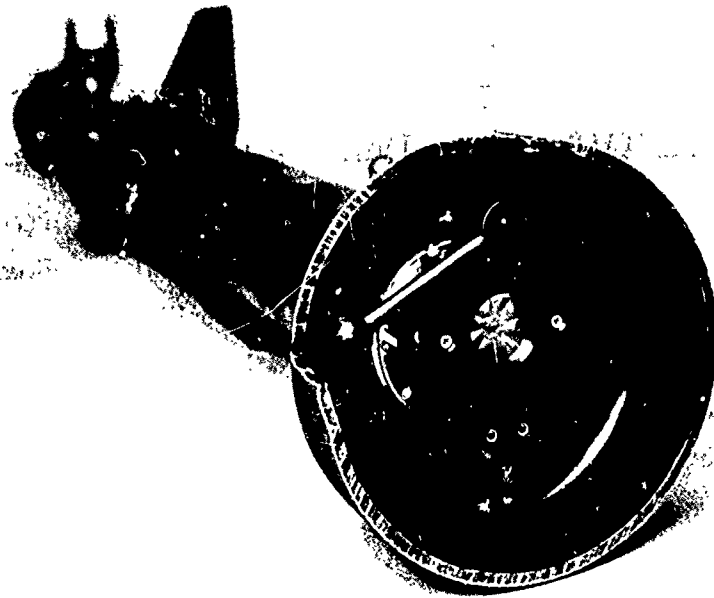
Figure 4-85. Dragon/Viper-to-ATWESS Switching





97932

Figure 4-86. Dragon/ATWESS System



97921

Figure 4-87. Viper/ATWESS System

Operationally, the TOW gunner goes through the same routine that he would with the real weapon with the exception that he loads ATWESS cartridges instead of launch tubes and that he must arm the ATWESS firing device before either MILES/TOW or ATWESS will fire.

When the TOW gunner triggers the weapon, ATWESS will fire immediately. After a 1-second delay, the MILES laser will start its transmission. The gunner must track his target for 10 seconds after the MILES transmission starts - 11 seconds from the time of TOW triggering. The expended ATWESS cartridge must be removed and replaced before MILES or ATWESS will again fire.

#### 4.7 WEAPON SIMULATION

##### 4.7.1 WEAPON HIERARCHY

As a part of combat tactical training realism, it is extremely important that the actual weapon hierarchy is preserved. MILES achieves this through its coding and decoding techniques. Thus, all weapons are capable of killing infantrymen, but the infantryman is ineffective against tanks or APCs. Table 4-4 lists the MILES ED weapon simulators and their effectiveness against five classes of targets: infantrymen (MWLD), armored personnel carriers, tanks, helicopters, trucks, and jeeps. Note that all hits on infantrymen are kills. Hits on vehicles are scored as hits or kills based on preselected probability of kill given a hit.

TABLE 4-4  
TARGET/WEAPON HIERARCHY

| WEAPON             | TARGET |             |             |             |                  |
|--------------------|--------|-------------|-------------|-------------|------------------|
|                    | CVLD   |             |             |             |                  |
|                    | MWLD   | APC         | TANK        | HELICOPTER  | TRUCKS AND JEEPS |
| M16 Rifle          | Kill   | -           | -           | Hit or Kill | Hit or Kill      |
| M60 Machine Gun    | Kill   | -           | -           | Hit or Kill | Hit or Kill      |
| M85 Machine Gun    | Kill   | Hit or Kill | -           | Hit or Kill | Hit or Kill      |
| M2 Machine Gun     | Kill   | Hit or Kill | -           | Hit or Kill | Hit or Kill      |
| Coax Machine Gun   | Kill   | -           | -           | Hit or Kill | Hit or Kill      |
| DRAGON Missile     | Kill   | Hit or Kill | -           | Hit or Kill | Hit or Kill      |
| VIPER              | Kill   | Hit or Kill | Hit or Kill | Hit or Kill | Hit or Kill      |
| TOW Missile        | Kill   | Hit or Kill | Hit or Kill | Hit or Kill | Hit or Kill      |
| Shillelagh Missile | Kill   | Hit or Kill | Hit or Kill | Hit or Kill | Hit or Kill      |
| 105mm Gun          | Kill   | Hit or Kill | Hit or Kill | Hit or Kill | Hit or Kill      |
| 152mm Gun          | Kill   | Hit or Kill | Hit or Kill | Hit or Kill | Hit or Kill      |

#### 4.7.2 KILL PROBABILITY

The MILES electronics in the Control Indicator Assembly (CIA) or Loaders Control Assembly (LCA) receives incoming coded weapon hit signatures and then, based upon the weapon/target relationship, performs a decision of hit or kill based on predetermined first round kill probabilities. The first round kill probabilities are listed for ED MILES weapons and the anticipated MILES weapons of the 1980's in table 4-5 with their corresponding first round kill probabilities against men, trucks/jeeps, aircraft and helicopters, APCs and tanks.

Kill probability is executed after each hit detection which for vehicles is for each two code words. Thus, for an eight word coded "round," the kill probability is exercised four times. This routine simplifies the software and provides future flexibility for MILES systems. It has no effect on hit probability vs range, but provides a decreased probability of kill as the range increases. Figure 4-88 compares the  $P_{KILL}$  when kill probability is looked up only once per message, and with  $P_{KILL}$  when the probability is looked up after each hit detection (two words). This graph shows how the MILES  $P_K$  given a hit routine reduces  $P_{KILL}$  as the range increases. \*

#### 4.7.3 WEAPON BASIC LOADS AND FIRING RATES

The MILES logic provides basic ammunition loads and firing rates based on the weapon and in many cases the vehicle in which the weapon is being used. The system was designed to provide for future growth into the 1980's so the CATB weapon's matrix was used to provide basic loads and firing rates in the ED MILES for both ED and future weapons. These weapons, their basic loads and firing rates, are shown in table 4-6.

#### 4.7.4 EFFECTIVE RANGE

Ranges are specified as minimum effective ranges and the MILES equipment is designed to meet these ranges. The ranges are specified as follows:

| <u>WEAPON</u>      | <u>KILL(meters)</u> | <u>NEAR MISS(meters)</u> |
|--------------------|---------------------|--------------------------|
| M16A1 Rifle        | 5 to 460            | 5 to 460                 |
| M60 Machine Gun    | 5 to 800            | 5 to 100                 |
| Coax Machine Gun   | 5 to 800            | 5 to 100                 |
| 105mm Gun          | 50 to 3000          | 50 to 3000               |
| 152mm Gun          | 50 to 2000          | 50 to 2000               |
| VIPER Missile      | 10 to 300           | 10 to 300                |
| DRAGON Missile     | 50 to 1000          | 50 to 1000               |
| TOW Missile        | 50 to 3000          | 50 to 3000               |
| Shillelagh Missile | 800 to 3000         | 800 to 3000              |

TABLE 4-5. KILL PROBABILITY

| CODE WORD<br>110 ..... | WEAPON                                     | WEAPON<br>CODE NO | SINGLE ROUND<br>KILL PROB<br>PERCENT |                        |             |                  |
|------------------------|--------------------------------------------|-------------------|--------------------------------------|------------------------|-------------|------------------|
|                        |                                            |                   | Tanks/<br>M551                       | Aircraft<br>Helicopter | M113<br>APC | Trucks/<br>Jeeps |
| 00101101               | Controller Gun, Universal<br>Hit, 100%     | 00                | 100.000                              | 100.000                | 100.000     | 100.000          |
| 10010011               | Maverick                                   | 01                | 100.000                              | 100.000                | 100.000     | 100.000          |
| 00110101               | TOW, Shillelagh, 100%                      | 02                | 100.000                              | 100.000                | 100.000     | 100.000          |
| 00101011               | Dragon, 100%                               | 03                | 100.000                              | 100.000                | 100.000     | 100.000          |
| 01010011               | Viper, 100%                                | 04                | 100.000                              | 100.000                | 100.000     | 100.000          |
| 10101001               | 152mm, 100%                                | 05                | 100.000                              | 100.000                | 100.000     | 100.000          |
| 01100101               | 105mm, 100%                                | 06                | 100.000                              | 100.000                | 100.000     | 100.000          |
| 11011000               | TOW, Shillelagh, Sagger,<br>Hellfire (ASH) | 07                | 96.875                               | 100.000                | 100.000     | 100.000          |
| 10110100               | Dragon                                     | 08                | 87.500                               | 100.000                | 100.000     | 100.000          |
| 11001001               | M202 Flame                                 | 09                | 78.125                               | 100.000                | 62.500      | 100.000          |
| 01101001               | M21 Anti-Tank                              | 10                | 62.500                               | 100.000                | 78.125      | 100.000          |
| 01001011               | Claymore M81A1, M16 Mine                   | 11                | 0.000                                | 78.125                 | 0.000       | 85.938           |
| 10110010               | 105mm                                      | 12                | 71.875                               | 96.875                 | 87.500      | 96.875           |
| 11001010               | 152mm, 155mm, 8 in.,<br>105 Howitzer       | 13                | 68.750                               | 96.875                 | 84.375      | 96.875           |
| 01011001               | 2.75 in. Rocket                            | 14                | 21.875                               | 96.875                 | 75.000      | 96.875           |
| 10101100               | Viper                                      | 15                | 56.250                               | 62.500                 | 84.375      | 96.875           |
| 01010101               | 120mm                                      | 16                | 73.438                               | 96.875                 | 89.063      | 96.875           |
| 10010101               | 90mm                                       | 17                | 65.625                               | 96.875                 | 82.813      | 96.875           |
| 01100011               | 75mm, 73mm, Russian APC                    | 18                | 62.500                               | 96.875                 | 81.250      | 96.875           |
| 10110001               | Grenade (40mm)                             | 19                | 0.000                                | 56.250                 | 3.125       | 56.250           |
| 11000101               | Rockeye, Cluster Bomb                      | 20                | 3.125                                | 81.250                 | 75.000      | 81.250           |
| 11010100               | GAU-8, AH (30mm)                           | 21                | 62.500                               | 84.375                 | 75.000      | 84.375           |
| 00110011               | Bushmaster (25mm, ZU23-4<br>23mm)          | 22                | 0.000                                | 50.000                 | 9.375       | 43.750           |
| 10001011               | Vulcan, Airborne (20mm)                    | 23                | 0.000                                | 18.750                 | 9.375       | 43.750           |
| 00010111               | M2 or M85 (.50 Cal)                        | 24                | 0.000                                | 15.625                 | 6.250       | 37.500           |
| 10001101               | Roland II, Chaparrel                       | 25                | 0.000                                | 96.875                 | 0.000       | 0.000            |
| 01001101               | Stinger                                    | 26                | 0.000                                | 85.938                 | 0.000       | 0.000            |
| 01000111               | M16 Rifle, M60 and Coax<br>Machine Gun     | 27                | 0.000                                | 9.375                  | 0.000       | 9.375            |

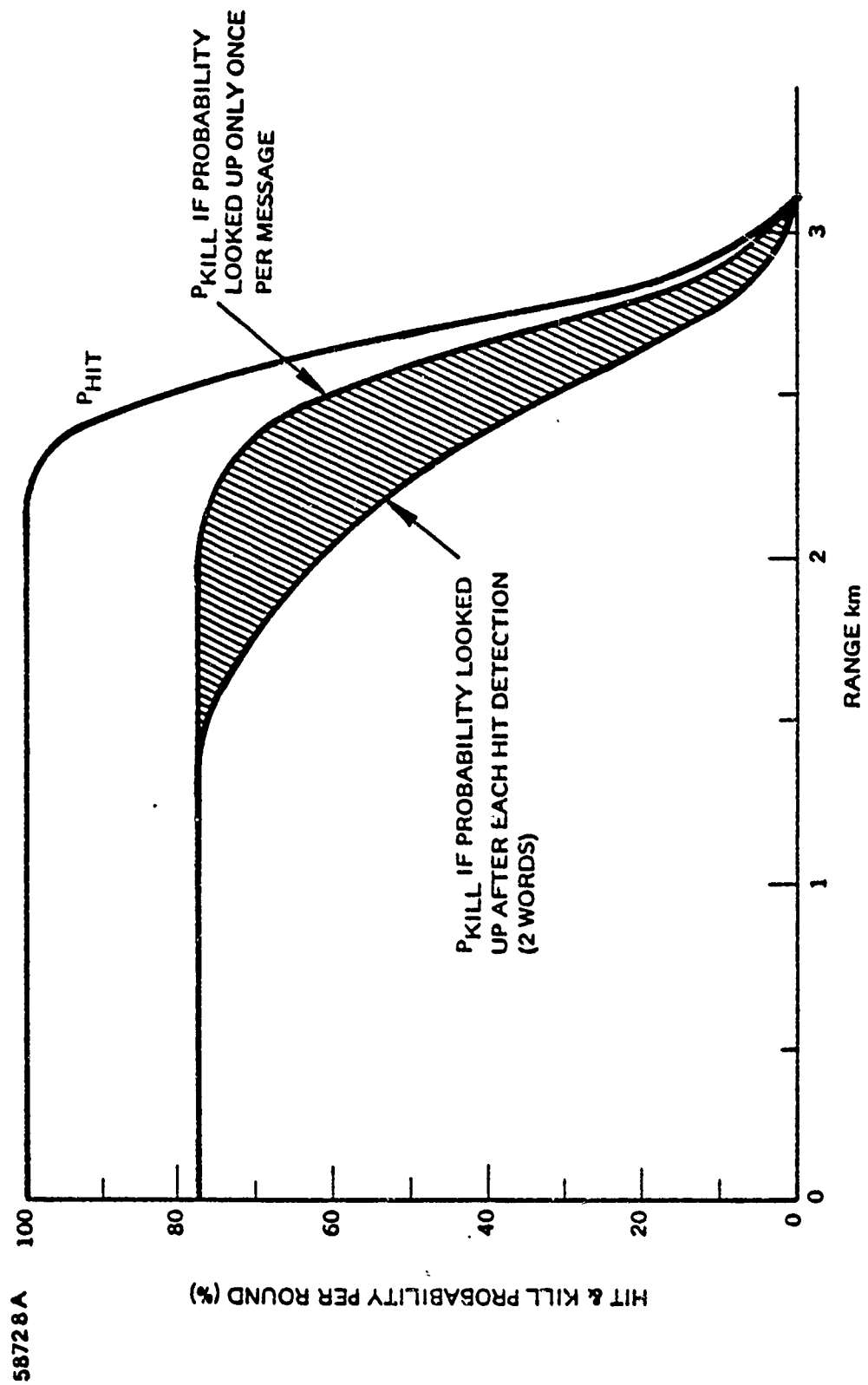


Figure 4-88. Comparison of Kill vs Range Curves for Two Kill Probability Alternatives

TABLE 4-6  
MILES WEAPON SIMULATION

| Weapon                    | Basic Load<br>[Actual] | Basic Load<br>MILES | Firing Rate<br>[Actual] | Firing Rate<br>MILES | Code<br>Hit/NM | Source                |
|---------------------------|------------------------|---------------------|-------------------------|----------------------|----------------|-----------------------|
| <u>SLOW FIRE WEAPONS</u>  |                        |                     |                         |                      |                |                       |
| 100 %105mm                | 63                     | 63                  | 12                      | 12                   | 6/28           | Specification         |
| 100%, 152mm               | 63                     | 30                  | 6                       | 6                    | 5/28           | Specification         |
| 2.75 in. Rocket [4 pods]  | 76                     | 76                  | -                       | 470                  | 14/28          | Army Ref. Guide       |
| 73mm Russian APC          | 30                     | 30                  | -                       | 8                    | 18/28          | MILES Task III Report |
| 105mm                     | 63                     | 63                  | 12                      | 12                   | 12/28          | Specification         |
| 120mm English             | 53                     | 53                  | -                       | 12                   | 16/28          | Janes, pg. 346        |
| 152mm (M551)              | 20                     | 20                  | 6                       | 6                    | 13/28          | Specification         |
| 152mm [M60A2]             | 33                     | 33                  | 6                       | 6                    | 13/28          | Specification         |
| 8 inch Howitzer           | -                      | 99                  | 0.5                     | 2                    | 13/28          | Janes, pg. 412        |
| 105mm Howitzer            | -                      | 99                  | 3                       | 3                    | 13/28          | Janes, pg. 419        |
| Maverick                  | -                      | 4                   | -                       | 2                    | 1/28           | Estimate              |
| Chaparral                 | 12                     | 12                  | 6                       | 4                    | 25/28          | MILES Task III Report |
| 40mm Grenade Launcher     | 300                    | 99                  | 400                     | 133                  | 19/29          | Army Ref. Guide       |
| 90mm M48                  | 60                     | 60                  | -                       | 12                   | 17/28          | Janes, pg. 356        |
| Viper                     | 4                      | 4                   | 6                       | 6                    | 15/28          | Specification         |
| <u>RAPID FIRE WEAPONS</u> |                        |                     |                         |                      |                |                       |
| M73/219 Coax [7.62mm]     | 1800                   | 1800                | 650                     | 682                  | 27/29          | Specification         |
| M60 Helo                  |                        |                     |                         |                      |                |                       |
| Minigun, M28 Helo         | 4000                   | 4000                | 1300                    | 1360                 | 27/29          | Army Ref. Guide       |
| Minigun, M28 Helo         | 4000                   | 4000                | 4000                    | 4090                 | 27/29          | Army Ref. Guide       |
| Minigun, 7.52mm           | 2000                   | 2000                | 2000                    | 2045                 | 27/29          | Army Ref. Guide       |
| M27E1 Helo                |                        |                     |                         |                      |                |                       |
| 20mm M97 Airborne         | 750                    | 800                 | 750                     | 744                  | 23/29          | Army Ref. Guide       |
| Vulcan 20mm               | 1100                   | 1100                | 1000                    | 1023                 | 23/29          | Janes, pg. 100        |
| Vulcan 20mm               | 1100                   | 1100                | 3000                    | 3273                 | 23/29          | Janes, pg. 100        |
| Vulcan 20mm [Airborne]    | 1200                   | 1200                | 6000                    | 5455                 | 23/29          | Janes, pg. 519        |
| ZU23-4                    | -                      | 1800                | 4000                    | 4090                 | 22/29          | Janes, pg. 101        |
| GAU-8 30mm                | 1350                   | 1400                | 2000                    | 2045                 | 21/28          | Janes, pg. 518        |
| GAU-8 30mm                | 1350                   | 1400                | 4000                    | 4090                 | 21/28          | Janes, pg. 518        |
| XM-188 [AH] 30mm          | 600                    | 600                 | 2000                    | 2045                 | 21/28          | Janes, pg. 521        |
| M16A1                     | 210                    | 210                 | 650                     | 682                  | 27/29          | Specification         |
| M2 Machine Gun            | 600                    | 600                 | 650                     | 682                  | 24/29          | Specification         |
| M85 Machine Gun           | 1200                   | 1200                | 650                     | 682                  | 24/29          | Specification         |
| M60 Machine Gun           | 1200                   | 1200                | 650                     | 682                  | 27/29          | Specification         |
| <u>MISSILES</u>           |                        |                     |                         |                      |                |                       |
| 100% TOW; Shillelagh      | 10                     | 10                  | 4                       | 4                    | 2              | Specification         |
| TOW                       | 10                     | 10                  | 4                       | 4                    | 7              | Specification         |
| Shillelagh [M551]         | 9                      | 9                   | 4                       | 4                    | 7              | Specification         |
| Shillelagh [M60A2]        | 13                     | 13                  | 4                       | 4                    | 7              | Specification         |
| Hellfire                  | 16                     | 16                  | 6                       | 4                    | 7              | Estimate              |
| Dragon                    | 10                     | 10                  | 4                       | 4                    | 8              | Specification         |

## 4.8 KILL/HIT/MISS INDICATORS

The indications for kill, hit, or near miss are common throughout the MILES system. Both audio and visual indications are used to alert individuals and controllers to infantry and vehicle status.

### 4.8.1 AUDIO INDICATORS

For the infantry systems, there is an alarm mounted on the left shoulder position of the MWLD harness approximately 9 inches from the soldier's ear (see figure 4-89). This alarm has a peak sound intensity of 65 to 78 dB at 12 inches at a frequency of 2900 + 560 Hz.

The vehicle's audio indicator is an audio tone which is inserted into the vehicles intercom system. The vehicle horn has a peak sound intensity of 115 dB at 5 feet at a frequency of 100 to 500 Hz. The audio indications used are as follows:

- a. Hit - (Vehicles only, not on the MWLD) - Indicates a hit, but not a disabling kill. A series of four to six beeps over a four second period. \*
- b. Near Miss - Two beeps.
- c. Kill - A continuous audio tone - requires a key insertion into a weapon key receptacle to shut off the alarm.

For the TOW system, an audio indicator is installed in the Missile Guidance Set (MGS) Simulator. This device plugs into the coil cord of the TOW traversing unit. If the detectors installed on the TOW tracker head receive a valid hit or near miss from an opposing MILES-equipped weapon, the alarm on the MGS is actuated. The alarm is identical to the one installed on the MWLD. The alarm beeps twice for a near miss and operates continuously for a kill. \*

### 4.8.2 VISUAL INDICATIONS

There are no visual indicators on the MWLD infantry systems.

Vehicle system visual indicators are as follows:

- a. Hit - CVKI flashes four to six times.
- b. Near Miss - CVKI flashes two times.
- c. Kill - There are two indicators, one internal and one external to the vehicle. Internally, the NOT READY light on the Control Console or Control Indicator illuminates and remains on until cleared by a Controller Key in the weapon receptacle of the Control Console or Control Indicator (see figures 4-64 and 4-65). Externally, the CVKI strobe light is activated and flashes continuously until the vehicle system is reset by the Controller. \*

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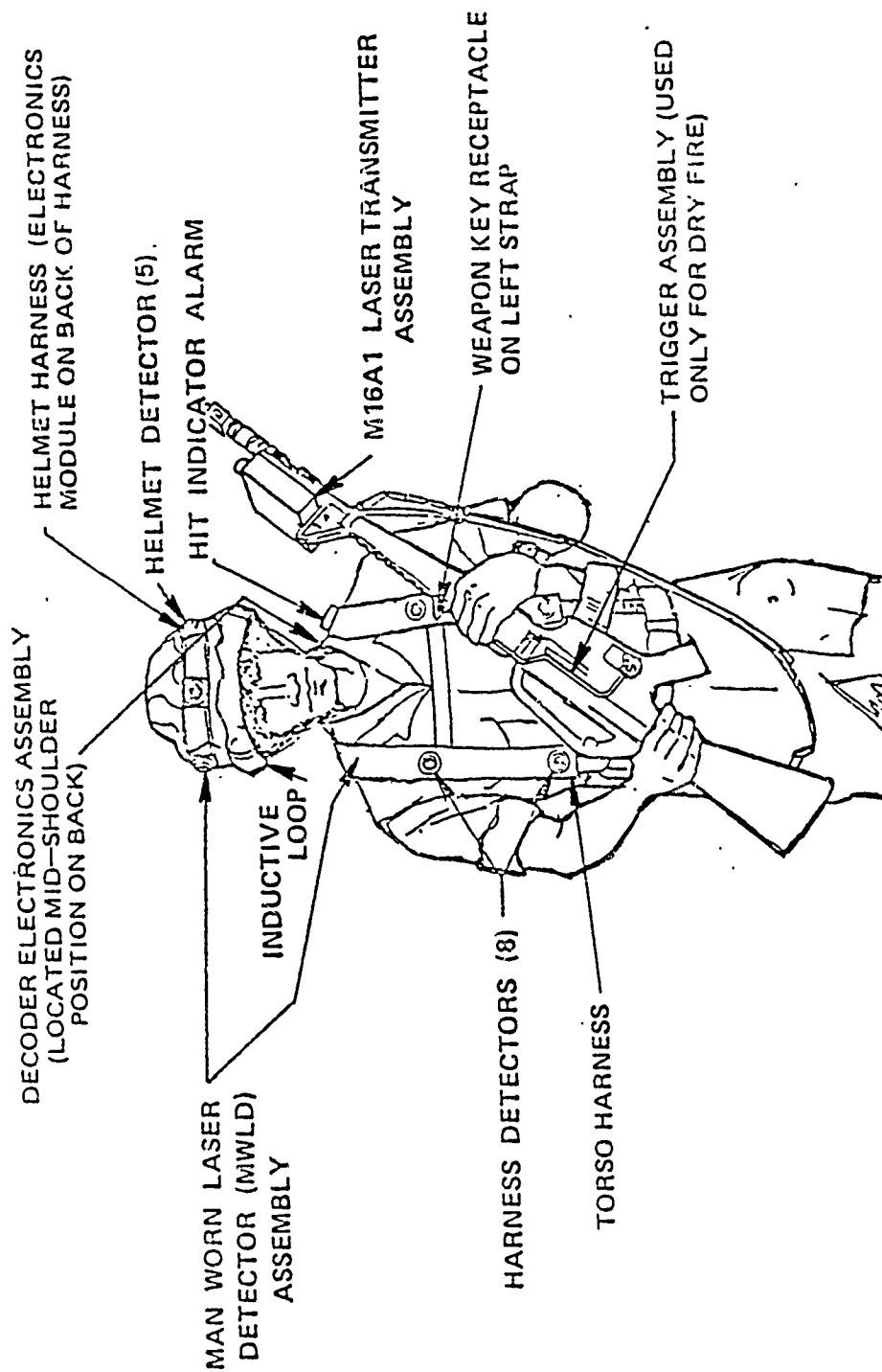


Figure 4-89. Hit Indicator Location - MWLD



Vehicle crewman can determine the type of weapon that hit or killed their vehicle by turning the selector switch on the Control Console or Control Indicator to HIT/KILL, WEP IDENT and pressing the PRESS TO READ button. An illuminated number will appear in the display window. This number can be identified to a weapon or weapon class by finding the number on a casualty assessment card provided to the vehicle crew. An assessment card is depicted in figure 4-63

#### **4.9 WEAPON KEY/CONTROLLER KEY DESCRIPTION AND OPERATION**

Three keys, made of aluminum alloy, are used in the operation of MILES systems. Each of the three keys is configured differently and is of a different color. The keys are designed to prevent incorrect insertion and to preclude the key from falling out of the guide during operation. Figure 4-90 shows the difference in physical configuration of the keys. It also shows a typical independent transmitter and its weapon key receptacle.

##### **4.9.1 KEY DESCRIPTIONS AND FUNCTIONS**

The keys and their functions are summarized below:

- a. Weapon Key - Yellow (Man System). This key is used with the following systems or assemblies:
  - 1. M16A1 Rifle System - Weapon enable/disable
  - 2. M60 Machine Gun System - Weapon enable/disable
  - 3. Man Worn Laser Detection Assembly - Alarm disable
  - 4. DRAGON Missile - Weapon enable/disable

None of the above weapon transmitters will operate without the weapon key installed. The VIPER transmitter will operate without a weapon key, however.

- b. Weapon Key - Orange (Vehicle Systems) This key is used with the following systems or assemblies:
  - 1. M113 APC System
    - M2 Machine Gun Assembly - Weapon enable/disable
    - Control Indicator Assembly - Alarm disable
  - 2. M60A1/A3 Tank System
    - M85 Machine Gun Assembly - Weapon enable/disable
    - Loaders Control Assembly - Alarm disable

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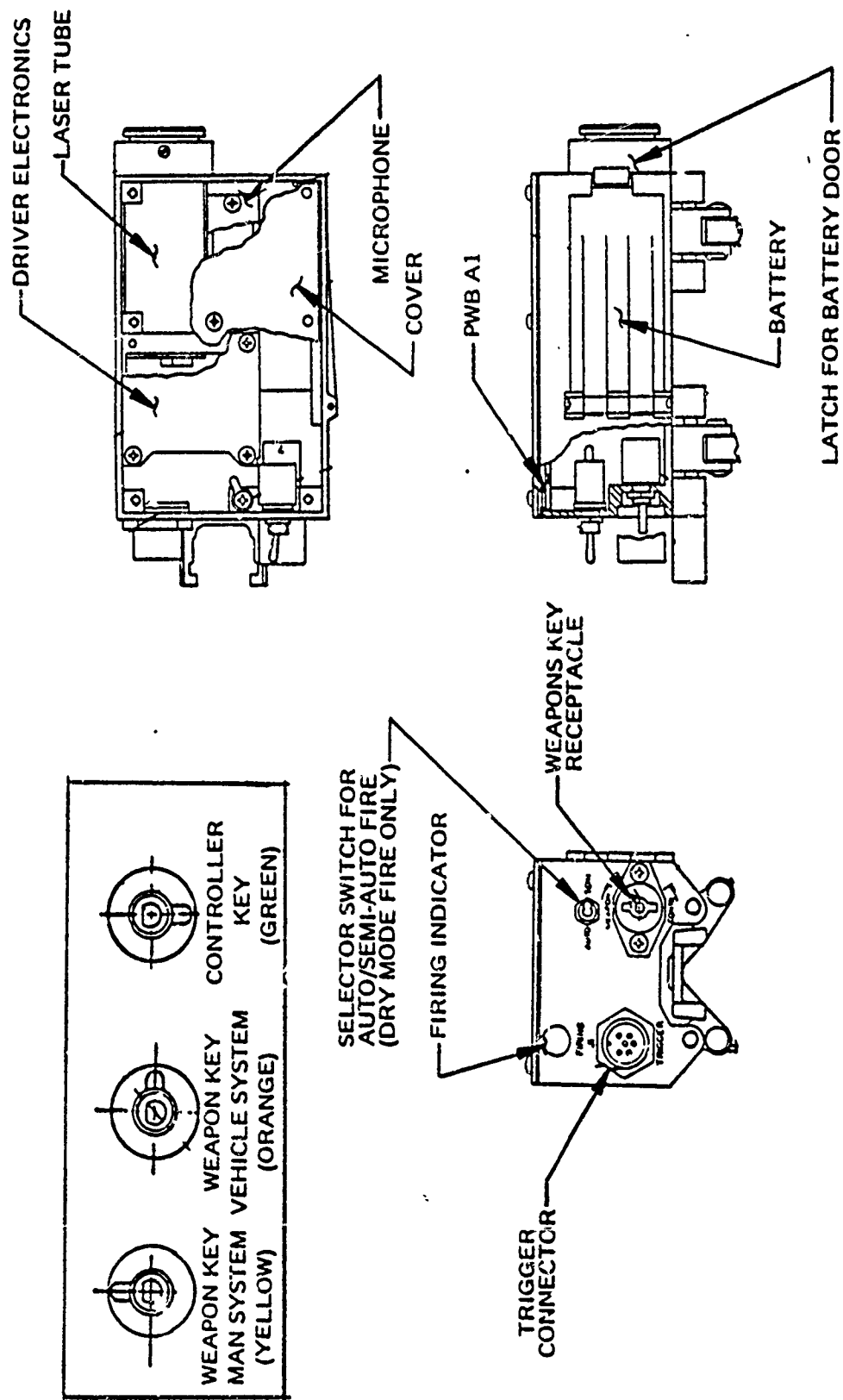


Figure 4-90. Small Weapons Laser Transmitter and Weapon Key Configurations

- c. Controller Key - Green Plastic. The controller key is attached to the lanyard of the Controller Gun (see figure 4-91) and is used with all of the above listed systems. The only exceptions where the controller key is not used or needed are as follows:

- 1. M16 rifle in blank fire mode.
- 2. M60, M2, and M85 machine guns in blank fire mode.

The basic uses of the controller key are to:

- a. Enable (turn on) transmitters in the dry fire mode and supply them with a basic load of ammunition.
- b. Enable dependent transmitters (via the control console) and supply them with a basic load of ammunition.
- c. Reset both the MWLD and CVLD so that they are restored from a *killed* or *standby* condition to an active state.
- d. Run special tests with laser transmitters.
- e. Set laser transmitter for ATWESS or Dry Fire modes.

#### 4.9.2 INDEPENDENT TRANSMITTERS - DRY FIRE MODE

The controller key is required to enable an independent transmitter (M16, M60, M2, M85, VIPER, and DRAGON) and supply it with ammunition. The controller key is inserted into the weapon key receptacle on the laser transmitter. For the TOW, the Controller key receptacle is located on the MGS Simulator. For the M16, M60, M2, or M85, the key is turned to the Controller position. The controller key is then rotated to its initial position and removed. For the DRAGON, VIPER or TOW, the controller key is inserted and rotated to the SET position, then rotated to either DRY FIRE or ATWESS and the key is then removed. Figure 4-92 shows the decal configurations for the VIPER and DRAGON which help to explain the weapon key/controller key operation. The weapon key (yellow for the M16, M60, and DRAGON; orange for the M2 and M85) is then inserted and turned to ON. The weapon is now ready to fire in the dry fire or ATWESS mode. There are no weapon keys for the VIPER or TOW transmitters and they are ready to fire after the controller key operation.

\*

Basic ammunition supply, firing rate, and burst limits are as follows:

- a. M16 - 210 rounds, 678 rounds per minute, 30 rounds per sustained squeeze
- b. M60 - 600 rounds, 678 rounds per minute, 200 rounds per sustained squeeze
- c. M2 and M85 - 1200 rounds, 678 rounds per minute, 200 rounds per sustained squeeze
- d. DRAGON - 4 rounds, 4 rounds per minute

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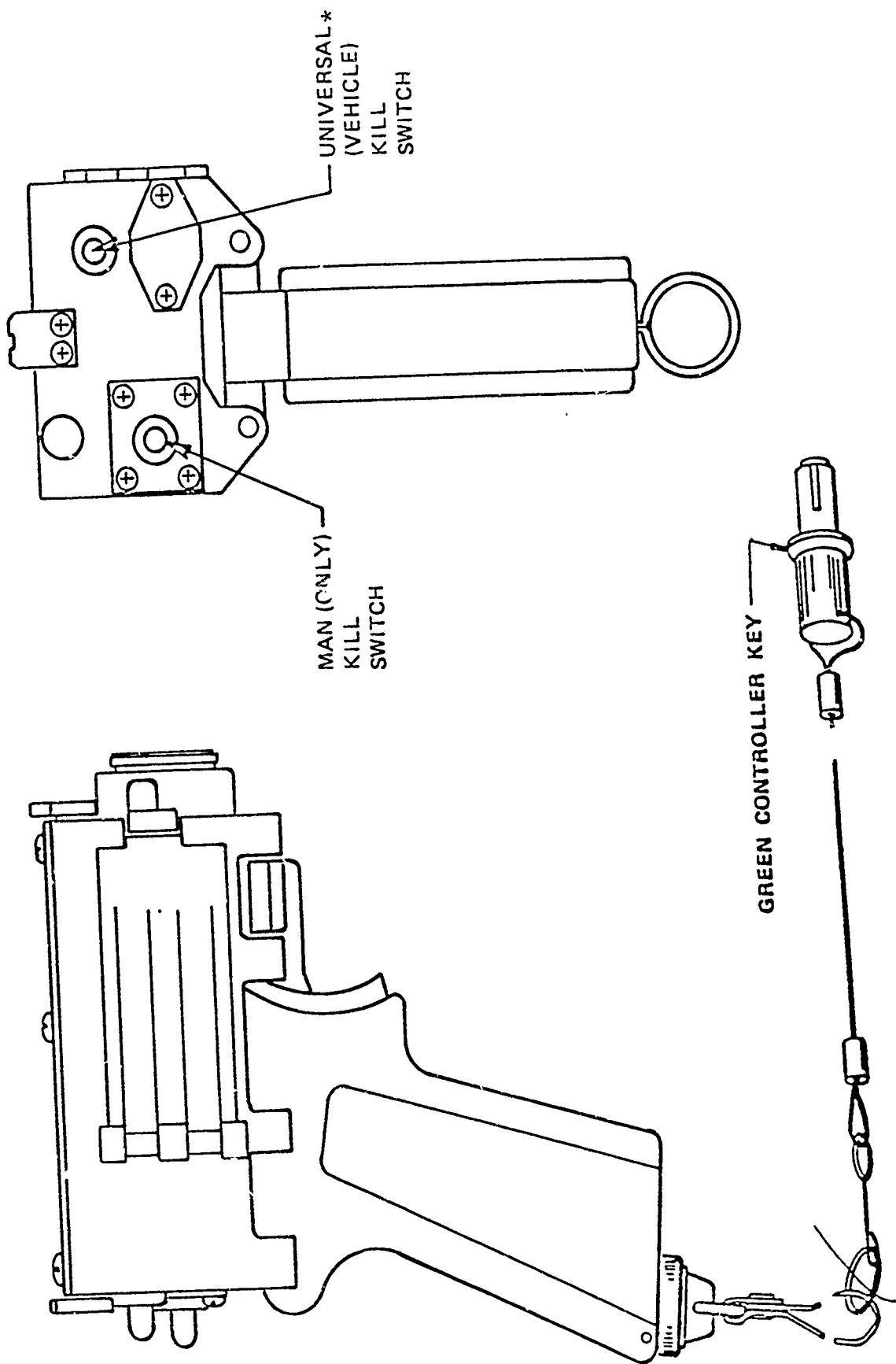
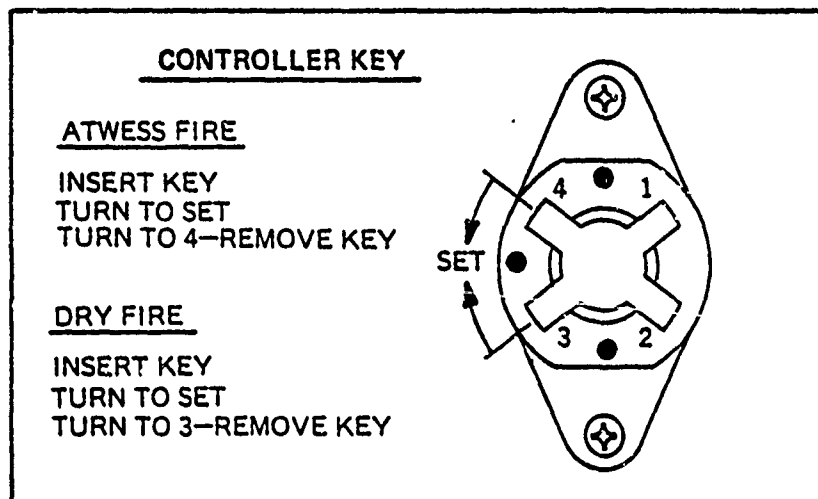
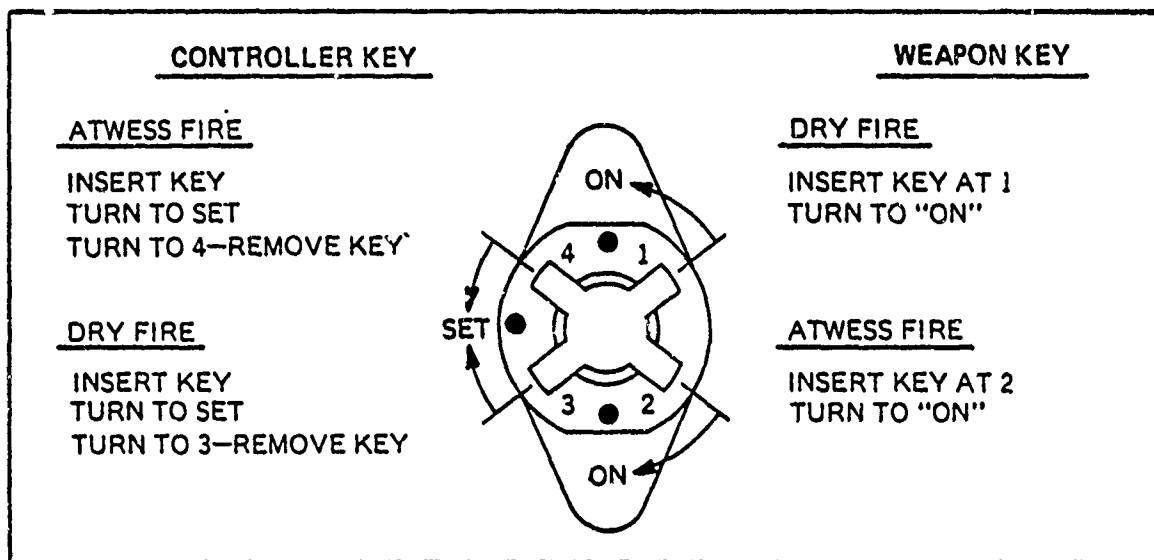


Figure 4-91. Controller Gun Outline Drawing



VIPER DECAL  
CONTROLLER KEY OPERATION  
(NO WEAPON KEY FOR VIPER)



DRAGON DECAL

Figure 4-92. Dragon and Viper Decals Weapon Key/Controller Key Operation

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- e. VIPER - 4 rounds, 6 rounds per minute
- f. TOW - 12 rounds, 4 rounds per minute

For the M16 rifle and the M60, M2, and M85 machine gun laser transmitters there is no indicator in the dry fire mode to show rounds remaining. Each of these weapons has a firing indicator light which illuminates each time a laser round is fired. When all ammunition is expended, the laser will cease to fire and the indicator light will not illuminate.

The DRAGON, VIPER and TOW, when used in the ATWESS mode, are dependent upon ATWESS and the transmitters will not fire unless a live ATWESS cartridge is properly inserted. A closure switch on the ATWESS cartridge allows firing of the laser transmitter when the fuse is intact. Firing of the ATWESS severs the fuse and the transmitter cannot fire again until a new ATWESS cartridge is loaded in the weapon.

The DRAGON, VIPER and TOW each have rounds counters that can be read by pushing a button. The number observed in the window is the total rounds remaining. A "00" indicates that all ammunition is expended. For the TOW, the rounds count button and display window are located on the MGS Simulator which plugs into the traverse unit coil cord.

#### 4.9.3 DEPENDENT TRANSMITTERS

The controller key is required to enable the three dependent transmitters and to restore their basic ammunition loads. This is accomplished by inserting the controller key in the weapon key receptacle on the control console or control indicator (see figures 4-56 and 4-57). The key is turned as shown for CONTROLLER then returned to the initial position and removed. All of the vehicles' dependent transmitters are now ready for action and have a basic load of ammunition.

The weapons, basic loads, and firing rates are as follows:

- a. 105mm/Coax transmitter Assembly
  - 1. 105mm - 63 rounds, 12 rounds per minute
  - 2. Coax Machine Gun - 1800 rounds, 678 rounds per minute. There is no burst limit on the Coax Machine Gun.
- b. 152mm/Coax/Shillelagh Transmitter Assembly
  - 1. 152mm/M60A2 Tank - 33 rounds, 6 rounds per minute
  - 2. 152mm/M551 AARV - 20 rounds, 6 rounds per minute

3. Coax Machine Gun - 1800 rounds, 678 rounds per minute. No burst limit.
4. Shillelagh/M60A2 Tank - 13 rounds, 4 rounds per minute
5. Shillelagh/M551 AARV - 9 rounds, 4 rounds per minute

The rounds remaining can be checked at the control console. This is done by turning the ROUNDS REMAINING switch to the weapon in question and pressing the PRESS TO READ switch. The remaining number of rounds appear as an illuminated number in the DISPLAY window. A "00" means all ammunition for that weapon has been expended.

#### 4.9.4 MWLD AND CVLD Reset

##### 4.9.4.1 MWLD

When the infantryman first checks out the MWLD for use and installs batteries in the torso harness, the kill indicator alarm will sound. This must be shut off with the controller key. The controller key is inserted into the weapon key receptacle on the left front strap of the harness, turned clockwise, then returned to the initial position and removed. the MWLD is now alive and ready for action. The weapon key could be used to silence the alarm, but upon removal of the key the alarm again sounds and the MWLD remains *killed*. When the infantryman is *killed* by an opposing MILES weapon, the alarm on his MWLD sounds continuously. His weapon key must be removed from the weapon and inserted into the weapon key receptacle on the harness, and rotated to shut off the alarm. The MWLD remains in the *killed* state until reset by the controller key. Also, weapon key insertion when MWLD has not yet been *killed* by an opposing MILES weapon will automatically *kill* the MWLD and the alarm will sound if the key is removed.

##### 4.9.4.2 CVLD

When battery power is first applied in the vehicle systems, the vehicle systems go into a standby state which requires the controller key for initialization. The control console will indicate this by displaying the number "33" in all positions when the PRESS TO READ button is pressed. To clear this condition and ready the vehicle for action, the controller key is inserted into the weapon key receptacle on the control console, turned in the direction marked CONTROLLER then returned to its initial position and removed. The CVLD is now initialized and ready for action. (All dependent transmitters have also been reset and supplied with basic loads of ammunition by the above action.)

When the vehicle is *killed*, the dependent transmitters are all automatically disabled by the control console. The orange weapon key from the cupola machine gun (either M2 or M85 depending upon the vehicle) is removed and must be inserted into the weapon key receptacle of the control console and rotated to shut down the intercom alarm. The CVKI strobe light will continue flashing until reset by

the Controller. Removal of the weapon key from the gun disables it. The yellow weapon keys issued to the vehicle crew for use with their MWI.D cannot be used for this function and cannot be inserted into the Control Console receptacle. The orange key, if used in the control console prior to a vehicle kill, will result in a self-kill. If the orange weapon key is removed, the intercom alarm will again be activated along with the CVKI strobe light.

To clear the killed condition of the vehicle, the weapon key must be removed and the controller key inserted, turned in the direction labeled CONTROLLER, returned to the initial position, and removed. The vehicle is then ready for action with all systems restored and resupplied with laser *ammunition*.  
Blank ammunition must be obtained for a full-up system.

\*

#### 4.9.5 SPECIAL TESTS WITH LASER TRANSMITTERS

When it is desired to run special tests on independent weapon laser transmitters where it would be undesired to continue resupplying ammunition, the controller key can be used. With the controller key in and the weapon transmitter turned on, the weapon has unlimited laser ammunition. The rounds count will not be decremented, however, other functions, such as firing rates and burst limits, remain the same.



SECTION 5  
SYSTEM TESTING

XEOS implemented a totally integrated MILES test program during the ED phase. This test program and its results are documented in the "Trainer Test Procedures and Results Report," Data Item A003 of the contract, and XEOS document No. 2350-23016 volumes I, II, III and IV.

The testing and test results were extensive and even a summary is beyond the scope of this document.

## SECTION 6

### RELIABILITY

The reliability requirements and the XEOS plan to achieve them on the MILES hardware were documented in the Trainer Reliability Program Plan, CDRL item D001, XEOS document No. 22640, dated 26 July 1976.

Reliability demonstrations were performed and the results documented in a "Reliability Demonstration Test Report," CDRL item D004 and XEOS document No. 2350-AD-143 and 2350-AD-170.

Table 6-1 is a summary showing the required MTBF for each unit and the estimated MTBF based on a reliability analysis.

Table 6-2 summarizes the reliability test requirements, and table 6-3 the test results. Details of the test results are in the Reliability Demonstration Test Reports.

Table 6-1. RELIABILITY MEAN-TIME-BETWEEN-FAILURE ANALYSIS STATUS

| DESCRIPTION                          | CALCULATED OR<br>ESTIMATED MTBF<br>(HRS) | SPECIFIED<br>MTBF (HRS) | MINIMUM ACCEPTABLE<br>VALUE (MAV) |            |
|--------------------------------------|------------------------------------------|-------------------------|-----------------------------------|------------|
|                                      |                                          |                         | MTBF (HRS)                        | MTBF (HRS) |
| 1. MWLD                              | 2321                                     | 1600                    |                                   | 800        |
| 2. M-16 RIFLE XMTR                   | 1821                                     | 1600                    |                                   | 800        |
| 3. M-2 M. G. XMTR                    | 1834                                     | 1600                    |                                   | 800        |
| 4. M-85 M. G. XMTR                   | 1834                                     | 1600                    |                                   | 800        |
| 5. M-60 M. G. XMTR                   | 1834                                     | 1600                    |                                   | 800        |
| 6. VIPER MISSILE                     | 1830                                     | 1600                    |                                   | 800        |
| 7. DRAGON MISSILE                    | 1801                                     | 1600                    |                                   | 800        |
| 8. CONTROLLER GUN                    | 1982                                     | 1600                    |                                   | 800        |
| 9. FIELD TESTER                      | 5070                                     | 800                     |                                   | 400        |
| 10. VEHICLE SYSTEM<br>CONSISTING OF: |                                          |                         |                                   |            |
| TOW/APC                              | 532                                      | 700                     |                                   | 350        |
| M113/APC                             | 648                                      | 700                     |                                   | 350        |
| M60 A1/A3                            | 532                                      | 700                     |                                   | 350        |
| M551/AARV                            | 539                                      | 700                     |                                   | 350        |
| M60 A2                               | 529                                      | 700                     |                                   | 350        |
| DETECTOR, BELT SETS                  |                                          |                         |                                   |            |
| M113 APC = 6,187 hrs.                |                                          |                         |                                   |            |
| M60 A1/A3 = 7,826 hrs.               |                                          |                         |                                   |            |
| M551 = 11,620 hrs.                   |                                          |                         |                                   |            |
| M60/A2 = 7,747 hrs.                  |                                          |                         |                                   |            |
| TOW/APC = 6,187 hrs.                 |                                          |                         |                                   |            |
| 152 mm/SHIL/COAX XMTR                | 7286                                     | ---                     |                                   | ---        |
| 105 mm/COAX XMTR                     | 7782                                     | ---                     |                                   | ---        |
| TOW XMTR                             | 13661                                    | ---                     |                                   | ---        |
| CVKI                                 | 11547                                    | ---                     |                                   | ---        |
| ASSY, LOADERS CONT                   | 679                                      | ---                     |                                   | ---        |
| ASSY, CONT. IND.                     | 766                                      | ---                     |                                   | ---        |
| 11. ATWESS                           | 1837 (RDS)                               | 1900 (RDS)              |                                   | 950 (RDS)  |

Table 6-2. RELIABILITY DEMONSTRATION

TEST PLAN XX USED FOR AL, TRANSMITTERS  
 TEST PLAN XX1 USED FOR ALL OTHERS  
 (IN ACCORDANCE WITH MIL-STD-781B TEST PLAN)

| DEVICE                 | QTY<br>REQ | DEVICE TEST<br>TIME (HRS) | CUM. TEST<br>TIME HRS |
|------------------------|------------|---------------------------|-----------------------|
| <u>Transmitters</u>    | 26         | ---                       | 6240                  |
| M16                    | 13         | 167                       | ----                  |
| M60                    | 2          | 167                       | ----                  |
| M2                     | 3          | 167                       | ----                  |
| M85                    | 2          | 167                       | ----                  |
| Dragon                 | 1          | 167                       | ----                  |
| Viper                  | 2          | 167                       | ----                  |
| Controller Gun         | 3          | 167                       | ----                  |
| <u>Detectors</u>       | 16         | ---                       | 2944                  |
| Field Tester           | 3          | 184                       | ----                  |
| MWLD                   | 13         | 184                       | ----                  |
| <u>Vehicle Systems</u> | 5          | ---                       | 1288                  |
| TOW                    | 1          | 258                       | ----                  |
| 152 mm/Shil/Coax       | 1          | 258                       | ----                  |
| 105 mm/Coax            | 3          | 258                       | ----                  |
| ATWESS                 | 2          | ---                       | 3496 RDS              |

Table 6-3. RELIABILITY TEST RESULTS SUMMARY

| TEST ITEM          | S/N | Started<br>Test | Comp.<br>Test | Required<br>Test Hrs. | Actual<br>Test Hrs. | Anomaly |
|--------------------|-----|-----------------|---------------|-----------------------|---------------------|---------|
| M16 XMTR           | 033 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M16 XMTR           | 030 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M16 XMTR           | 014 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M16 XMTR           | 034 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M16 XMTR           | 020 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M16 XMTR           | 006 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M16 XMTR           | 027 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M16 XMTR           | 032 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M16 XMTR           | 012 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M16 XMTR           | 016 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M16 XMTR           | 037 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M60 XMTR           | 003 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M2 XMTR            | 009 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M2 XMTR            | 008 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M2 XMTR            | 002 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M85 XMTR           | 009 | 5/24            | 6/1           | 167                   | 185                 | None    |
| M85 XMTR           | 011 | 5/24            | 6/1           | 167                   | 185                 | None    |
| DRAGON XMTR        | 004 | 5/24            | 6/1           | 167                   | 185                 | None    |
| VIPER XMTR         | 012 | 5/24            | 6/1           | 167                   | 185                 | None    |
| VIPER XMTR         | 008 | 5/24            | 6/1           | 167                   | 185                 | None    |
| CONTROLLER GUN     | 004 | 5/24            | 6/1           | 167                   | 185                 | None    |
| CONTROLLER GUN     | 003 | 5/24            | 6/1           | 167                   | 185                 | None    |
| CONTROLLER GUN     | 007 | 5/24            | 6/1           | <u>167</u>            | <u>185</u>          | None    |
| TRANSMITTER TOTALS |     |                 |               | 3841                  | 4255                |         |

Table 6-3. RELIABILITY TEST RESULTS SUMMARY (Cont)

| TEST ITEM             | S/N | Started<br>Test | Comp.<br>Test | Required<br>Test Hrs. | Actual<br>Test Hrs. | Anomaly |
|-----------------------|-----|-----------------|---------------|-----------------------|---------------------|---------|
| FIELD TESTER          | C36 | 6/14            | 6/22          | 184                   | 189                 | None    |
| FIELD TESTER          | 010 | 6/14            | 6/22          | 184                   | 189                 | None    |
| FIELD TESTER          | 002 | 6/14            | 6/22          | 184                   | 189                 | Yes**   |
| MWLD SET 1 T018/H036* |     | 5/24            | 6/1           | 184                   | 185                 | None    |
| MWLD SET 2 T016/H113  |     | 5/24            | 6/1           | 184                   | 185                 | None    |
| MWLD SET 3 T015/H041  |     | 5/24            | 6/1           | 184                   | 185                 | None    |
| MWLD SET 4 T015/H115  |     | 5/24            | 6/1           | 184                   | 185                 | None    |
| MWLD SET 5 T020/H037  |     | 5/24            | 6/1           | 184                   | 185                 | None    |
| MWLD SET 6 T058/H039  |     | 5/24            | 6/1           | 184                   | 185                 | None    |
| MWLD SET 7 T012/H038  |     | 5/24            | 6/1           | 184                   | 185                 | None    |
| MWLD SET 8 T021/H120  |     | 5/24            | 6/1           | 184                   | 185                 | None    |
| MWLD SET 9 T075/H007  |     | 5/24            | 6/1           | 184                   | 185                 | None    |
| MWLD SET 10 T105/H008 |     | 5/24            | 6/1           | 184                   | 185                 | None    |
| MWLD SET 11 T062/H035 |     | 5/24            | 6/1           | 184                   | 185                 | None    |
| MWLD SET 12 T093/H040 |     | 5/24            | 6/1           | 184                   | 185                 | None    |
| MWLD SET 13 T069/H009 |     | 5/24            | 6/1           | 184                   | 185                 | None    |
| DETECTOR TOTALS       |     |                 |               | 2944                  | 2960                |         |

\* T = Torso

H = Helmet

\*\* See Book I Part I  
Section 7.0 of  
2350-AD-143

Table 6-3. RELIABILITY TEST RESULTS SUMMARY (Cont)

| TEST ITEM             | S/N | Start<br>Test | Comp.<br>Test | Required<br>Test Hrs. | Actual<br>Test Hrs. | Anomaly |
|-----------------------|-----|---------------|---------------|-----------------------|---------------------|---------|
| LCA                   | 006 | 5/24          | 6/5           | 258                   | 284                 | None    |
| LCA                   | 024 | 5/24          | 6/5           | 258                   | 284                 | None    |
| LCA                   | 012 | 5/24          | 6/5           | 258                   | 284                 | None    |
| LCA                   | 014 | 5/24          | 6/5           | 250                   | 284                 | None    |
| LCA                   | 017 | 5/24          | 6/5           | 258                   | 284                 | None    |
| APC BELT SET          | 001 | 5/24          | 6/5           | 258                   | 284                 | None    |
| CVKI                  | 010 | 5/24          | 5/5           | 258                   | 284                 | None    |
| CVKI                  | 006 | 5/24          | 6/5           | 258                   | 284                 | None    |
| CVKI                  | 007 | 5/24          | 6/5           | 258                   | 284                 | None    |
| CVKI                  | 009 | 5/24          | 6/5           | 258                   | 284                 | None    |
| CVKI                  | 002 | 5/24          | 6/5           | 250                   | 284                 | None    |
| 152 mm XMTR           | 001 | 5/24          | 6/5           | 258                   | 284                 | None    |
| TOW XMTR              | 002 | 5/24          | 6/5           | 258                   | 284                 | Yes**   |
| TOW XMTR              | 004 | 6/14          | 6/26          | 258                   | 285                 | None    |
| 105 mm XMTR           | 013 | 5/24          | 6/5           | 258                   | 284                 | None    |
| 105 mm XMTR           | 014 | 5/24          | 6/5           | 258                   | 284                 | None    |
| 105 mm XMTR           | 002 | 5/24          | 6/15          | 258                   | 284                 | None    |
| M60 BELT SET          | 001 | 5/24          | 6/5           | 258                   | 284                 | None    |
| M60 BELT SET          | 002 | 5/24          | 6/5           | 258                   | 284                 | None    |
| M5C BELT SET          | 033 | 5/24          | 6/5           | 258                   | 284                 | None    |
| M551 BELT SET         | 011 | 5/24          | 6/5           | 258                   | 284                 | None    |
| VEHICLE SYSTEMS TOTAL |     |               |               | 5160                  | 5965                |         |

\*\* See Book I Part I  
Section 7.0 Par. 3.  
of 2350-AD-143

Retest

Table 6-3. RELIABILITY TEST RESULTS SUMMARY (Cont)

| TEST ITEM             | 3/N   | Started<br>Test | Comp.<br>Test | Required<br>Rounds Fired | Actual<br>Rounds Fired     | Anomaly |
|-----------------------|-------|-----------------|---------------|--------------------------|----------------------------|---------|
| M16 XMTR              | 075   | 5/26            | 7/5           | 5000                     | 5166                       | Yes **  |
| M16 XMTR              | 117   | 5/26            | 7/5           | 5000                     | 5130                       | Yes **  |
| M60 XMTR              | 007   | 5/26            | 7/5           | <u>22000</u>             | <u>22682</u>               | Yes **  |
| BLANK FIRE TOTALS     |       |                 |               | 32000                    | 32978                      |         |
| 11749562<br>SIMULATOR | 023   | 5/2/79          | 5/31/79       |                          | 1256                       | Yes *** |
| 11749562<br>SIMULATOR | 030   | 5/2/79          | 5/31/79       | 3496                     | <u>2240</u><br><u>3496</u> | Yes *** |
| 11749380<br>CARTRIDGE | (LOT) | 5/2/79          | 5/31/79       |                          | <u>3496</u>                | Yes *** |
| ATWESS TOTALS         |       |                 |               |                          | 3496                       |         |

\*\* See Book I Part II  
Section 7.0 of  
2350-AD-143

\*\*\* See Book I Part II  
Section 7 and 8.0  
of 2350-AD-170



SECTION 7  
MAINTAINABILITY

The maintainability requirements and the XEOS plan to achieve them on the MILES hardware are documented in the Trainer Maintainability Program Plan, CDRL item D005, XEOS document No. 22644, issued 23 July 1976 to NTEC.

Results of the Maintainability Demonstration are documented in the "Trainer Maintainability Demonstration Test Report," CDRL item D008, XEOS document No. 2350-AD-148. Table 7-1 summarizes the test results.

Table 7-1. Maintainability Test Results Summary

|                               | MTTR<br>Required | MTTR<br>Demonstrated* |
|-------------------------------|------------------|-----------------------|
| Organizational<br>Level Tasks | 30 Min<br>Max    | 4 Min, 13 Sec.        |
| Intermediate<br>Level Tasks   | 60 Min<br>Max    | 27 Min, 58 Sec.       |

\*MTTRs shown are an average of all MILES systems tested.

SECTION 8  
EMI SUPPRESSION

For the ED program, an Electromagnetic Interference (EMI) Control Plan was written, CDRL item D00A and XEOS document No. 22646. The plan was a guideline for the ED design and testing.

Results of EMI testing of the MILES systems are documented in CDRL item A003 of the contract and XEOS document No. 2350-23016.

## SECTION 9

### WORST CASE ANALYSIS

Worst case analysis combines the worst tolerance variations of all circuit components. Statistically, the situation described by such cases is extremely unlikely. Worst case analysis, therefore, gives a highly prejudicial view of the ability of a system to perform adequately. The intention here, and the real value of such an analysis, is to demonstrate that even at the tolerance extremes, there is no catastrophic failure and that reasonable performance continues.

#### 9.1 LASER OUTPUT ENERGY

Since all transmitters are calibrated at room temperature, we treat here effects only at the temperature extremes. Further, since the temperature compensation network is designed for all components having nominal temperature characteristics, we only address variations from the nominal temperature characteristics of the components.

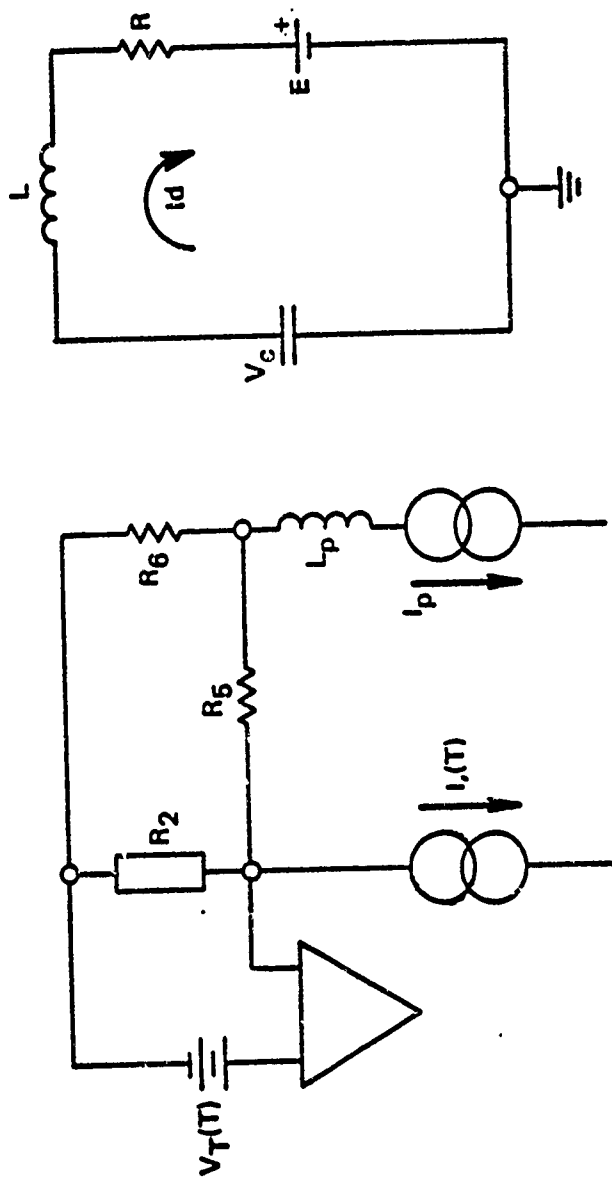
Figure 9-1 gives the model and equations governing  $I_D$ , the laser peak drive current. Table 9-1 defines the parameters used in this model and equations. The following assumptions apply:

- a.  $E \ll V_c$  so errors in the  $E$  term may be neglected.
- b. All carbon composition resistors have repeatable TCs and their variation over temperature, although significant, is repeatable to a high ( $\pm 1$  percent) precision. Therefore, they contribute to TC errors in the order of  $\pm 2$  percent in  $I_D$ .
- c. Thermistors are highly accurate and do not contribute more than  $\pm 1$  percent to output current error.

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ED MILES PARAMETER VALUES

$L = 75 \times 10^{-9} \text{ H}$   
 $R = 2 \text{ OHMS}$   
 $R_6 = 2 \text{ TO } 10 \text{ OHMS}$   
 $R_5 = 11 \text{ K}$   
 $R_2 = 3 \text{ K TO } 28 \text{ K}$   
 $V_T (25^\circ \text{C}) = 1.1 \text{ V}$   
 $I_1 (25^\circ \text{C}) = 100 \mu \text{ A}$   
 $L_p = 1.25 \times 10^{-3} \text{ H}$



$$(2) V_c = I_p \sqrt{L_p/C}$$

NOTE: IN PRACTICE, R IS  
NEGLEGIBLY SMALL AND  
EQUATION 3 REDUCES TO:

$$(3a) I_d \approx (V_c - E) \sqrt{C/L}$$

$$(1) I_p = 1/R_6 [V_T(1+R_5/R_2) - I_1, K_5]$$

$$(3) I_D = \frac{(V_c - E)(1 - R^2 C/4L) \exp[-RA/2Lw]}{wL}$$

WHERE

$$w = \sqrt{1/LC - R^2/4L^2}$$

$$A = \tan^{-1} \sqrt{4L/R^2C} - 1$$

Figure 9-1. Laser Output Energy Model

TABLE 9-1

## DEFINITION OF PARAMETERS

|                |   |                                                 |
|----------------|---|-------------------------------------------------|
| E              | = | laser and SCR voltage drop during current pulse |
| V <sub>c</sub> | = | storage capacitor voltage                       |
| TC             | = | temperature compensation                        |
| I <sub>D</sub> | = | laser peak drive current                        |
| L              | = | discharge loop inductance                       |
| L <sub>p</sub> | = | transformer primary inductance                  |
| C              | = | capacitance (of storage capacitor)              |
| T              | = | temperature                                     |
| I <sub>p</sub> | = | peak current in L <sub>p</sub>                  |
| I <sub>T</sub> | = | diode threshold current                         |
| K              | = | slope efficiency                                |
| PW             | = | pulsewidth                                      |
| I <sub>1</sub> | = | LSI input bias current                          |
| H              | = | laser output energy                             |

- d. The sense resistors, being wire-wound from low temperature coefficient wire do not contribute to I<sub>D</sub> error. This leaves, as the only other error sources in generating a TC'd laser drive current, unpredictable errors in L, L<sub>p</sub>, and C.

Looking at figure 9-1, if we substitute Eq. 1 into Eq. 2, and Eq. 2 into Eq. 3, and neglect E, we obtain:

$$I_D \approx \sqrt{\frac{L_p}{L}} \cdot \frac{1}{R_6} [V_T (1+R_5/R_2) - I_1 R_5] \quad (4)$$

Now, L<sub>p</sub>, the transformer primary inductance, is specified to be within ±10 percent over the temperature range. This will, of course, yield ±5 percent in I<sub>D</sub> if we assume that unit-to-unit unpredictability in L<sub>p</sub> (CT) will indeed vary this much. (This is rather unlikely, but must be assumed in the worst case.)

The discharge loop inductance, L, is not controlled by specification, but has never been observed to vary significantly with temperature. Nevertheless, we shall assign a worst case variation of ±5 percent to it. This will yield a ±2.5 percent variation in drive current, but will produce a partially compensating ±2.5 percent change in pulsewidth. Change in pulsewidth will be tabulated in table 9-3.

Finally, we have unpredictable variations in C. They do not affect  $I_D$ , since C is transparent in the energy transfer from  $1/2 I_p^2/L_p$  to  $1/2 I_D^2 L$ . They do, however, affect pulsewidth.

$$H = 2 \sqrt{L_p C} \cdot K \left\{ \sqrt{I_D^2 \cdot I_T^2} - I_T \sin^{-1} [(I_T/I_D)] \right\} \quad (5)$$

where:

K = diode slope efficiency  
 $I_T$  = diode threshold current

Equation 5 shows that pulsewidth (and energy output) is proportional to the square root of C. The MIL Spec for ceramic capacitors allows a  $\pm 15$  percent capacitance change at  $-55^\circ$  and  $+125^\circ\text{C}$ . We shall assume the MILES capacitors have worst case unpredictable capacitance variations of  $\pm 10$  percent at the MILES temperature extremes. This reflects into a  $\pm 5$  percent variation in pulsewidth (and energy output) as will be shown in table 9-3).

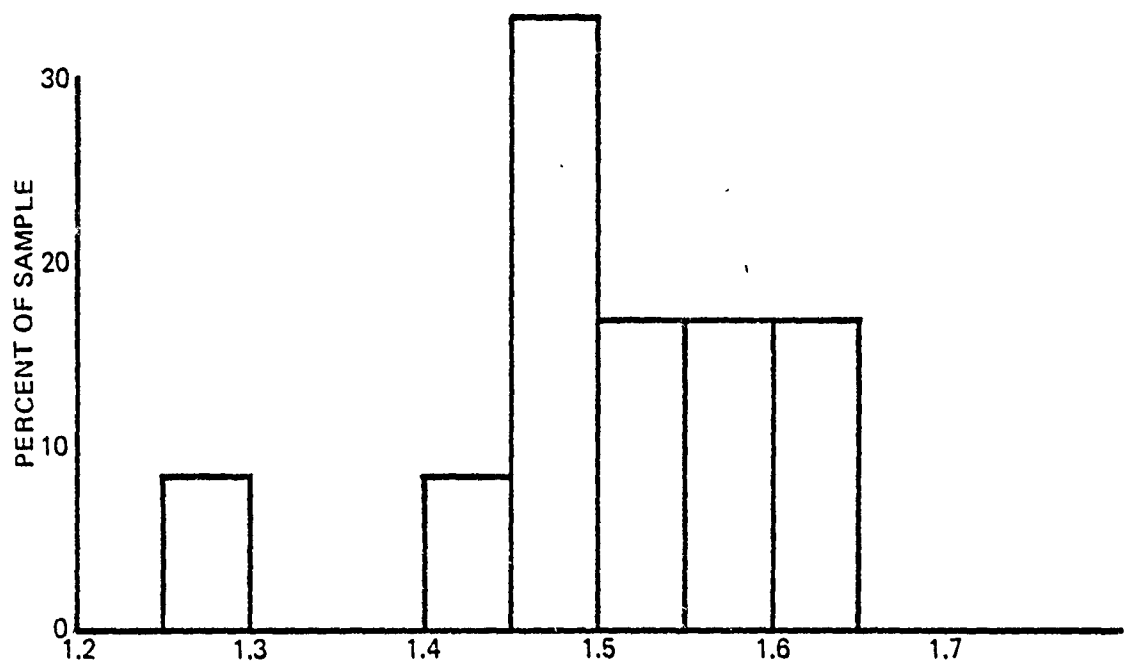
Unpredictability in  $I_D$  is now given by the following budget of errors:

|                                        | $\Delta I_D$<br>(%)          |
|----------------------------------------|------------------------------|
| Carbon composition resistors           | 2.0                          |
| Thermistors                            | 1.0                          |
| E (SCR and laser voltage drop)         | -0-                          |
| Wire-wound resistors                   | -0-                          |
| $L_p$ (transformer primary inductance) | 5.0                          |
| L (discharge loop inductance)          | 2.5                          |
| C (storage capacitor)                  | -0-                          |
|                                        | <u><math>\pm 10.5</math></u> |

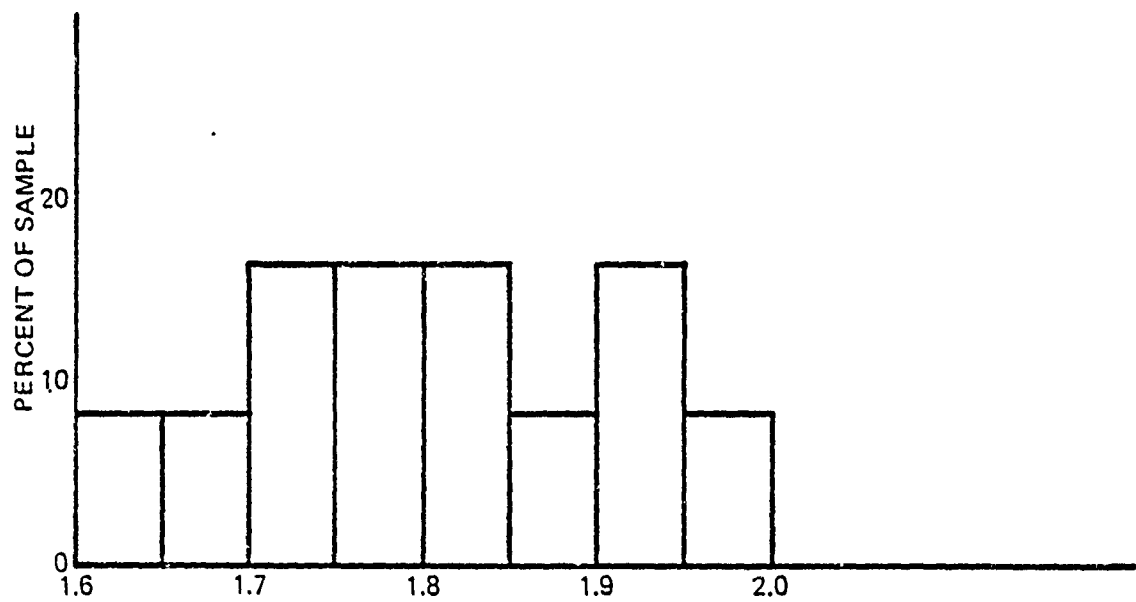
In the worst case, errors add together linearly as shown.

Finally, we must treat the effects of diode-to-diode variations. These effects are not present when 6-mil, single heterostructure diodes are used, since TC networks are designed for each individual diode. However, on multiheterostructure (MH) diodes, unit-to-unit variations are small enough so that we attempt to use a common TC network for each weapon type.

Figures 9-2 and 9-3 show variations in current drive compensation required over a sample of diodes. The variables presented here are the factors by which current must be increased or decreased at temperature extremes to maintain constant output energy. The temperatures for which we have data are  $-25^\circ\text{C}$  and  $+75^\circ\text{C}$ . The histograms show that the worst case distribution (6 mils @  $-25^\circ\text{C}$ ) has a  $\pm 13.8$  percent uncertainty. We shall use  $\pm 15$  percent for worst case.

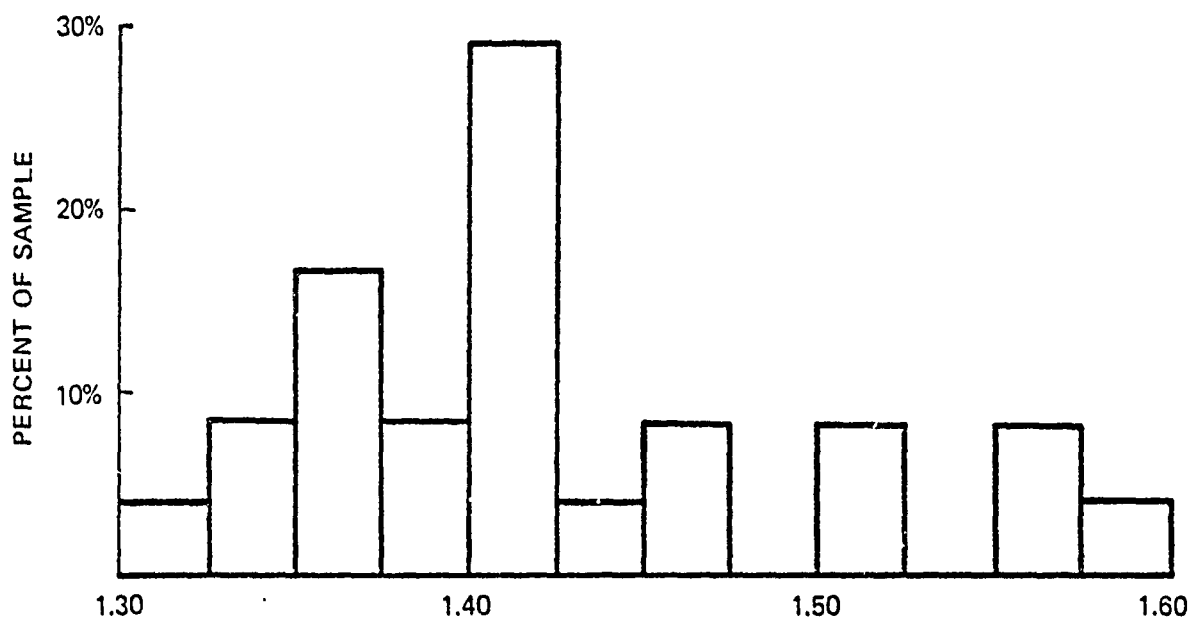


(a)  $I_{25}/I_{25}$  FOR CONSTANT OUTPUT POWER

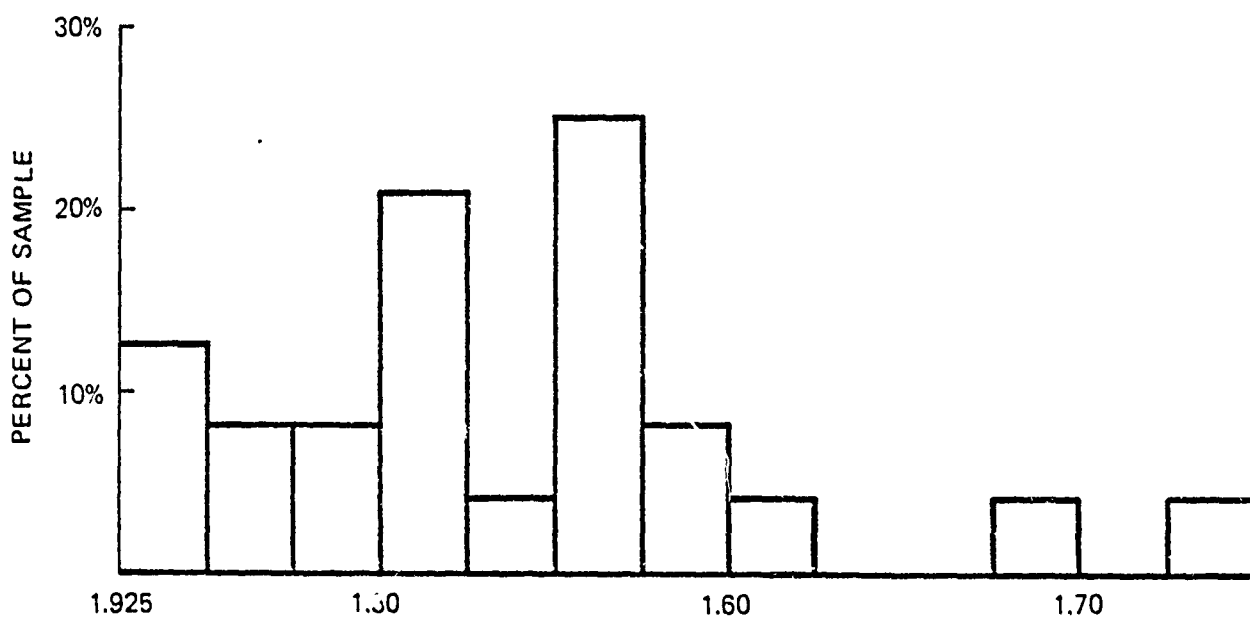


(b)  $I_{75}/I_{25}$  FOR CONSTANT OUTPUT POWER

Figure 9-2. Current Drive Ratio Histograms, 6-Mil  
RCA Multi-Heterostructure Prototypes



(a)  $I_{25}/I_{-25}$  FOR CONSTANT  $P_o$



(b)  $I_{75}/I_{25}$  FOR CONSTANT  $P_o$

Figure 9-3. Current Drive Ratio Histograms, 3-Mil RCA Multi-Heterostructure Prototypes



We must now allocate the  $\pm 15$  percent between slope efficiency,  $K$ , and threshold,  $I_T$ . We assume that  $K$  and  $I_T$  uncertainties are both  $\pm 10$  percent.

The expression in braces (from Eq. 5) is now evaluated at worst case extremes of  $I_T$  and  $I_D$  for a unit operating as close to threshold as is allowed on ED MILES:  $I_D/I_T = 1.4$ . Table 9-2 presents the results.

TABLE 9-2  
OUTPUT VARIATIONS DUE TO CHANGES IN  $I_T$  AND  $I_D$

| Condition               | $I_T$ | $I_D$ | { * } | { * }<br>Normalized |
|-------------------------|-------|-------|-------|---------------------|
| $I_T+10\%$ ; $I_D-10\%$ | 7.7   | 9     | 0.48  | 0.30                |
| Nominal                 | 7.0   | 10    | 1.58  | 1.00                |
| $I_T-10\%$ ; $I_D+10\%$ | 6.4   | 11    | 2.86  | 1.81                |

\*{from Eq. 5}

Table 9-3 now summarizes error sources and presents the total worst case laser output error at temperature extremes.

TABLE 9-3  
LASER OUTPUT ENERGY  
ERROR SUMMARY

|                                                                                     |                        |
|-------------------------------------------------------------------------------------|------------------------|
| Variation in drive current, $I_D$                                                   | $\pm 10.5\%$           |
| Variation in threshold current, $I_T$                                               | $\pm 10\%$             |
| Variation in output energy due to<br>$\Delta I_D$ and $\Delta I_T$ (from table 9-2) | {+81%}<br>{-70%}       |
| Variation in PW due to C                                                            | $\pm 5\%$              |
| Variation in PW due to L**                                                          | $\pm 2.5\%$            |
| Total output energy variation<br>due to $\Delta PW$                                 | $\pm 5\%$              |
| Variation in output energy due to<br>slope efficiency variations                    | $\pm 10\%$             |
| Total possible variation in output<br>energy                                        | {+100.4%}<br>{- 73.7%} |

\*\*The variation in PW due to L always partially compensates for variation in peak current.

Table 9-3 indicates that the low output energy may, in the worst case, drop to one-fourth its nominal value, thus halving the system range and beam size at a temperature extreme. However, it should be remembered that it is extremely unlikely that all the necessary conditions would occur simultaneously to cause this event to happen.

## 9.2 REGULATORS

Tables 9-4 and 9-5 give typical values for output voltages of the two voltage regulators in MILES. Tolerances are also shown. Data are measured, and tolerances are the 3  $\delta$  values from Interdesign, the monochip manufacturer.

TABLE 9-4

### LOOP RECEIVER-HORN DRIVER REGULATOR VOLTAGE

|      |      | <u>Battery Voltage</u> |            |             | ±5% Mfg. tolerance on<br>monochip 3 $\delta$ values. |
|------|------|------------------------|------------|-------------|------------------------------------------------------|
|      |      | <u>+6V</u>             | <u>+9V</u> | <u>+12V</u> |                                                      |
| Temp | +75° | 3.56                   | 3.60       | 3.64        |                                                      |
|      | +25° | 4.26                   | 4.30       | 4.34        |                                                      |
|      | -31° | 5.04                   | 5.09       | 5.14        |                                                      |

Regulation: 0.1 to 2.0 mA  $\approx$  -90 mV

TABLE 9-5

### LASER DRIVER INTERFACE REGULATOR VOLTAGE

|          |      | <u>Battery Voltage</u> |            |             | ±10% |
|----------|------|------------------------|------------|-------------|------|
|          |      | <u>+6.8V</u>           | <u>+9V</u> | <u>+12V</u> |      |
| PIN      | +75° | 3.75                   | 3.79       | 3.83        |      |
| 14       | +25° | 4.47                   | 4.51       | 4.55        |      |
| (Hi Cur) | -31° | 5.27                   | 5.32       | 5.37        |      |

Regulation: 0.0 to 40 mA = -7 mV

|          |      | <u>Battery Voltage</u> |            |             | ±10% |
|----------|------|------------------------|------------|-------------|------|
|          |      | <u>+6.8V</u>           | <u>+9V</u> | <u>+12V</u> |      |
| PIN      | +75° | 4.38                   | 4.42       | 4.46        |      |
| 1        | +25° | 5.10                   | 5.14       | 5.19        |      |
| (Lo Cur) | -31° | 5.90                   | 5.95       | 6.0         |      |

Regulation: 0.0 to 40 mA on pin 14 = +0.2V

The LRHD (Loop Receiver Horn Driver) regulator is used in the MWLD to power the CMOS LSI decoder, which requires a voltage range of 3 to 6.0V. The worst case low voltage occurs at end of battery life and at 75°C where the voltage is  $0.95 \times 3.56 - 0.09V = 3.114V$  which is safe. Worst case high voltage is at a 12V battery voltage and -31°C where the voltage is  $1.05 \times 5.14V = 5.397V$ , again, a safe value.

The LDI (Laser Driver Interface) regulator is used in all independent transmitters and in the LCA/CIA. Its most demanding load is the 1802 microprocessor, which requires 3.5V to 6.0V.

The microprocessor is driven by different regulator outputs according to the high temperature extreme it will be exposed to. Weapons exposed to blank fire heating (M16, M60, M85, M2) have their 1802s connected to pin 1, the low current, high voltage pin. Weapons not exposed to this environment, but containing displays requiring high current, are configured using the high current low voltage output, pin 14. Data were taken only at +75°C, so we must interpolate to obtain pin 14 data at +65°C. Linear interpolation yields a typical output voltage of 3.89V for pin 14 at +65°C and a battery voltage of 6.8V. Applying a factor of 0.9 for the  $\pm 10\%$  tolerance yields a worst case microprocessor voltage of 3.5V, just meeting the worst case microprocessor requirement.

In blank fire heated transmitters using pin 1 at 75°C, we have a worst case low voltage of  $0.9 \times 4.38V = 3.942V$ , again, sufficient for the microprocessor. Worst case high voltage will occur on pin 1 at -31°C and 12V battery voltage. That voltage is  $1.1 \times 6.6 + 0.2 = 5.8V$ . (The voltage at pin 1 increases as load is applied to pin 14 owing to the fact that pin 1 is a control voltage which is automatically raised to account for increased load on pin 14.)

### 9.3 RECEIVER SENSITIVITY

Table 9-6 presents energy-to-threshold data measured on ED production units. The most sensitive parameter in MILES signal detection is the fraction of detectors exposed. If only one detector is exposed, all the energy must be captured by it, and a high exposure in  $\text{ergs/cm}^2$  is required. If all are exposed, then the effective aperture is increased, and a lower exposure will trigger the system.

TABLE 9-6

TYPICAL THRESHOLD ENERGY IN  $\mu\text{ergs}$

|             |      | Battery Voltage |      |      |      |
|-------------|------|-----------------|------|------|------|
|             |      | +6.8V           | +9V  | +12V |      |
| 8 Detectors | Temp | +65°            | 29.0 | 28.0 | 27.0 |
|             |      | +25°            | 26.0 | 25.0 | 24.0 |
|             |      | -35°            | 22.0 | 21.5 | 21.0 |

|             |      | Battery Voltage |      |      |      |
|-------------|------|-----------------|------|------|------|
|             |      | +6.8V           | +9V  | +11V |      |
| 5 Detectors | Temp | +65°            | 23.0 | 22.0 | 21.0 |
|             |      | +25°            | 21.0 |      | 19.0 |
|             |      | -35°            | 18.0 |      | 17.5 |

- a. Most sensitive - An eight-detector belt, at the low end of the  $\pm 25\%$  tolerance, with all eight detectors receiving signal, at 12V and  $-25^\circ\text{C}$ .

$$* \underline{E_x} = 21 \times 0.75/8 = 1.97 \mu\text{ergs/cm}^2$$

- b. Least sensitive - An eight-detector belt at the high end of the  $\pm 25\%$  tolerance, with only one detector exposed, at 6.5V and  $65^\circ\text{C}$ .

$$\overline{E_x} = (29.0)(1.25)/1 = 36.25 \mu\text{ergs/cm}^2$$

This difference in sensitivity as detectors are covered or exposed is used to advantage.

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$$* \underline{E_x} = \text{exposure, } \mu\text{ergs/cm}^2$$

MILES belts are configured on vehicles and men in order to use variations in number of detectors to tailor hit probabilities to target profile. A more useful calculation is to determine, for a given number of detectors exposed, what the worst case variation in threshold exposure is.

The eight-detector belt has slightly more variation with battery and temperature:

Most sensitive +12V, -35°C, -25% => 15.75  $\mu$ ergs

Least sensitive +6.8V, +65°C, +25% => 36.25  $\mu$ ergs

Thus the difference between the two extreme (3  $\sigma$ ) units is slightly over a factor of two.

#### 9.4 CONCLUSIONS

The foregoing worst case analyses indicate that even with extreme combinations of tolerances, the MILES system will function and not suffer catastrophic failure.

The most variable feature is the laser output energy which, as shown in table 9-3, may vary from one-fourth to twice the nominal value. This situation may be improved significantly if the nominal ratio of peak diode current-to-threshold current is raised to about two to one as shown in table 9-7. This change is contemplated as a future product improvement wherein laser output at a nominal drive current will be standardized by selecting neutral density filters to be associated with each laser.

Table 9-7 should be contrasted with table 9-2. Rather than the original worst case variations of +81 percent and -70 percent, the variations are now reduced to +35 percent and -42 percent. This reduction results from using a nominal ratio of  $I_D/I_T$  of 2.

TABLE 9-7

OUTPUT VARIATIONS DUE TO CHANGES IN  $I_T$  AND  $I_D$   
 FOR  $I_T/I_D = 2.0$  NOMINAL

|                      | <u><math>I_T</math></u> | <u><math>I_D</math></u> | <u>{ * }</u> | <u>{ <sup>*</sup> Normalized }</u> |
|----------------------|-------------------------|-------------------------|--------------|------------------------------------|
| $I_T+10\%; I_D-10\%$ | 7.7                     | 12.6                    | 4.91         | 0.58                               |
| Nominal              | 7.0                     | 14.0                    | 8.46         | 1.00                               |
| $I_T-10\%; I_D+10\%$ | 6.3                     | 15.4                    | 11.40        | 1.35                               |

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\* From Eq. 5

## SECTION 10

\*

### FIELD SUPPORT EQUIPMENT

#### 10.1 INTRODUCTION

This report describes the engineering design of the MILES Vehicle Test Set and the Small Arms Alignment Fixture. The Vehicle Test Set is used to troubleshoot and fault isolate MILES equipment used on vehicles and the Small Arms Alignment Fixture is used to boresight small arms MILES transmitters (specifically the M16A1 rifle and M60 machine gun) to the weapon sights.

##### 10.1.1 VEHICLE TEST SET

The Vehicle Test Set is a small, portable support equipment item used to fault isolate MILES vehicle systems to the level of vehicle belt segments, control or indicator consoles, kill indicators, cables, and power supplies (vehicle power or MILES battery supplies). This device is designed to be carried to MILES-equipped vehicles in the field.

All power to operate the test set is received from the system under test, therefore, the test set contains no internal power. All gauges, switches, and input and output connectors are located on the front panel which is protected when in transit by a hinged, gasketed water resistant cover.

Analog displays mounted on the front panel are used to indicate belt noise levels and dc voltages. An audio indicator is used to indicate the presence of the combat vehicle kill indicator (CVKI) trigger signal from the vehicle's control console.

The test set may be used at any time vehicle equipment problems occur, but is primarily used for troubleshooting during initial installation of MILES equipment on vehicles. In addition, the test set may be used to check the condition of 6 volt and 9 volt batteries used in all MILES systems including those used in the small arms systems.

#### 10.1.2 SMALL ARMS ALIGNMENT FIXTURE

The Small Arms Alignment Fixture is an electronically operated device used to aid in boresighting the MILES laser transmitter to the sights of the M16A1 rifle and M60 machine gun. This procedure is conducted when a MILES laser transmitter is first attached to the weapon and at any other time that a soldier would normally be expected to adjust his sights.

Weapon sight alignment is performed at a standard range of 25 meters. The center of the front panel of the alignment fixture resembles a standard paper target used in the Army including the notched rectangular "bullseye." With the MILES transmitter attached to his weapon, a soldier aims and fires at the target. An array of receiving diodes located behind the target face receive the laser signal and calculate how far and the direction the laser signal was from the center. Numbers displayed on the front panel indicate the number of "clicks" and direction the soldier must adjust his sights in order to hit the center of the target.

Subsection 10.2 of this report provides a system analysis including a description of the training problem and technical approach. Subsection 10.3 contains the design approach, design considerations, and assumptions used in the design of these support items. Subsection 10.4 contains the quality assurance, reliability, and maintainability requirements.



## 10.2 SYSTEM ANALYSIS

### 10.2.1 VEHICLE TEST SET

If a MILES vehicle system does not operate properly, a number of fault possibilities exist, depending upon the symptoms. The problem could lie with a defective component, such as a malfunctioning detector belt segment, a faulty control or indicator console, an inoperative combat vehicle kill indicator (CVKI), or a low battery. A problem could also exist in the interconnecting cabling. Other fault possibilities include dirty connections or a defect in the vehicle's own electrical system.

The purpose of the Vehicle Test Set is to provide a means to quickly test the vehicle system in the field and to isolate the problem to a MILES component that can be repaired or replaced by the vehicle crew.

### 10.2.2 SMALL ARMS ALIGNMENT FIXTURE

Unlike the Vehicle Test Set, which is used only for troubleshooting, the Small Arms Alignment Fixture is typically used at the beginning of every exercise. Following initial installation of MILES transmitters on the M16A1 rifle and M60 machine gun, some means must be provided to adjust the sights on these weapons to the optical axis of the transmitter.

The path of the laser transmitter signal differs from the trajectory of a live round fired from the same weapon because of two reasons:

- a. The path of the transmitter signal is straight rather than following a curved trajectory as would a live round.
- b. The optical axis of the transmitter is offset from the center of the gun barrel by a small amount.

These two factors, therefore, cause the sight adjustments to be different than the soldier would normally have them set for firing live rounds, and the Small Arms Alignment Fixture provides the means to accurately and quickly perform the weapon sight adjustment.

In use, the alignment fixture is set up in the field and each soldier, in turn, fires his MILES-equipped weapon at the target on the front panel from a standard distance of 25 meters. An array of receiving detectors installed behind the target face register the location where the MILES laser beam hit the display and the internal microprocessor calculates the vector from the target center. This value is calculated in terms of the number of "clicks" and the direction the soldier must turn the adjustments on his weapon sights in order to bring the firing point to the center of the display.

These numbers are displayed on four electromagnetic displays located adjacent to the four sides of the target. When zeroes appear in all four displays, the target center was hit and no further weapon sight adjustment is necessary.

Because the number of weapon sight "clicks" differ between the M16A1 rifle and M60 machine gun, a switch on the front panel of the alignment fixture changes the operating mode for the weapon type being aligned.

### 10.3 DESIGN APPROACH

#### 10.3.1 VEHICLE TEST SET

In arriving at a final configuration for the Vehicle Test Set, consideration was heavily affected by how the test set was to be used and who would be using and operating it. Since the Controller's Gun is needed to perform final vehicle system checkout and to initialize the system, the controller was designated to provide and to operate the test set. If a problem occurred requiring use of the test set, the controller, based on the symptom, would determine which tests to perform. He would connect the test set and with the help of the vehicle crew, check out the system. If a component was discovered to be faulty, the vehicle crew would be responsible for replacing it.

##### 10.3.1.1 Physical Description

Since the test set must be carried to the vehicle, it must be small, lightweight, and be able to withstand the environmental conditions imposed on equipment used on the battlefield such as temperature, humidity, shock, dust, and vibration. The final physical configuration, as shown in figure 10.1, was the use of an aluminum case approximately 13.5 inches by 8 inches by 5.7 inches. Total unit weight is approximately 10 pounds.

The cover is attached to the case with a piano-type hinge and the inside of the cover has a hinged tray. A decal with operating instructions is attached to the face of the tray. The space below the tray

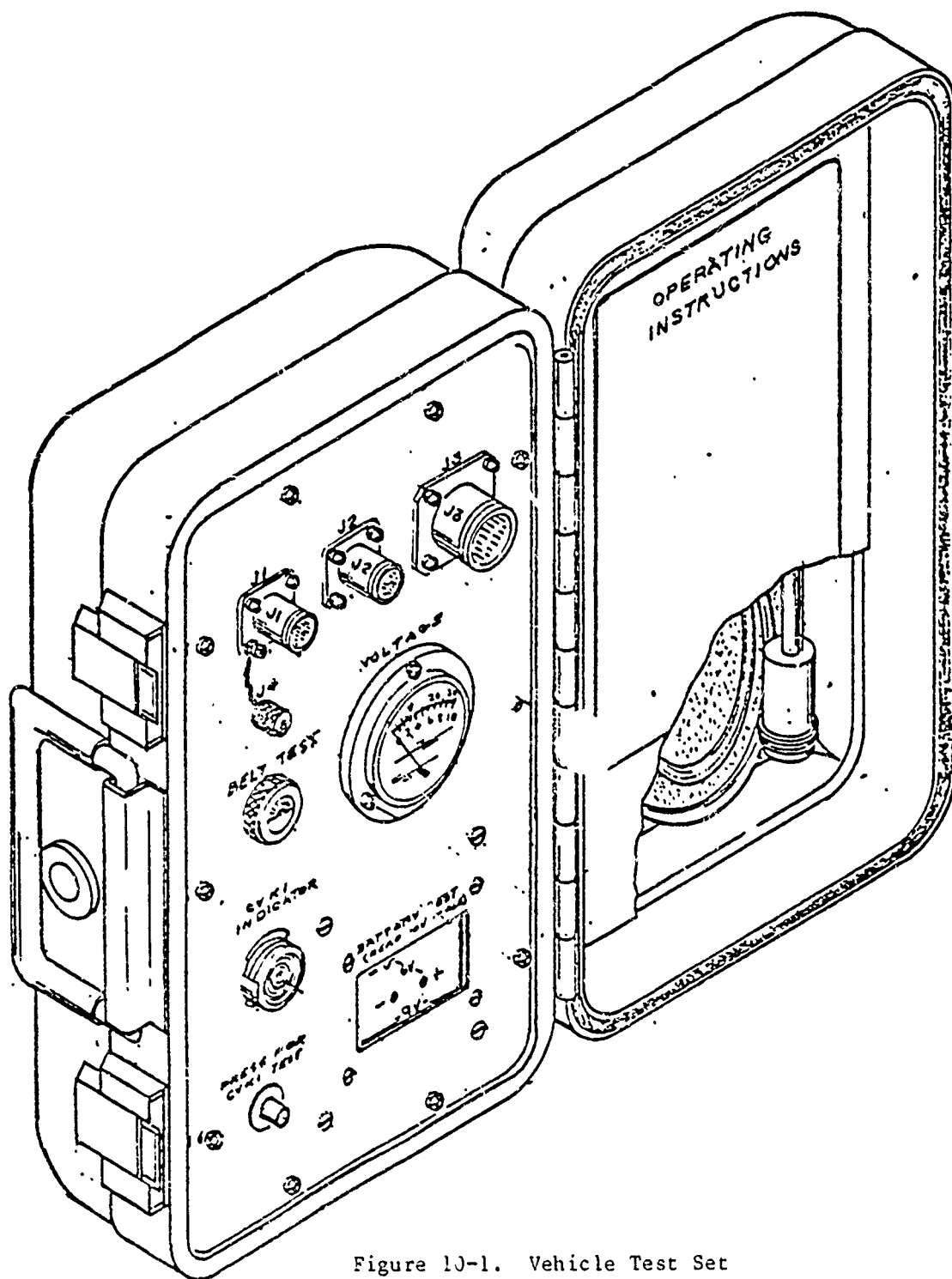


Figure 10-1. Vehicle Test Set

is used to store the jumper cable which is used for certain trouble-shooting tests. The side opposite the hinge contains a carrying handle, two guarded, springloaded latches, one on either side of the handle, and a pressure relief valve. When the cover is closed and latched, the interior of the case is protected from external environmental conditions.

The front panel of the test set contains all of the meters, gauges, and input jacks. All of the electronic components are contained on one plug-in printed circuit board. Access to the board is gained by removing the ten screws from around the edge of the front panel and lifting the front panel from the case. The printed circuit board can then be removed by unplugging the four connectors from the board and removing the four screws holding the board to the case.

Because of the different size plugs and pin arrangements used in the MILES cables, it is not possible to insert a plug into the wrong jack on the test set. Since only dc voltages are present in the MILES system with a maximum value of less than 30 volts, one voltmeter with two scales (0 to 30 volts and 0 to 10 volts) is used to measure all voltages. The 0 to 10 volt scale is used when testing the condition of batteries using the front panel test pads.

#### 10.3.1.2 Basic Operation

An analysis of MILES vehicle systems indicated that there are five major tasks required of the test set. These are:

##### a. Control Console/Indicator Check

To check operation of a vehicle control console or control indicator, the CVKI cable is disconnected from the console or indicator and attached to the appropriate jack on the test set. Battery voltages can then be read on the test

set voltmeter and false bit counts from the detector belts can be read on the test set bit count meter. Also, the CVKI and interconnecting cabling can be checked by depressing a push button on the test set and observing the CVKI for proper operation.

b. Belt Segment Check

To check one or more vehicle detector belt segments, the test set is connected in series with the detector belts. The test set may be connected at various locations around the vehicle depending on which belt or belts are to be checked. A jumper cable, normally stored behind a tray in the front cover, is provided for connecting into the system. Once connected to the vehicle belts the false bit count value is read on the bit count meter on the test set. The maximum allowable bit count value varies depending on how many belts are connected and whether the detectors are in the sun or shade. Instructions which accompany the test set list the various acceptable false bit count values.

c. CVKI Check

To check operation of the CVKI, the cable to the CVKI is disconnected and attached to a jack on the test set. An audio indicator on the test set sounds when detector belts are illuminated by the Controller Gun. This tone indicates the presence of a signal to the CVKI.

d. Battery Check

To check battery voltages, the battery terminals are pressed against test pads on the front panel of the test set and the voltage is read on a meter. Since only two types of batteries are used in the MILES system (6-volt lantern type and 9-volt transistor type), the test pads are so arranged to accept only these two types of batteries.

e. Trigger Signal Check

To ensure the vehicle control console is receiving the proper trigger signal voltage, the trigger cable to the console is connected to the test set, the appropriate trigger is pulled, and the voltage level of that signal is read on the Voltage meter on the 30V scale. Schematic diagrams for the Vehicle Test and its jumper cable are shown in figures 10-2 and 10-3.

f. Battery Box Check

To ensure that the MILES system is receiving the proper voltage level from the Battery Box, a jumper cable, normally stored behind a tray in front cover, is provided to connect to the Battery Box. Once connected to the Battery Box the voltage output will be displayed on the VOLTAGE meter.

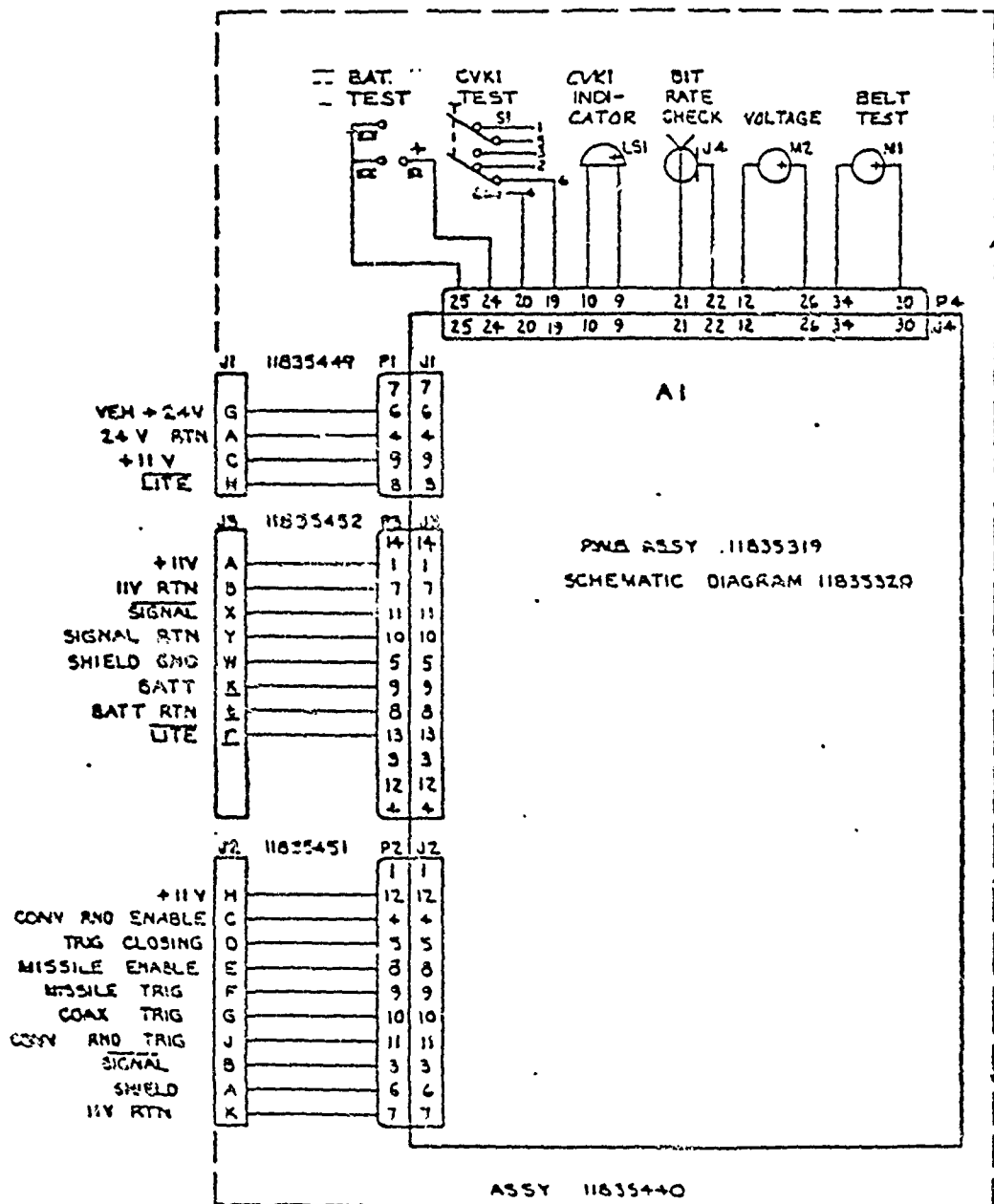


Figure 10-2. Vehicle Test Set Connection Diagram

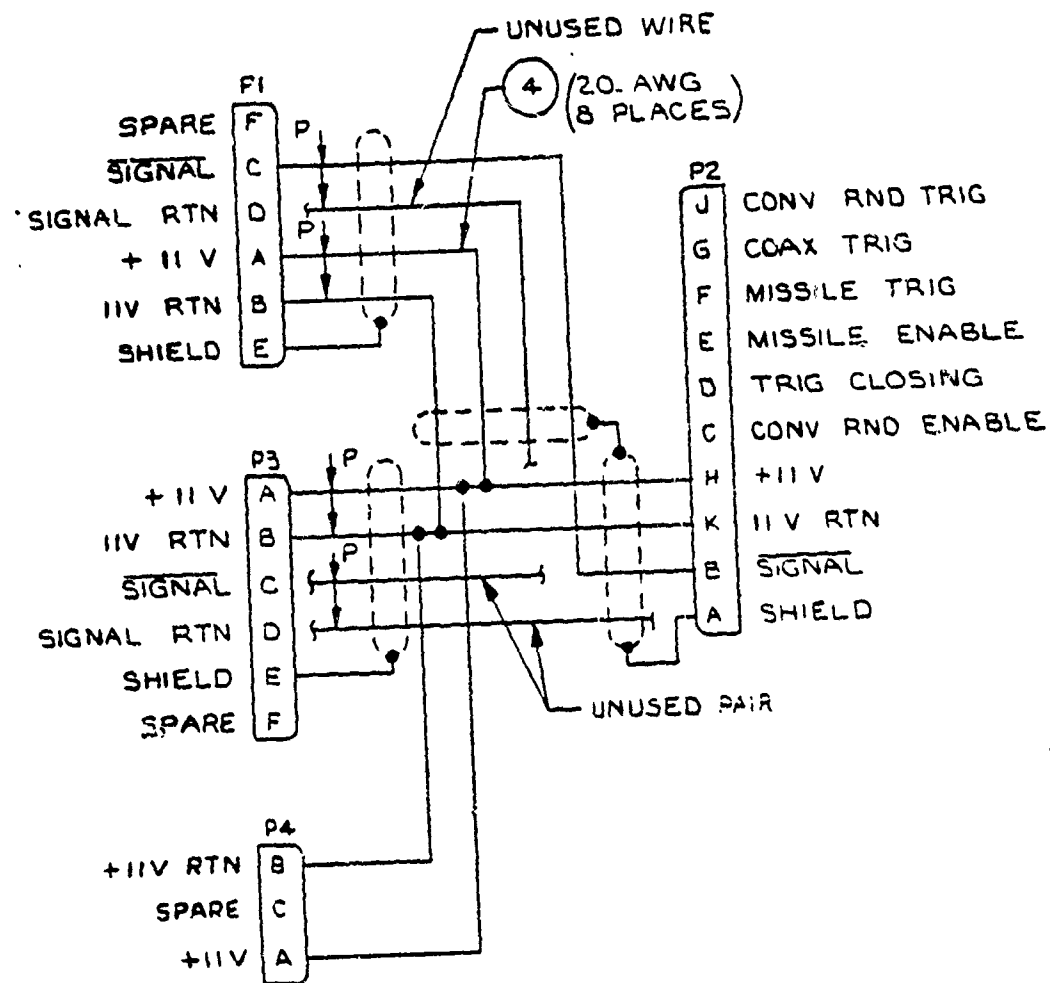


Figure 10-3. Jumper Cable, Schematic Diagram



### 10.3.1.3 Electrical Design

The printed circuit board for Vehicle Test Set (shown in figures 10-4) can be divided into two sections: (1) a bit rate integrator with meter interface; and (2) a meter interface for various voltage sources.

The bit rate integrator receives its inputs from BIT RATE CHECK (J4) (via connector J4, pin 21) or SIGNAL (via connector J2, pin 3 or connector J3, pin 11). These signals generate standard-sized pulses which are continuously integrated by a meter interface circuit. The meter interface circuit will condition the signal for compatibility with the BELT TEST meter (via connector J4, pin 30 and pin 34).

The meter interface circuit for the various voltage sources takes into consideration each different source. The impedance match and voltage division necessary for each source to make it compatible with the VOLTAGE meter is incorporated in the meter interface. VR1 protects the VOLTAGE meter by limiting meter current to approximately 120 percent of full scale. The VOLTAGE meter output is via connector J4, pin 26 and pin 12.

### 10.3.2 SMALL ARMS ALIGNMENT FIXTURE

#### 10.3.2.1 Physical Description

The major physical design constraint was that the fixture must be packaged to withstand the environmental rigors of field use. The exterior dimensions of the fixture are 23 by 23 by 12 inches and weight is approximately 60 pounds. The case is constructed of aluminum and painted olive drab.

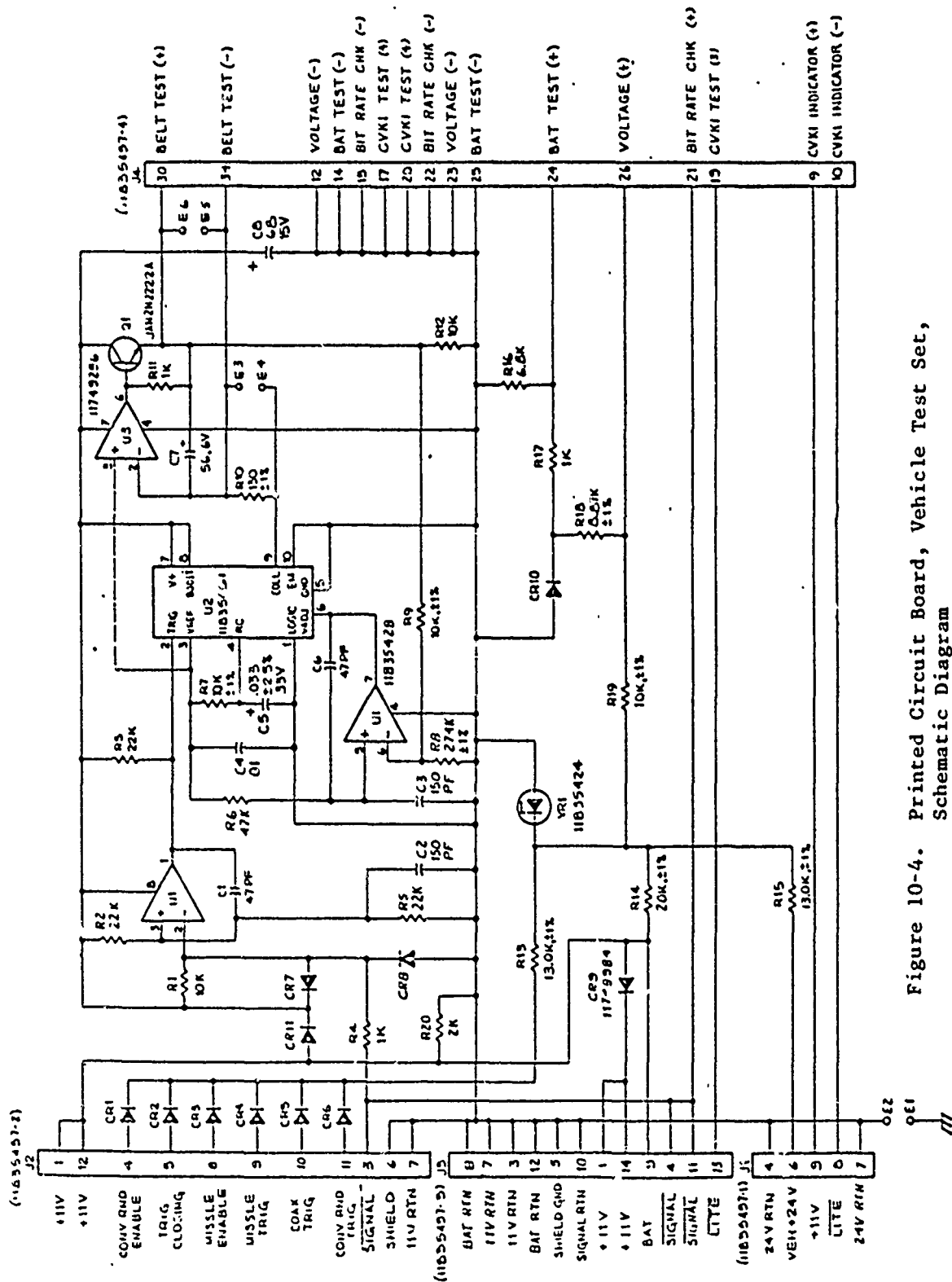


Figure 10-4. Printed Circuit Board, Vehicle Test Set, Schematic Diagram

To operate, the fixture was designed to be placed on the ground. As shown in figure 10-5, the bottom portion of the case remains flat on the ground and the top opens to a vertical position, similar to an open suitcase.

Since the vertical portion contains all of the operating components of the fixture, most of the weight is concentrated in this portion of the case. Therefore, to support and stabilize the heavy open portion of the case, a small stand is attached to the side that would normally face the ground when the case is open and two support braces lock with the case in the 90 degree open position.

Two handles, one on each side of the case swing open for use and have spring returns. Seven cam action positive locking latches are provided to secure and seal the case during transportation. A pressure relief valve is also installed on the side of the case.

All operating controls and displays are located on the front panel. Three hinged doors, also located on the front panel, provide access to the three 6-volt lantern type batteries which power the fixture.

To assure that the soldiers boresight their weapons at the proper distance of 25 meters, a cord 25 meters in length is stored inside a nylon bag located in the bottom portion of the case. The bag also contains an instruction card for the SAAF. There is adequate room within the bag to store 10 small arms trigger cable assemblies.

The front panel of the fixture contains an array of 144 high speed photodiodes. These diodes detect the laser beam and analog and digital processing circuitry interpret the received signals to provide accurate beam positioning data. The diodes require a minimum laser energy coded signal of 0.1 erg over  $1 \text{ cm}^2$  to react.

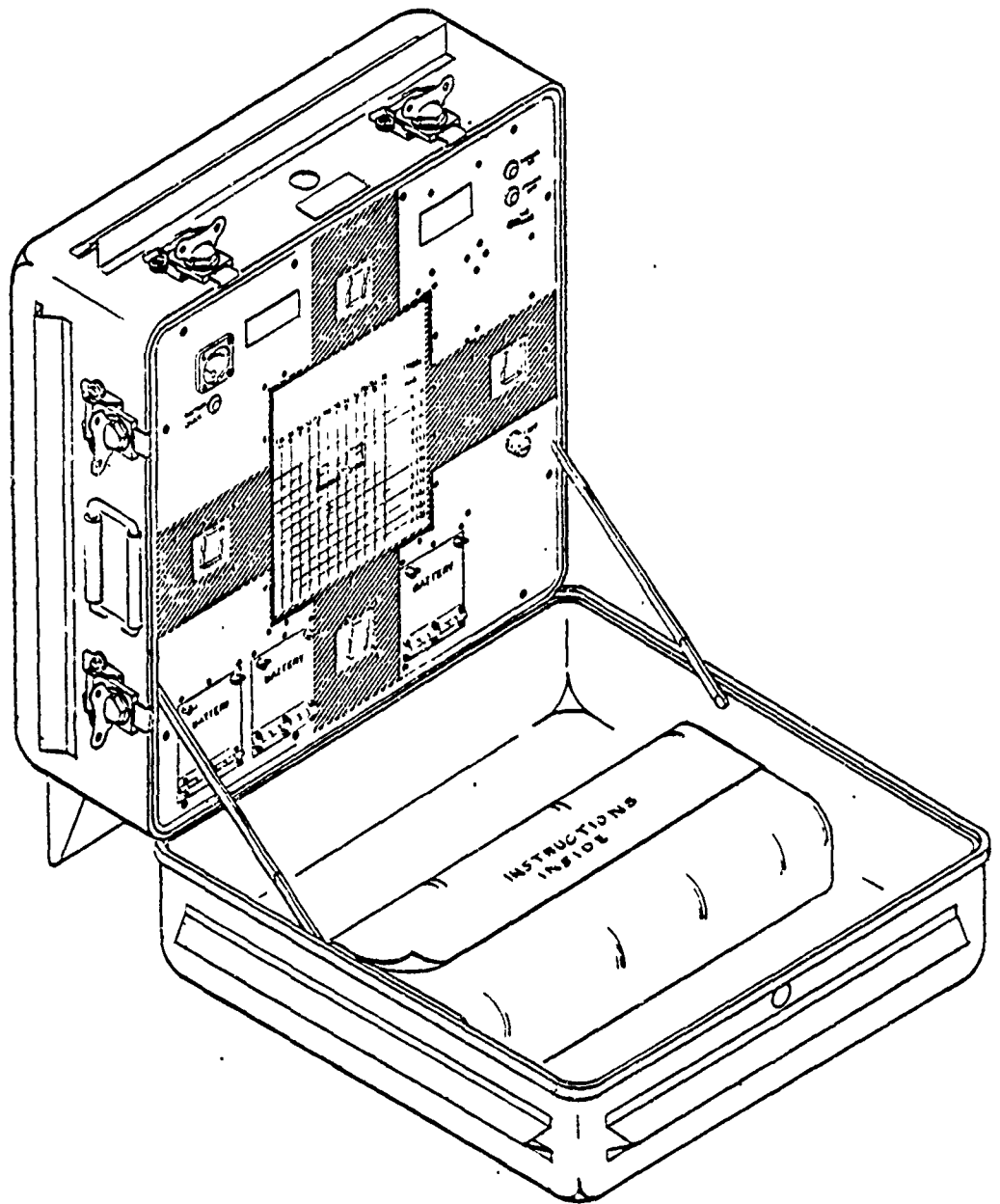


Figure 10-5. Small Arms Alignment Fixture

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Four positions on the fixture face, up, down, left, and right of center contain two digit displays. The displays are of such a size and contrast that an individual can distinguish the numerals with an unaided eye at distances up to 25 meters. The display indicates the number of sight adjustment "clicks" and direction (up, down, left, or right) that the laser beam strike point must be moved to align the laser optical axis.

#### 10.3.2.2 Basic Operation

The alignment fixture is powered by three 6-volt lantern type batteries. The battery compartments are designed to accommodate either the MIL-Spec battery (BA200/U or BA3200/U) or the commercial equivalent batteries. Power to the fixture is turned on and off by push button switches located on the front panel. A panel-mounted voltmeter is used to measure battery voltage. The meter face is marked with a green zone to allow easy determination of the condition of the batteries. The minimum voltage as indicated by the green band on the voltmeter is 13 volts. A front panel installed push button must be pressed to connect the voltmeter into the battery circuit.

When power is first turned on, each of the four displays show the number "18." This number indicates that the displays and the electronic circuits are operating properly. The numbers remain on until receipt of the first laser round or until power is turned off. To save battery power and prevent inadvertent battery discharge, power to the fixture is automatically disconnected approximately 24 minutes after the last laser round is received. If no laser round has been received, power is disconnected 24 minutes after the fixture has been turned on. Power may be restored to the fixture by pressing the ON push button.

The number displays are electromechanical devices and require power only to change the displayed number. No power is needed to maintain the display.

The displays are triggered by receipt of the proper coded MILE3 laser signal on the target face of the alignment fixture. The fixture will respond only to code number 27, which is the M16A1 rifle and M60 machine gun hit code. If the transmitters are operated in the dry fire mode, the fixture will also respond to the boresight code. (The dry fire mode is normally not used on the battlefield.) The electronic circuit will reject all other codes including code number 29, which is the near miss code for the M16 and M60. Upon receipt of a valid code, the displays blank for approximately a half a second and then indicate the appropriate aim correction data.

The displays will show misalignment of the small arms sight, when the weapons are fired from a distance of 25 meters, to within +1 "click" of the weapon's sights. For example, a "6" in the top display and a "3" in the right side display indicates that the strike point must be moved up 6 clicks and to the right by 3 clicks in order to hit the center of the target bullseye.

A mode switch located on the front panel must be set to the type of weapon being aligned. When set for the M16 rifle, the display will read a maximum number of "11" indicating 11 clicks of sight adjustment. When set to the M60 position, the display drivers will compensate for the difference in weapon sight adjustment and will read a maximum number of "3" indicating 3 clicks of sight adjustment in the right and left displays and a maximum reading of "13" indicating 13 clicks of sight adjustment in the up and down displays.

A schematic diagram of the alignment fixture's electronic circuits is shown in figure 10-6.

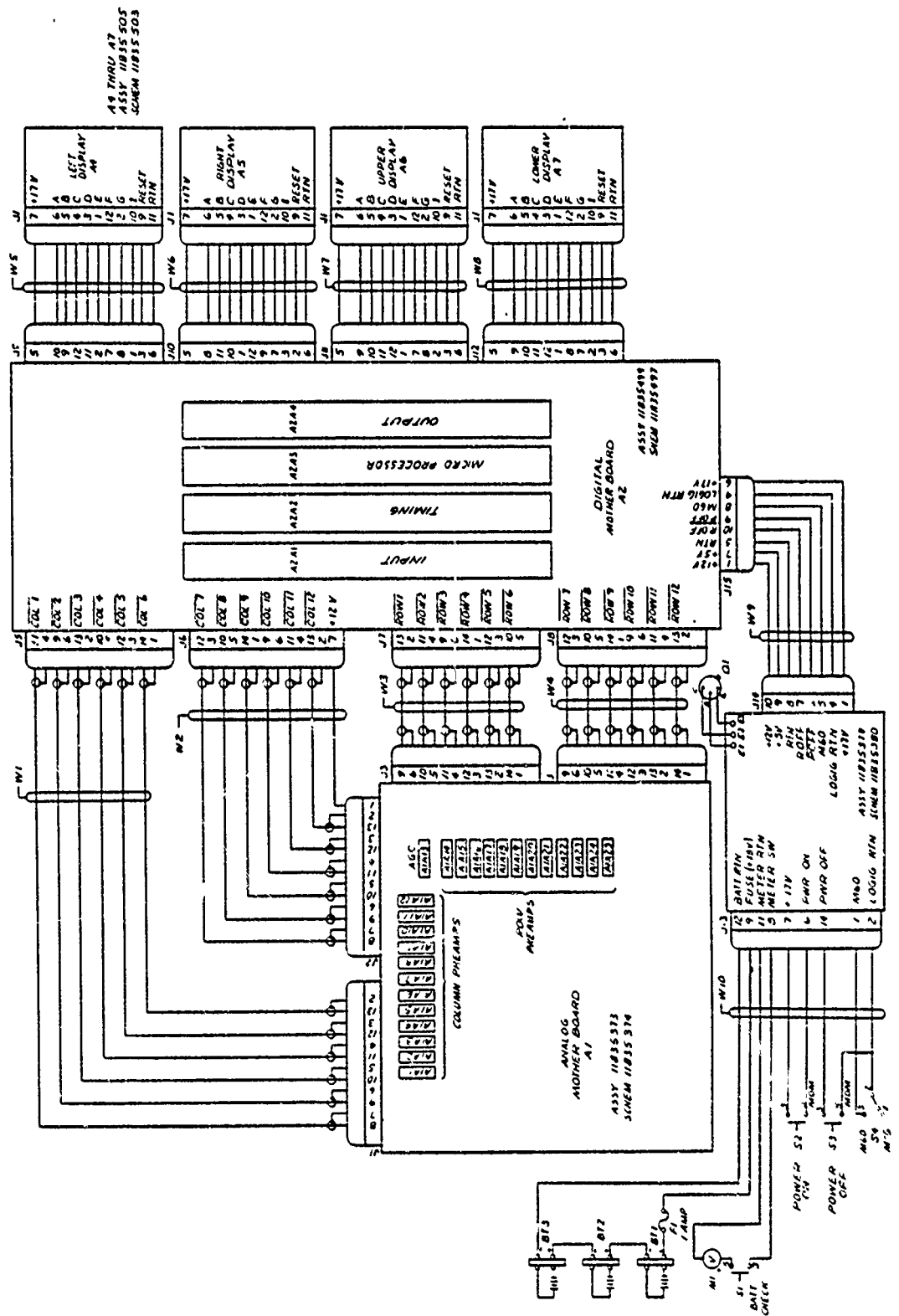
#### 10.3.2.3 Operating Principles

The circuitry of the SAAF is designed around a flat square array of 144 photodiodes approximately 6 inches on a side. This array is located behind a simulated boresight target face which is transparent to the infrared energy of the laser beam. The effective diameter of the beam is on the order of 0.5 inch at the specified 25 meter range, so that an array of this size can provide high resolution of the laser beam position.

The signals from the photodiode array are connected to a system of high-speed amplifiers and comparators, arranged so that each individual photodiode provides both a ROW and a COLUMN signal. The result is, as shown in figure 10-7, 24 parallel output lines, 12 ROW and 12 COLUMN. These are connected to microcomputer logic circuitry which monitors them, determines which laser pulse code bits are the appropriate ones, and calculates the position of the center of the laser beam by analyzing which ROW and COLUMN signal lines are active. It then compares this calculated position to the ideal position (which coincides with the center of the diode array) and sends aim correction data to large numeric displays which are located on the front panel of the SAAF, surrounding the target face.

#### 10.3.2.4 Optical Design

The SAAF was designed around the characteristics of the M16A1 rifle. The spacing between adjacent photodiodes in the detector array is therefore 0.550 inch, which is a very close approximation of the





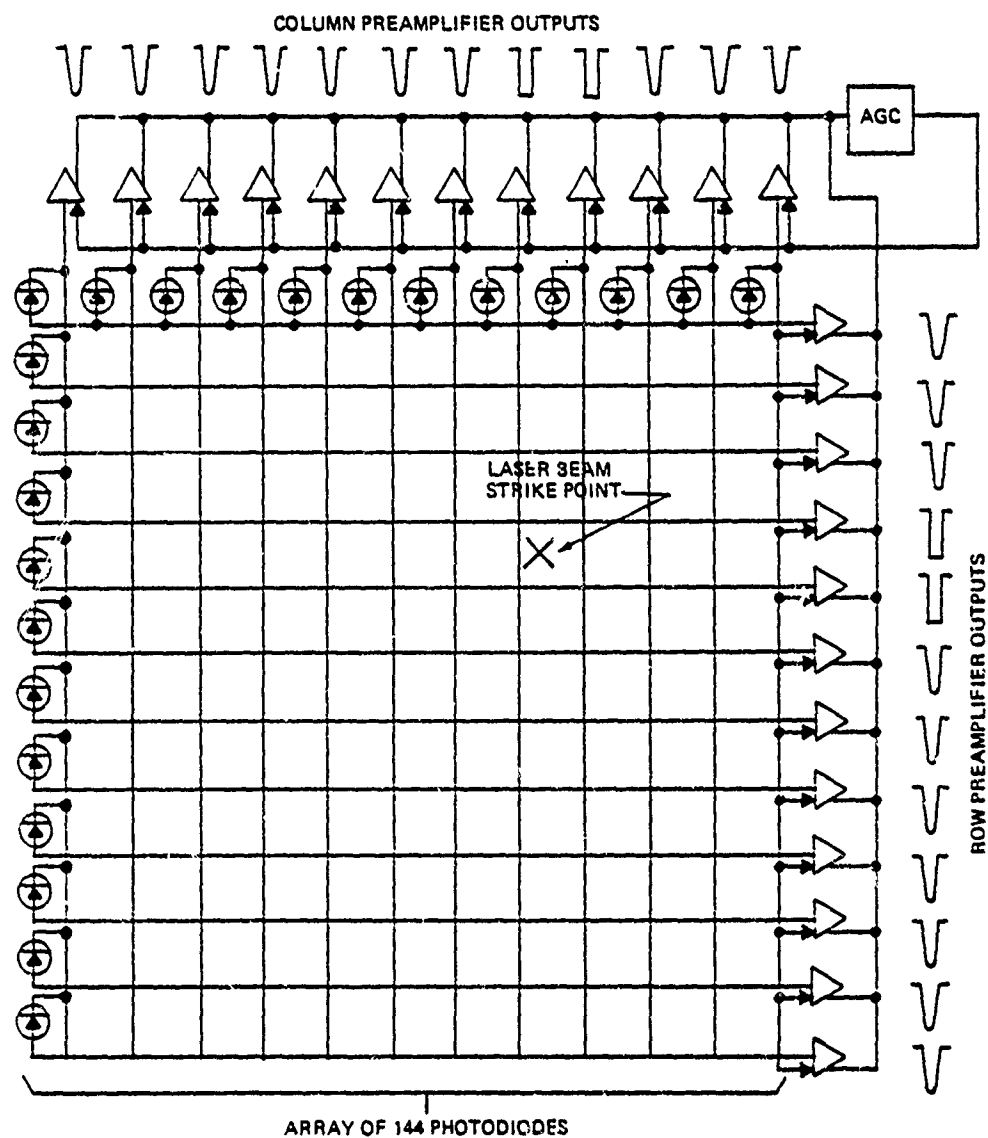


Figure 10-7. SAAF Detector Configuration

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distance the strike point moves when either the windage or elevation sights of the M16A1 are adjusted two clicks. The effective resolution of the SAAF is one click because the microcomputer is programmed to interpolate; in effect, synthesizing additional photodiodes.

Since the active area of each photodiode is only 0.10 inch in diameter, a dead area of considerable size is present between adjacent diodes; larger, in fact than the width of the laser beam, which is elliptical with the major axis aligned vertically. This potential problem is averted by including a beam-diffusing layer behind the target face. This layer spreads the beam so that several photodiodes in each axis are illuminated.

The photodiodes operate in the photoconductive mode to achieve sufficiently fast response. This means that direct sunlight would produce excessive current drain. A solar filter is therefore included in the target face sandwich, allowing 70 percent of the infrared to pass while reducing solar-induced current by a factor of four.

#### 10.3.2.5 Analog Circuit Design

##### 10.3.2.5.1 Photodiode Array

The photodiodes are reverse biased at approximately 12 volts and connected in a matrix configuration. Thus, the cathodes of all the photodiodes in any column are connected together and share a single load resistor and amplifier. Likewise the anodes of all the photodiodes in any row share a single load resistor and a single amplifier. In this way ROW amplifier inputs are isolated from COLUMN amplifier inputs, yet any given photodiode drives both equally and simultaneously. All load resistors are 200 ohms, which is a compromise

between low values which absorb too much of the photodiode signal, and high values which produce too much drop in the 12 volt bias voltage as a result of sunlight.

The photodiode array is housed on a large etched circuit board (the analog mother board) into which the preamplifier and AGC boards are plugged.

#### 10.3.2.5.2 Preamplifiers

The COLUMN signals from the photodiode array are capacitively-coupled into the current-summing node of a high speed operational amplifier. Since the COLUMN signals are negative-going, the amplifier's output is positive-going and can be several volts in amplitude. The ROW signals are positive-going so that an inverter stage is needed to allow the use of an identical high-speed op-amp circuit. This inverter stage is a simple transistor circuit using a 2N918, with values selected to produce a gain of minus one.

The positive-pulse output of the high-speed amplifier is applied to an integrator circuit which serves as a pulse stretcher. The output of the integrator is fed to a comparator, along with an AGC voltage. Whenever the pulse energy from the ROW or COLUMN in question exceeds a certain level, the comparator's output goes low and this constitutes the output signal from the preamplifier board. The AGC voltage is common to all 24 preamplifiers and is supplied by the AGC board.

Each preamplifier board includes a secondary signal output which is connected to the "pulse sample" input of the AGC board.

#### 10.3.2.5.3 AGC

The function of the AGC board is to raise the AGC voltage sent to the preamplifiers, in response to high laser beam power. Without this feature, a high-powered laser beam could activate too many ROW and COLUMN signals for the logic circuits to correctly interpret. The task of the AGC circuit is to control the AGC voltage so that approximately six signal lines are active during the critical period when the logic circuits store ROW and COLUMN data. This occurs during the third HIT word, so that the AGC circuit must finish its task by the end of the second HIT word.

The "pulse sample" input to the AGC circuit is configured so that seven or more ROW and COLUMN outputs are required to have an effect on the AGC voltage, which has a quiescent value of about 0.1 volt. The magnitude of the effect is roughly proportional to the difference between the number of active outputs and six.

When a high-powered laser beam is received, the first bit of the first word will activate many ROW and COLUMN outputs. This will, in turn, cause a stepwise increase in the AGC voltage, which has a long relaxation time constant. The second bit will cause a similar increase, but somewhat smaller since fewer outputs are now active. This procedure continues until about six outputs are active. At that point the AGC voltage stops increasing, and decreases so slowly that it is essentially constant for the remainder of the four HIT words.

#### 10.3.2.5.4 Regulator

The regulator board has two basic functions. The first is to provide constant voltage levels to the analog (12 volt) and digital (5 volt) circuitry so that performance does not vary as battery voltage decreases from 18 volts to 13 volts.

The second function is to accommodate the automatic turn-off feature of the SAAF. This feature is very desirable since it extends battery life considerably; however, it means that the power-on and power-off switching of the SAAF cannot be performed with the usual toggle switch. Instead, the regulator is designed to latch in the power-on mode in response to the actuation of a momentary pushbutton switch, and to be reset either manually by a second pushbutton switch or automatically by a logic signal approximately 24 minutes after the last display update.

Battery life is also extended by the use of a discrete transistor pass element instead of an integrated-circuit regulator. This allows the batteries another 1.5 to 2 volts of decrease before they must be replaced.

#### 10.3.2.6 Digital Circuit Design

##### 10.3.2.6.1 Timing and Decoding

The logic circuitry interfaces with the analog circuitry (preamp and AGC circuits) only during the first three words of the received laser message. The associated waveforms are shown in figure 10-8.

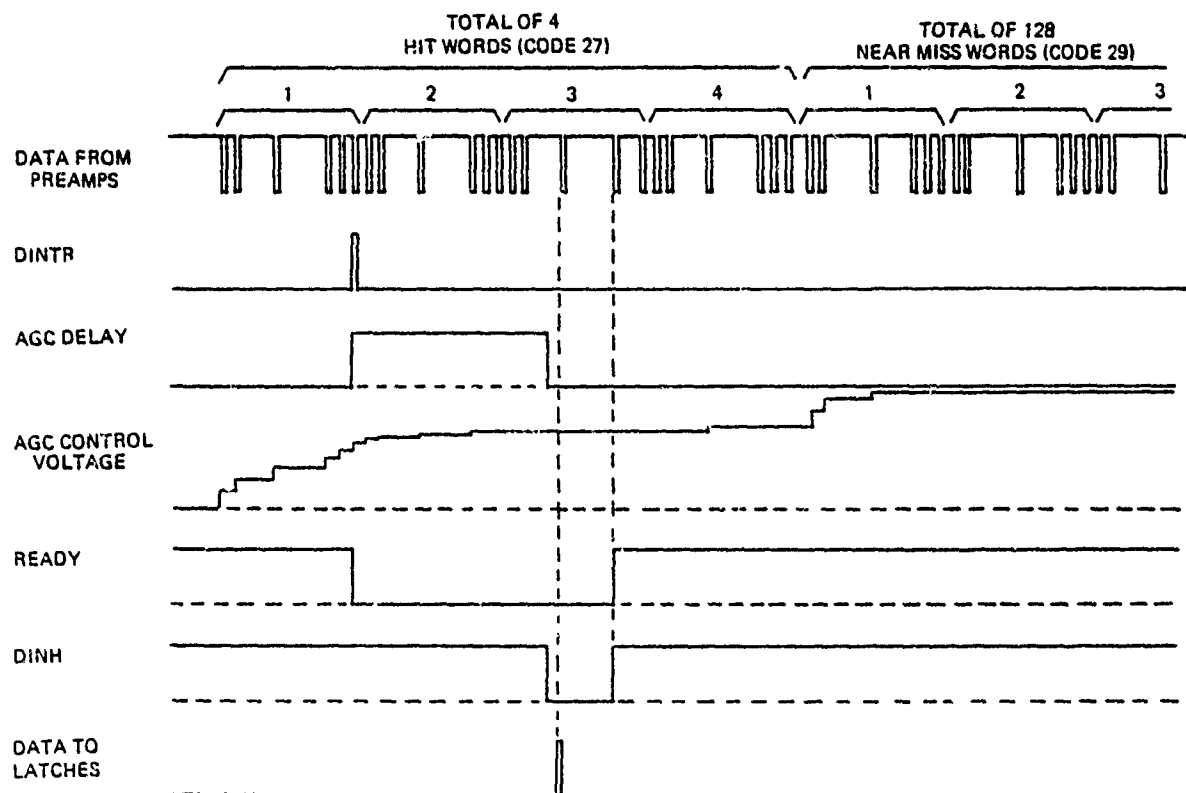


Figure 10-8. Input Data Timing Diagram

65135

A composite of all ROW preamp data is sampled by several logic circuits. The presence of the small arms HIT code (code 27) is detected at the end of the first HIT word and a DATA INTERRUPT (DINTR) pulse is produced. This pulse triggers a monostable multivibrator (one-shot) with a period of 3.9 milliseconds. Its purpose is to delay data sampling until the third HIT word, at which time the analog AGC control voltage will have settled to an acceptably steady level. This is important in getting a good data sample, particularly if the laser transmitter being used is of greater than average output power. The DINTR pulse also signals the microprocessor to blank all displays.

At the end of the AGC DELAY period, a window is created by the action of the DATA INHIBIT (DINH) signal, and the first data pulse to occur during this window is the one which is received by the data latches. There is a data latch for each ROW and each COLUMN data line; of these 24, the AGC action previously described ensures that no more than about six receive data. The second data pulse to occur after the opening of this window causes the window to close and signals the microprocessor to begin data analysis.

The microprocessor first sequentially examines the contents of the COLUMN data latches, beginning with the left column (as seen from the firing position). It notes the column numbers of the first and last latches to contain data, and from this calculates the position of the center of the laser beam in the horizontal axis. The program allows this calculation for both odd and even quantities of active data latches; therefore the microprocessor is capable of providing a position resolution (one M16 sight click) twice as fine as the spacing of the detectors (two M16 sight clicks). When the microprocessor has found this position data, it stores the appropriate ROM look-up address in its internal memory, and then repeats the entire process with the ROW data to find the center of the beam in the vertical axis.

When these operations are completed, the microprocessor causes the display registers on the output board to receive display information from the two ROM look-up addresses which resulted from the calculations described above.

Approximately one-half second after the displays were blanked, a strobe pulse is initiated which sends the new display information to the display boards. The half-second of blanked displays serves to notify the firer that his laser "round" has been received.

#### 10.3.2.6.2 Weapon Modes

The SAAF will operate with the MILES system of either the M16A1 rifle or the M60 machine gun, since both use the same HIT and NEAR MISS codes and format. The sight adjustment increments of the two weapons differ, however, so that a switch is incorporated on the SAAF front panel to let the logic circuits know what number to display. Accordingly, the ROM contains separate look-up tables for the M60 with numbers appropriate for the M60 sight adjustment characteristics.

#### 10.3.2.6.3 Displays

Each of the four numeric displays of the SAAF consists of an etched circuit board on which are mounted two seven-segment electromagnetic displays, two integrated circuit drivers, and a large filter capacitor. A portion of the tens digit display is masked, since the highest number to be displayed is 18.

Operation of the SAAF from batteries limits the choice of display types to either liquid crystal or electromagnetic. Liquid crystal displays capable of operating over the required temperature range do not exist. The electromagnetic devices are acceptable because they draw power only when changing numbers.



The driver circuits receive signals directly from the digital circuits located on the output logic boards. No data manipulation takes place on the display boards.

The value of the filter capacitor is several thousand microfarads and stores sufficient energy to allow all nine active display segments to be driven simultaneously without allowing the voltage to drop below 9 volts.

The display boards are powered directly from unregulated voltage with only the polarity-protection diode of the regulator board between them and the battery potential. However, to restrict the high display-drive currents to the display boards, each filter capacitor is isolated by a 68 ohm resistor.

#### 10.4 QUALITY ASSURANCE TESTING

The XEOS Quality Assurance program has been organized to ensure quality throughout all areas of fabrication, processing, assembly, inspection tests, maintenance, preparation for delivery, and shipping. Certain requirements, such as testing, may be considered common to both the Quality and Reliability programs.

Two types of inspections are performed: (1) First Article Inspection; and (2) Quality Conformance Inspection.

##### 10.4.1 FIRST ARTICLE INSPECTION

Both the Vehicle Test Set and the Small Arms Alignment Fixture will be subject to various operating and non-operating environmental tests in accordance with the requirements of MIL-STD-810, Environmental Test Methods. The tests to be conducted are documented in CDRL item A00Y of the contract and include the following:

##### Vehicle Test Set:

- a. Operating
  - High Temperature
  - Low Temperature
  - Low Pressure
  - Humidity
  - Rain

b. Non-operating

- Shock
- Vibration
- Dust
- Salt Fog
- Loose Cargo

Small Arms Alignment Fixture

a. Operating

- High Temperature
- Low Temperature
- Low Pressure
- Humidity
- Rain

b. Non-operating

- Shock
- Vibration
- Dust
- Salt Fog
- Loose Cargo

Operational testing of both the Vehicle Test Set and Small Arms Alignment Fixture is accomplished by observing the response on the meters and indicators to simulated signal inputs. The Test Set and SAAF have both successfully completed their respective environmental tests.

#### 10.4.2 RELIABILITY AND MAINTAINABILITY

The test set and alignment fixture have both been designed to meet the reliability requirements of MIL-STD-781, Fixed Ground Test Conditions, Thermal Stress B, PRST-Test Plan VIII C.

The quantitative reliability in terms of Mean-time-between failure (MTBF) for the Vehicle Test Set and Small Arms Alignment Fixture are as follows:

Vehicle Test Set

Specified Value ( $\theta_0$ ) = 800 hours

Minimum acceptable value ( $\theta_1$ ) = 400 hours

These vehicle test sets were subjected to Reliability testing and underwent 147 hours each or a total of 441 hours without failure, thereby exceeding the minimum MTBF of 400 hours.

Small Arms Alignment Fixture

Specified Value ( $\theta_0$ ) = 400 hours

Minimum acceptable value ( $\theta_1$ ) = 200 hours

The general reliability requirements are to subject the sample test sets to an elevated temperature of  $40 \pm 5^\circ\text{C}$  and  $2.0 \pm 0.2$  g vibration at a non-resonant frequency between 20 and 60 Hz. The Vehicle Test Set will then be tested for proper readings of bit rate, voltage, and proper CVKI simulation.

The Small Arms Alignment Fixture will be tested to assure the unit responds to the code number 27 (which is the hit code for the M16A1 rifle and the M60 machine gun) and not respond to code number 29 (which is the near miss code for these weapons).

Two SAAF test sets were subjected to reliability testing and underwent 110 hours each for a total of 220 hours without failure, thereby exceeding the minimum MTBF of 200 hours.

Maintainability in terms of Mean-Time-To-Repair (MTTR) will be as follows:

Vehicle Test Set

|                                             |              |
|---------------------------------------------|--------------|
| Required Value ( $M_0$ )                    | = 60 minutes |
| Desired Value ( $M_1$ )                     | = 30 minutes |
| Actual (from Maintainability Demonstration) | = 19 minutes |

Small Arms Alignment Fixture

|                                             |               |
|---------------------------------------------|---------------|
| Required Value ( $M_0$ )                    | = 120 minutes |
| Desired Value ( $M_1$ )                     | = 60 minutes  |
| Actual (from Maintainability Demonstration) | = 28 minutes  |

APPENDIX A  
POWER REQUIREMENTS

APPENDIX A  
POWER REQUIREMENTS

A.1 TEMPERATURE EFFECTS ON BATTERIES

MILES Specification N2234-122, subsection 3.4, defines the environmental criteria for the MILES training device. The referenced specification requires a performance from  $-25^{\circ}\text{F}$  to  $+110^{\circ}\text{F}$ . The detailed requirements include operation at temperatures greater than  $105^{\circ}\text{F}$  for four hours out of each 24 hours, with operation at  $110^{\circ}\text{F}$  for a maximum of one hour out of 24 hours. Low temperature requirements include operation at  $-25^{\circ}\text{F}$  for a maximum period of six hours out of 24 hours. Analysis of the characteristics of various types of dry batteries available for this application has been performed and two types of battery chemical systems have been chosen to operate MILES. See table A-1 and figure A-1 for data.

It has been concluded that alkaline batteries (alkaline-manganese-zinc) will be used for temperatures down to  $26^{\circ}\text{F}$ . Temperatures below  $26^{\circ}\text{F}$  will require the use of a new lithium organic battery. Figure D-2 gives the curves relating the two batteries.

The use of these two types of dry batteries for electrical power will satisfy the temperature requirements of the MILES program.

A.2 TOTAL CURRENT DRAIN

Portable weapons and detector systems have been designed to have very low current drain so that the common 9-volt "transistor" type of battery is used in these devices (see table A-1).

TABLE A-1

## BATTERY, 100 HOURS, 70°F LOAD CURRENT

| <u>Battery Type</u>                             | <u>Availability Status</u>                               | <u>Max/Min Voltage (V)</u> | <u>70°F, 100 hours Load Current Capability (mA)</u> | <u>Lowest Qual. Test Temp. (°F)</u> | <u>MILES Application</u>      |
|-------------------------------------------------|----------------------------------------------------------|----------------------------|-----------------------------------------------------|-------------------------------------|-------------------------------|
| <u>Alkaline</u>                                 |                                                          |                            |                                                     |                                     |                               |
| Mallory P/N MN1604 (MIL-B-18D)<br>P/N BA3090/U) | Commercially mass produced. Being qualified for Military | 9.0/6.0                    | 5                                                   | -0-                                 | Portable Systems down to 26°F |
| <u>Lithium Organic</u>                          |                                                          |                            |                                                     |                                     |                               |
| Mallory (MIL-B-18D, P/N BA5090/U)               | Developed and being packaged for Military Qualification  |                            | 6.5                                                 | -20                                 | Portable Systems below 26°F   |
| <u>Carbon Zinc</u>                              |                                                          |                            |                                                     |                                     |                               |
| (MIL-B-18D P/N BA-200/U)                        | Available in Federal supply system                       | 6.0/4.5                    | 37.5                                                | -70                                 | Vehicle Systems down to 26°F  |
| <u>Alkaline</u>                                 |                                                          |                            |                                                     |                                     |                               |
| BA-3200/U (MIL-B-49030)                         | Available in Federal supply system                       | 6.0/4.5                    | 118                                                 | -0-                                 | Vehicle Systems below 26°F    |



56050

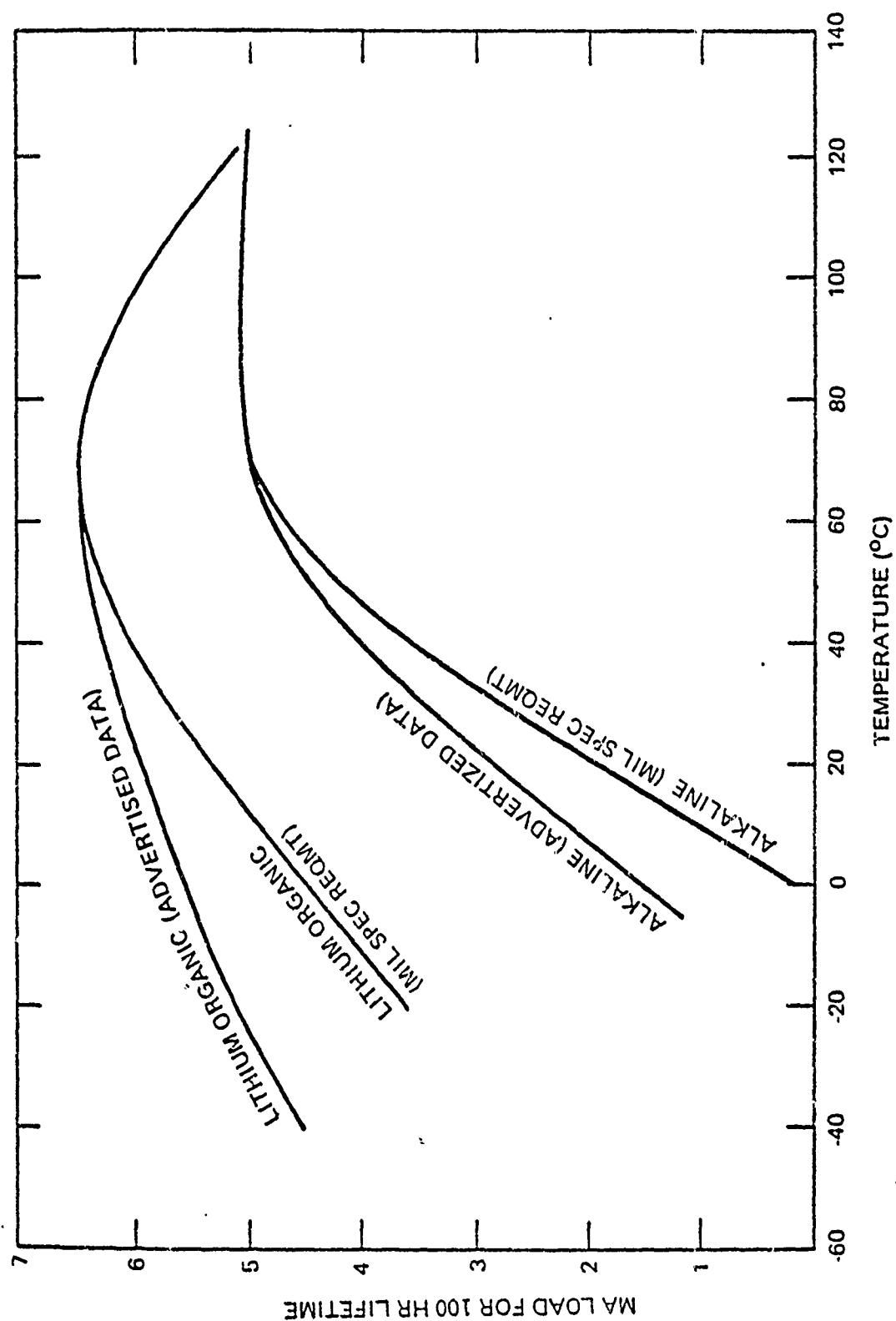


Figure A-1. Comparison of Lithium Organic and Alkaline Battery Load Capabilities for 100 hr/6 volt End of Life Definition

The vehicular systems require more power than the portable systems. As a consequence, a 12-volt source made up of 2 6-volt lantern batteries is used as a power source so that satisfactory continuous operating time may be obtained.

Table A-2 shows typical current drain for each simulator. It will be noted that the requirements match the battery capabilities quite well so that more than 100 operating hours per battery can be obtained in most cases.

### A.3 VEHICLE POWER

The MILES vehicle system interfaces with vehicle power in two cases: (1) as a power source for the kill indicator and, (2) for trigger signals.

The kill indicator, a strobe light, is switched to vehicle power by relays at the kill indicator. There is no conductive connection between vehicle power and the MILES electronics.

TABLE A-2  
BATTERY CURRENT DRAIN

|                         |                                      | Typical Current<br>Drain (per Battery) -mA |      |
|-------------------------|--------------------------------------|--------------------------------------------|------|
| A. MWLD                 |                                      |                                            |      |
|                         | Harness                              | 2.5                                        |      |
|                         | Helmet                               | 1.5                                        |      |
| B.                      |                                      |                                            |      |
|                         | Laser Transmitter - M16A1            | 2.5                                        |      |
|                         | Laser Transmitter - M60 Machine Gun  | 2.5                                        |      |
|                         | Laser Transmitter - M2 Machine Gun   | 2.5                                        |      |
|                         | Laser Transmitter - M85 Machine Gun  | 2.5                                        |      |
|                         | Laser Transmitter - DRAGON           | 3.0                                        |      |
|                         | Laser Transmitter - VIPER            | 3.0                                        |      |
| C. M60A1/A3             |                                      |                                            |      |
|                         | Laser Transmitter - 105 mm           | } *                                        | 25.0 |
|                         | Laser Transmitter - Coax Machine Gun |                                            |      |
|                         | CVLD                                 |                                            |      |
|                         | CVKI                                 |                                            |      |
|                         | LCA                                  |                                            |      |
| D. M60A2/M551           |                                      |                                            |      |
|                         | Laser Transmitter - 152 mm           | } *                                        | 25.0 |
|                         | Laser Transmitter - Coax Machine Gun |                                            |      |
|                         | CVLD                                 |                                            |      |
|                         | CVKI                                 |                                            |      |
|                         | LCA                                  |                                            |      |
| E. APC - M2 Machine Gun |                                      |                                            |      |
|                         | Laser Transmitter - M2 Machine Gun   | 2.5                                        |      |
|                         | CVLD                                 | } *                                        | 20.0 |
|                         | CVKI                                 |                                            |      |
|                         | CIA                                  |                                            |      |
| F. TOW                  |                                      |                                            |      |
|                         | Laser Transmitter - TOW              | 2.5                                        | *    |
|                         | Receiver                             | 2.5                                        | *    |
|                         |                                      | } *                                        | *    |
|                         |                                      |                                            |      |

\* Uses two 6V lantern batteries in series

APPENDIX B

TEMPERATURE ENVIRONMENT ANALYSIS

APPENDIX B  
TEMPERATURE ENVIRONMENT ANALYSIS

B.1 TEMPERATURE

The environmental extremes to which the laser transmitter will be exposed are defined in AR70-38; "Research, Development, Test, and Evaluation of Material for Extreme Climate Conditions," 1 July 1969. Applicable environments are summarized below:

|                              | Operational Conditions |                              |                                 | Storage & Transient Conditions |                                 |
|------------------------------|------------------------|------------------------------|---------------------------------|--------------------------------|---------------------------------|
| Climatic                     | Ambient Air Temp<br>°F | Solar Radiation<br>BTU/hr-ft | Ambient Rel. Hum.<br>%          | Air Temp<br>°F                 | Induced Rel. Hum.<br>%          |
| 5<br>Intermediate<br>Hot-Dry | 70 to 110              | 0 to 360                     | 20 to 85                        | 70 to 145                      | 5 to 50                         |
| 6<br>Intermediate<br>Cold    | -5 to -25              | -                            | Tending<br>Toward<br>Saturation | -10 to -30                     | Tending<br>Toward<br>Saturation |

The transmitter temperature limits, prior to firing blanks, are calculated from the following energy balance:

$$\alpha G A_R = \epsilon A (\sigma T^4 - \sigma T_a^4) + h A (T - T_a) \quad (1)$$

where

$A_R$  = Area of simulator receiving solar radiation (ft<sup>2</sup>)

$A$  = Total area of simulator (ft<sup>2</sup>)

$G$  = Solar radiation (BTU/hr ft<sup>2</sup>)

- T = Simulator temperature ( $^{\circ}\text{F}$ )
- Ta = Ambient temperature ( $^{\circ}\text{F}$ )
- h = Convective heat transfer coefficient ( $\text{BTU/hr ft}^2 \text{ }^{\circ}\text{F}$ )
- $\alpha$  = Solar absorptivity
- $\epsilon$  = Emissivity
- $\sigma$  = Stephan-Boltzmann Constant ( $\text{BTU/hr ft}^2 \text{ }^{\circ}\text{R}^4$ )

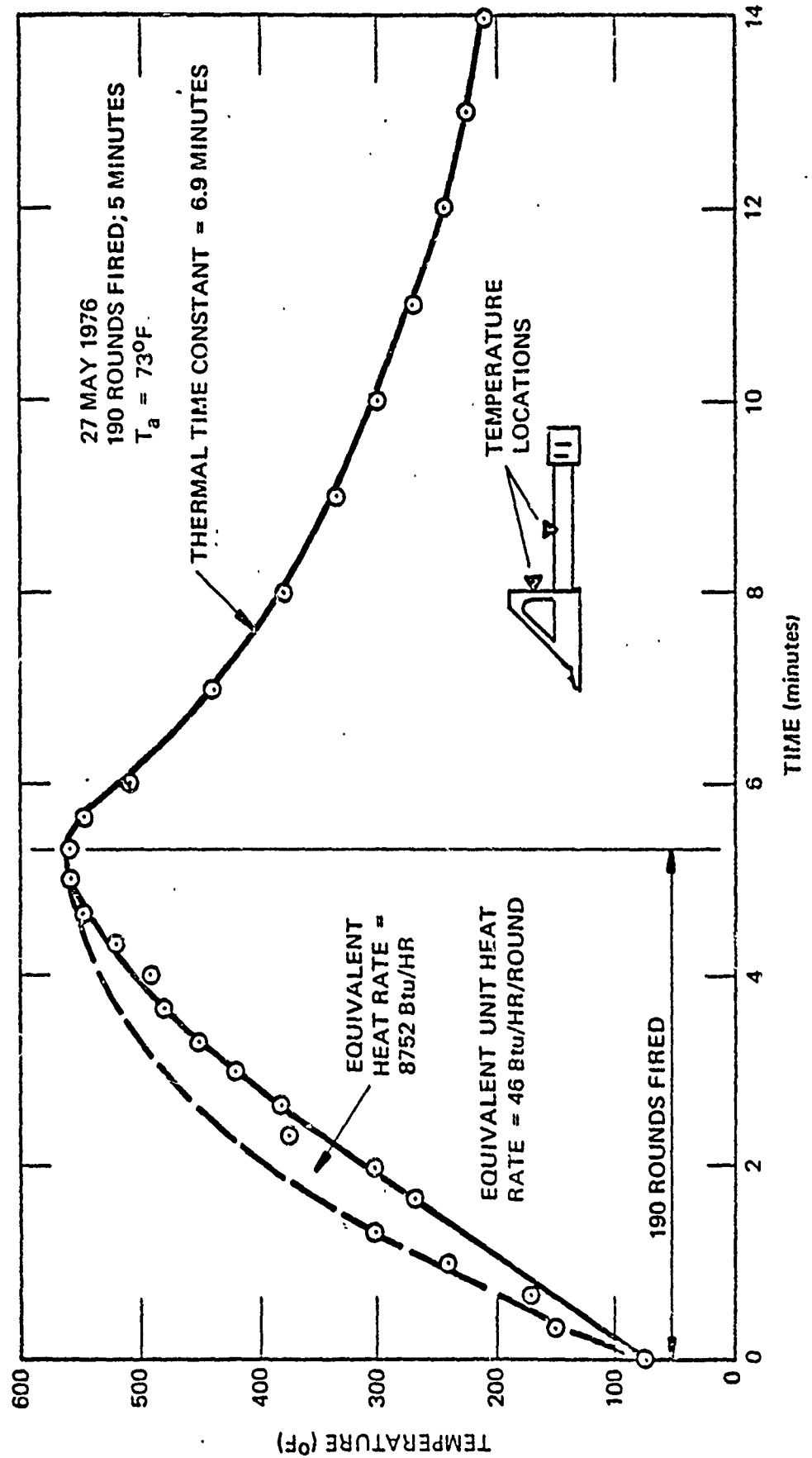
Solution of equation (1) yields an equilibrium simulator temperature of  $145^{\circ}\text{F}$  for category 5 and  $-25^{\circ}\text{F}$  for category 6.

Firing blank ammunition heats the barrel of the weapon. This heated barrel, in turn, conducts heat through the simulator adapter into the weapon simulator, causing the simulator temperature to rise. Barrel temperature data were obtained experimentally for both the M-16 and the M-60 to provide simulator adaptor design criteria.

The results of the testing are summarized in figures B-1 and B-2. Data from the first figure shows the M16 barrel temperature rising from  $73^{\circ}\text{F}$  to  $560^{\circ}\text{F}$  in five minutes while expending 190 rounds of blank ammunition. The M60 machine gun barrel temperature (figure B-2) is shown to increase from  $73^{\circ}\text{F}$  to  $905^{\circ}\text{F}$  while expending 750 rounds of blank ammunition. In each case the highest temperature reached would be about  $70^{\circ}\text{F}$  higher than measured if the initial temperature had been  $145^{\circ}\text{F}$ , as calculated for environmental category 5 of AR 70-38.

A computer model of the simulator/adaptor has been developed to support hardware design. This preliminary model has been updated to reflect a current design configuration. The computer model is shown in figure B-3. This model is three dimensional and has the capability of calculating transient temperature response for either constant or time varying heat inputs and/or boundary conditions.

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B-3

Figure B-1. Temperature History M16A1 Rifle

56253

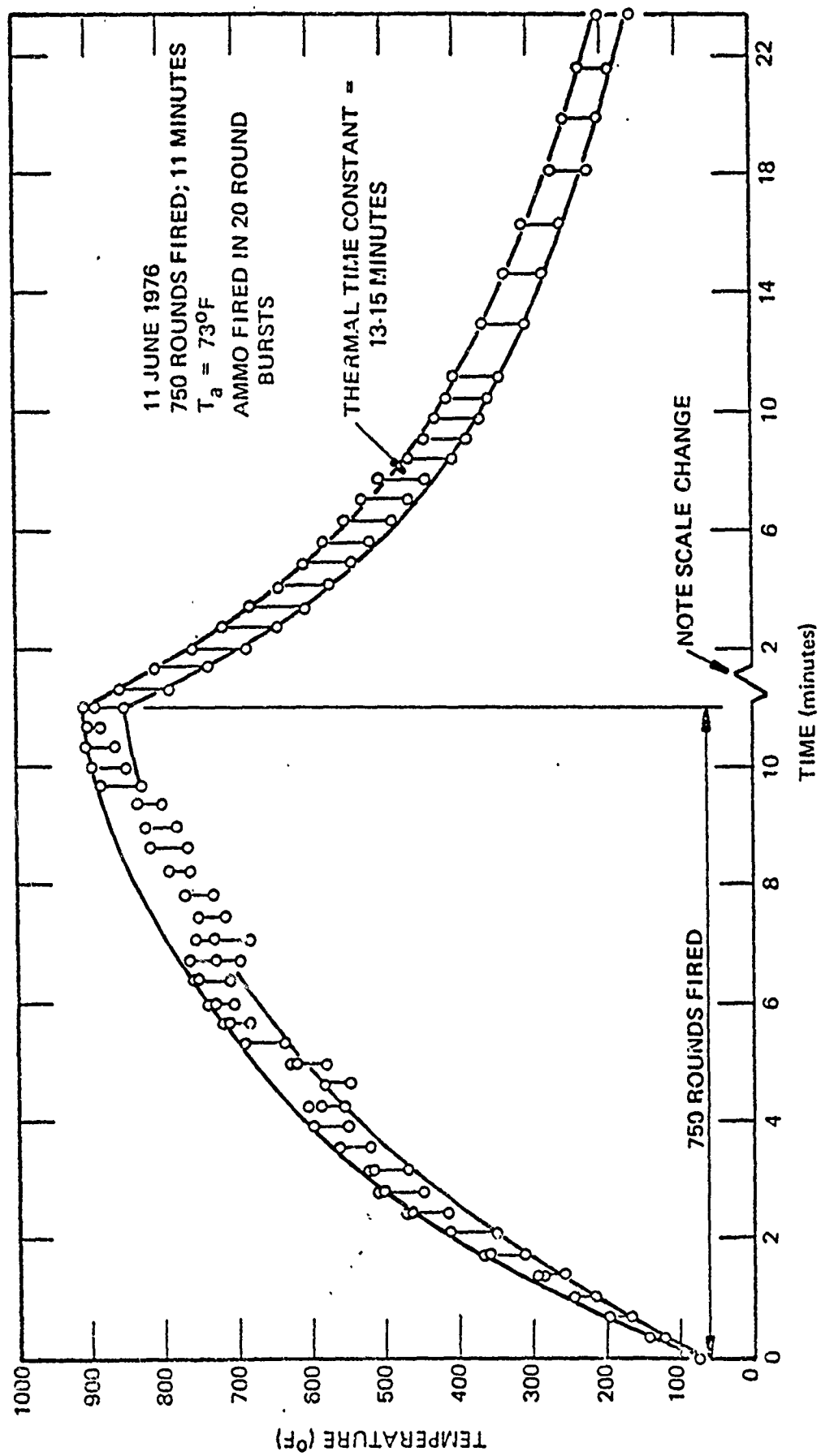


Figure B-2. Temperature History M60 Machine Gun



60732

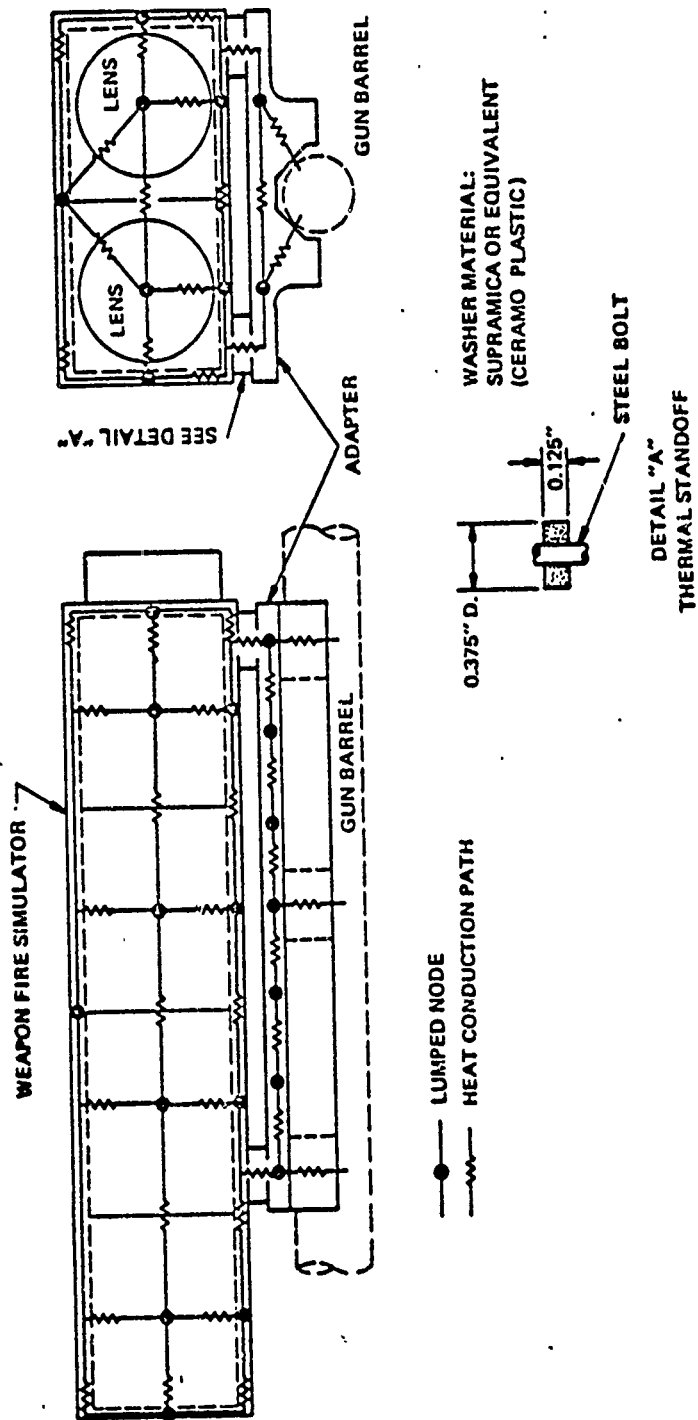
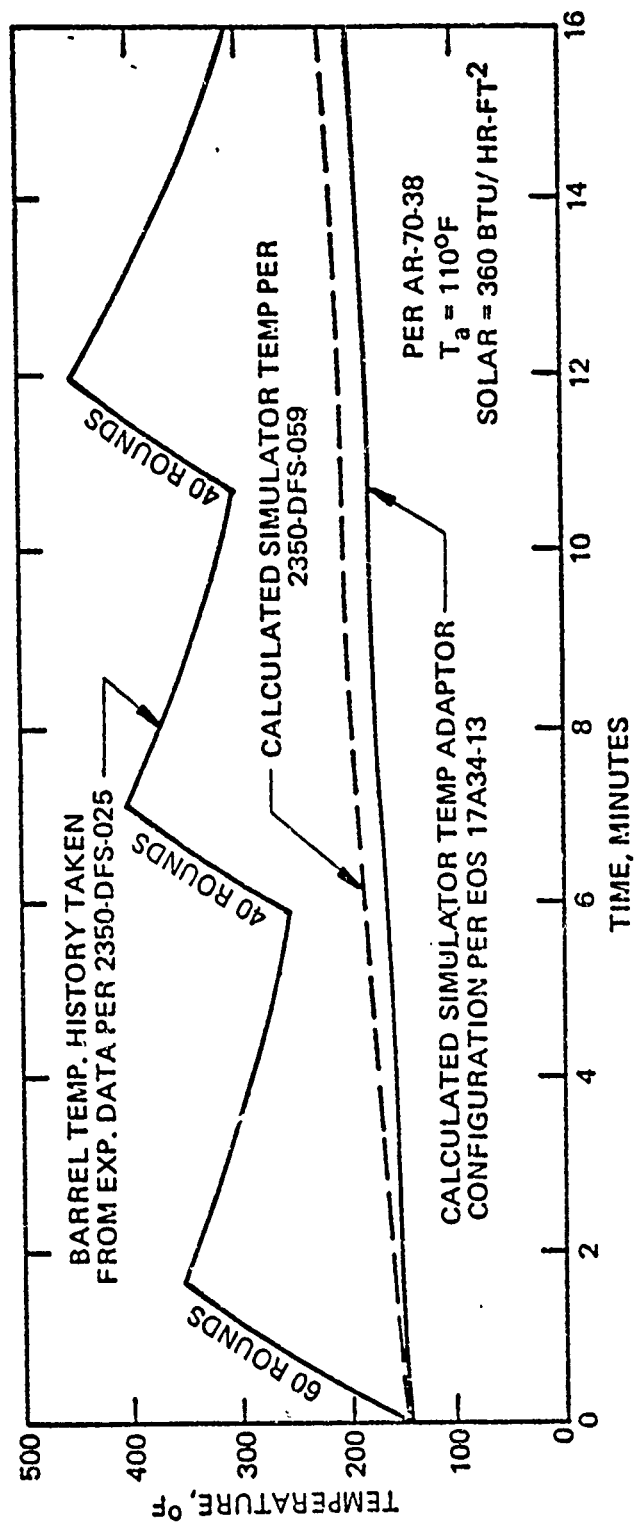


Figure B-3. Weapon Fire Simulator/Adapter Computer Model

Calculated simulator temperatures for a hypothetical firing sequence (see figure B-4) show an increase of 45°F in a period of 16 minutes with an expenditure of 100 rounds of blank ammunition.

The computer model will continue to be refined as the design evolves and will be used to analytically verify the thermal design of the final configuration. Values of the thermal insulation material used in the model are listed in table B-1.

56171



B-7

Figure B-4. Weapon Fire Simulator Temperature History

TABLE B-1

## PHYSICAL - ELECTRICAL - THERMAL PROPERTIES

|                                                    | Supramica 620 "BB"<br>Ceramoplastic<br><u>Precision-Molded</u> |
|----------------------------------------------------|----------------------------------------------------------------|
| Dissipation Factor $10^6$ cycles/sec               | 0.0023                                                         |
| Dielectric Constant $10^6$ cycles/sec              | 8.8                                                            |
| Loss Factor $10^6$ cycles/sec                      | 0.020                                                          |
| Dielectric Strength 1/8" thick v/mil               | 270                                                            |
| Arc Resistance ASTM Seconds                        | 300                                                            |
| Maximum Temperature Endurance °F                   | 1200                                                           |
| Thermal Expansion $10^{-6}/^{\circ}\text{C}$       | 9.4                                                            |
| Thermal Conductivity cal/cm <sup>2</sup> sec °C/cm | 0.0012                                                         |
| Tensile Strength psi                               | 5,000                                                          |
| Compressive Strength psi                           | 30,000                                                         |
| Flexural Strength psi                              | 12,000                                                         |
| Modulus of Elasticity $10^6$ psi                   | 12.0                                                           |
| Impact Strength Charpy ft. lbs. per sq. in.        | 1.2                                                            |
| Water Absorption 1/8" thick 24 hours - %           | nil                                                            |
| Specific Gravity                                   | 3.8                                                            |

APPENDIX C  
SPECTRAL FILTER ANALYSIS

## APPENDIX C

### SPECTRAL FILTER ANALYSIS

#### C.1 INTRODUCTION

The dominant source of noise in the MILES detector/amplifier circuit is shot noise resulting from the solar background. Thus, one important aspect of noise reduction in MILES is the spectral filter. From the Shottky equation, the shot noise is given by

$$I_n = \sqrt{2eBI_b}$$

where

- $I_n$  = shot noise current
- $I_b$  = background current
- $e$  = unit electrical charge
- $B$  = system electrical bandpass

The prime functions of the spectral filter are therefore:

- a. To reduce  $I_b$  to the smallest possible value while
- b. Maintaining the maximum possible signal transmission at GaAs wavelength.

#### C.2 ANALYSIS

Sunlight is the dominant MILES background source. Figure C-1 shows the solar spectral distribution at earth sea level (i.e., including atmospheric absorption) as taken from References 10-12. The function  $S_\lambda$  has been normalized to 100 percent at the maximum spectral irradiance level at 5000Å.

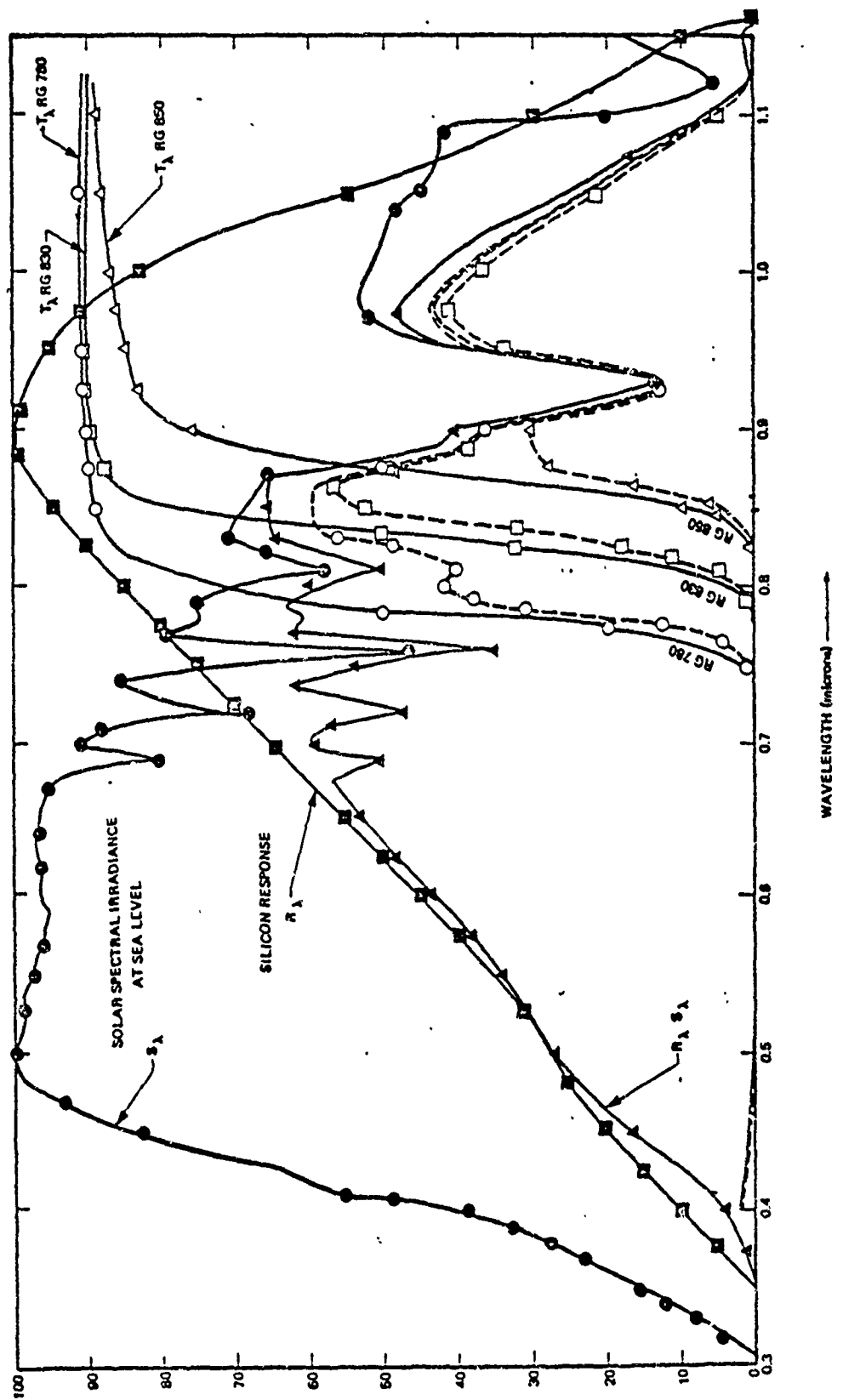


Figure C-1. Solar Spectral Distribution with Silicon Detector and Filter Plots

Furthermore, since MILES will utilize silicon detectors, the silicon detector spectral responsivity,  $R_\lambda$ , is shown as the dashed curve on figure C-1. The product function,  $R_\lambda S_\lambda$ , represents the fundamental spectral response of a silicon detector to sunlight. This is shown by the solid curve.

Next, the transmission,  $T_\lambda$ , of an RG 780, RG 830, and RG 850 filter is plotted with respect to wavelength. Figures C-2, C-3, and C-4 show experimentally measured filter transmission with respect to wavelength plots which were obtained using a Beckman DK-2 Spectrophotometer. The data were obtained at two arbitrary locations on each Shott filter to check for repeatability. Each plot is, therefore, actually an overlay of two different plots corresponding to two arbitrary locations. The repeatability is excellent for all three filters with the only variations occurring at  $\lambda > 0.9\mu$  for the RG 850 filter. In the region  $0.4 \leq \lambda \leq 0.8\mu$ , the plots were repeated a third time, but with the scale expanded by a factor of ten to check transmission in the visible. Except for about 2 percent transmission at  $\lambda = 0.4\mu$  (where the silicon detector response is low), the average transmission is less than 0.1 percent from 0.5 to 0.7 $\mu$  for all three filters. The three filter curves have similar shapes but are displaced from one another in wavelength. Multiplying the transmission curve for the RG 780 by  $R_\lambda S_\lambda$ , the spectral response of a silicon detector to sunlight is obtained as seen through an RG 780 filter. Similar curves are then generated for  $T_\lambda R_\lambda S_\lambda$  for the RG 830 and RG 850 filters, respectively. These are the three dotted curves under the  $R_\lambda S_\lambda$  curve. Since the overall response of a silicon detector to sunlight is given by

$$R_{\text{sun}} = \int_0^{\infty} R_\lambda S_\lambda d\lambda$$



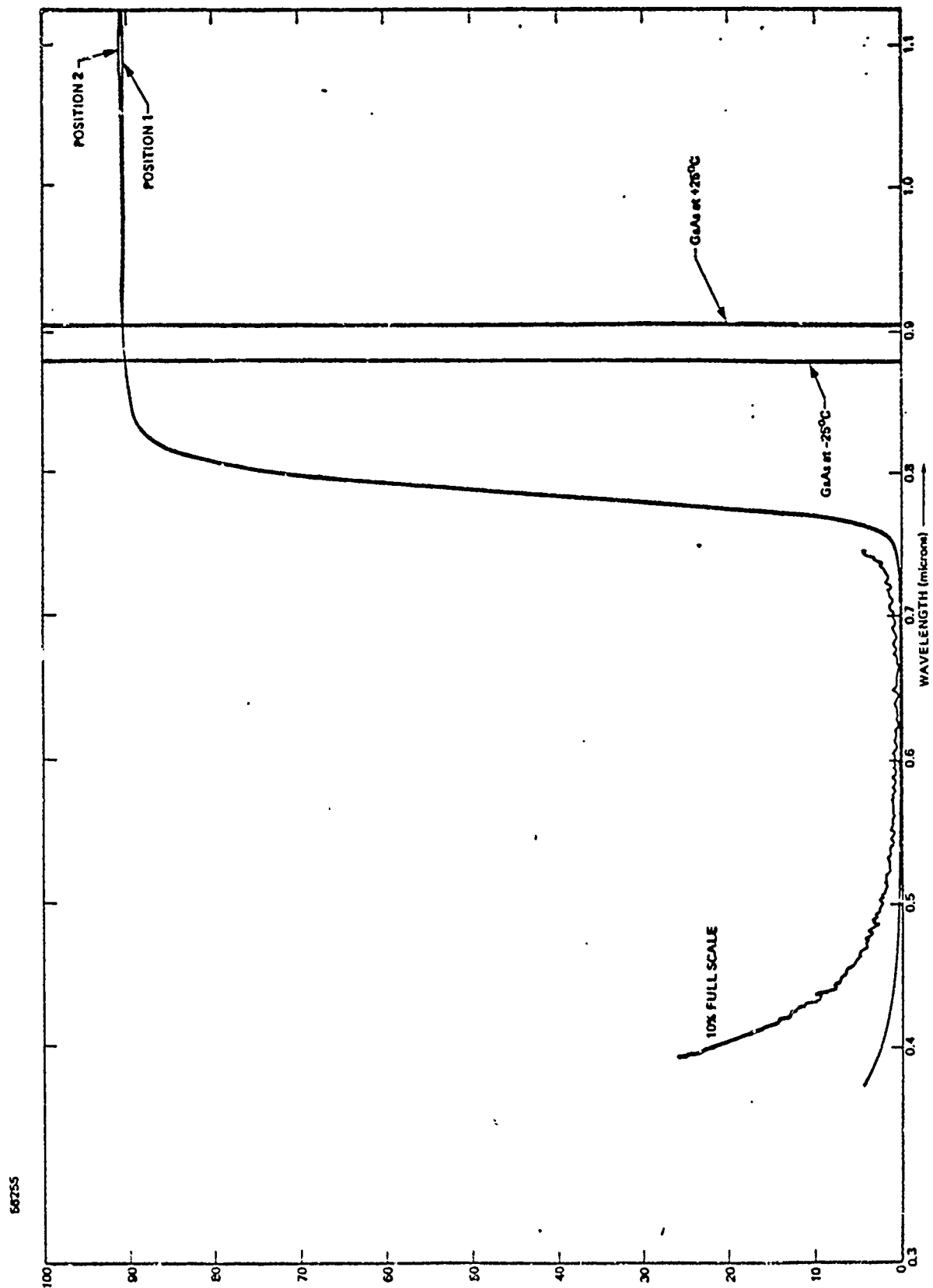


Figure C-2. Spectral Response RG 780 Filter

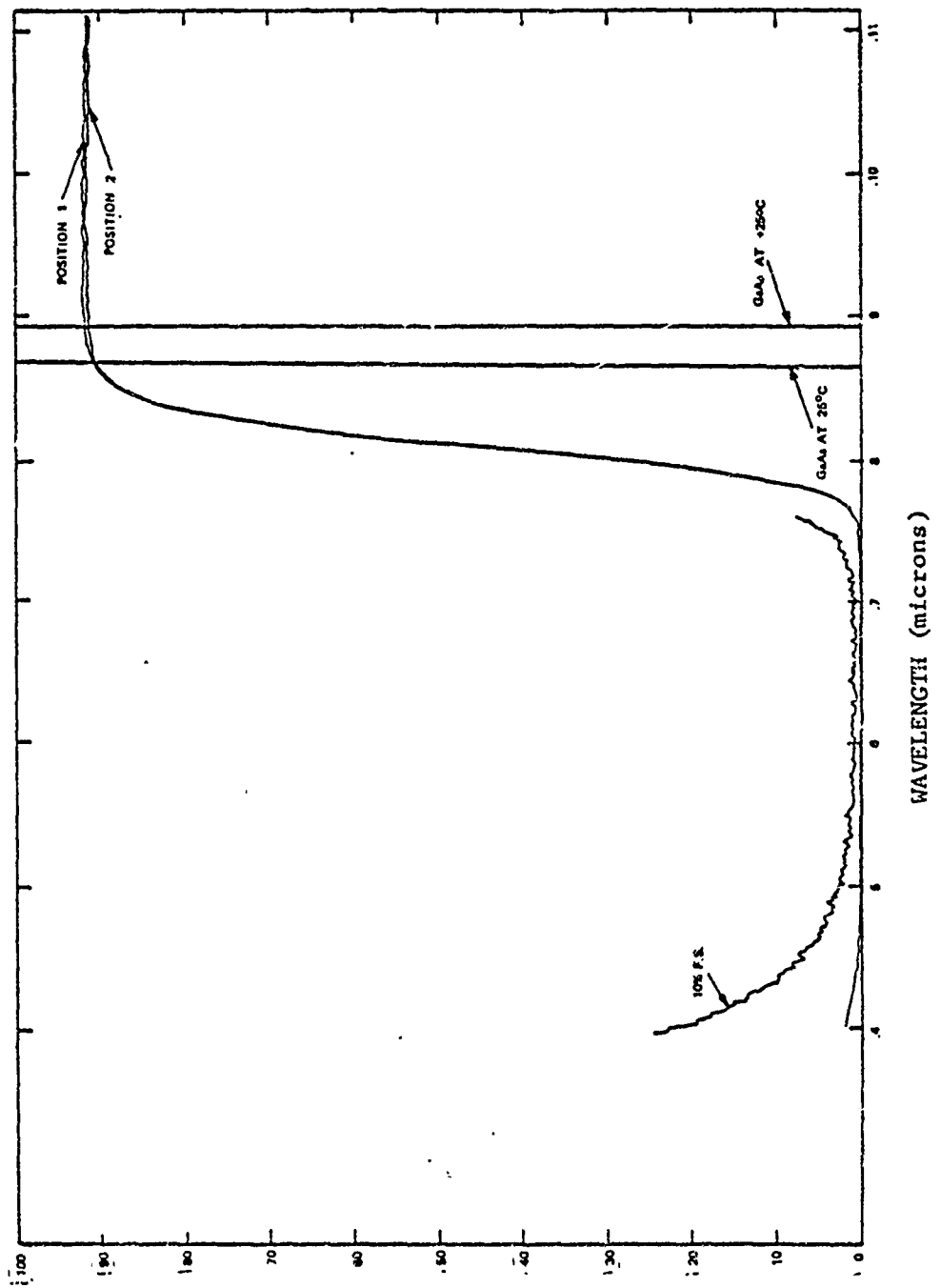


Figure C-3. Spectral Response RG 830 Filter

156251

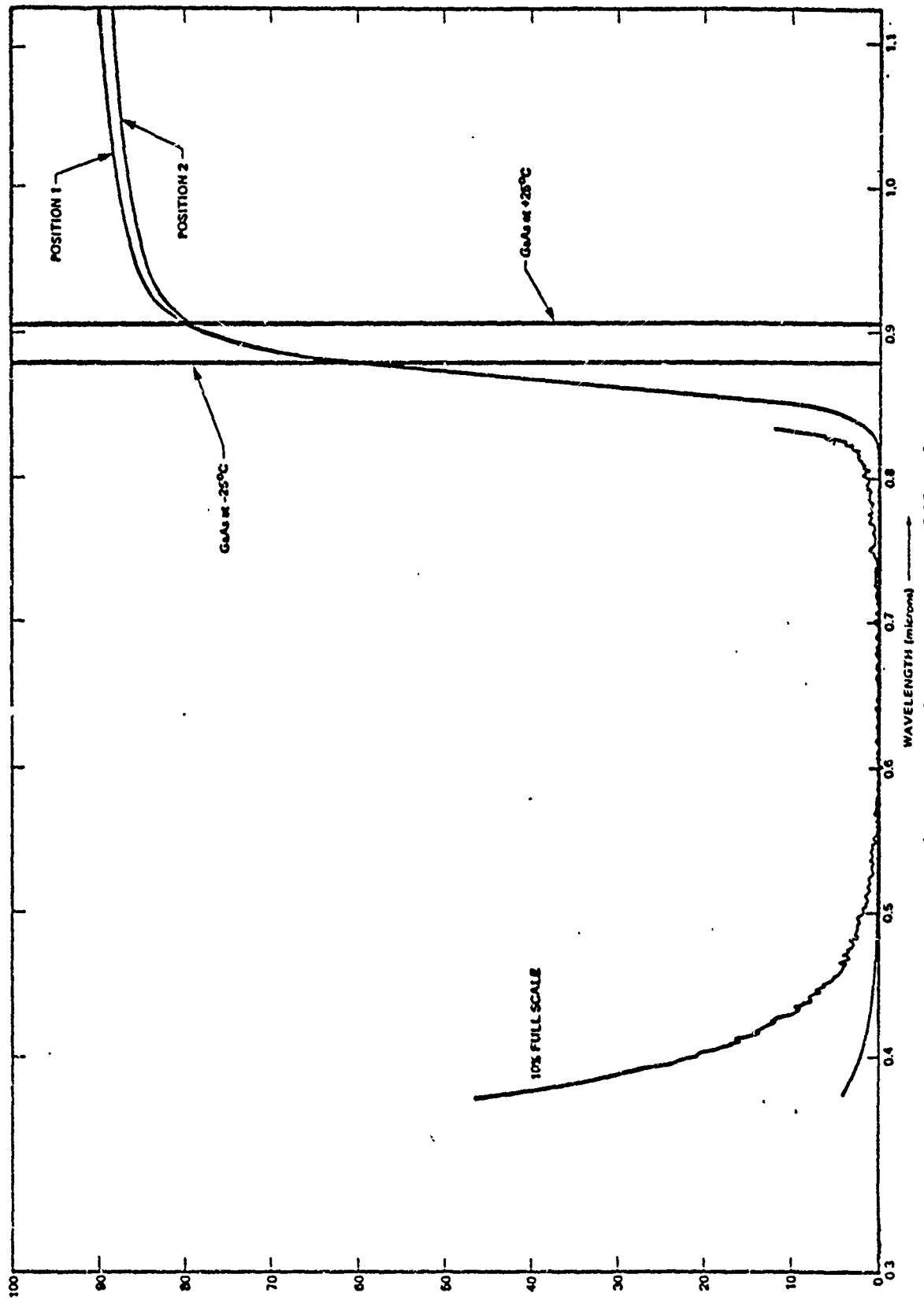


Figure C-4. Spectral Response, RC 850 Filter

then the response for a given filter is

$$R_{\text{filter}} = \int_0^{\infty} T_{\lambda} R_{\lambda} S_{\lambda} d\lambda$$

If we then normalize the filter performance relative to the direct sunlight case (i.e., no filter at all), we obtain

$$N_{\text{filter}} = \frac{\int_0^{\infty} T_{\lambda} R_{\lambda} S_{\lambda} d\lambda}{\int_0^{\infty} R_{\lambda} S_{\lambda} d\lambda}$$

Direct numerical integration of these analytically developed curves yields

$$N_{\text{RG 780}} = 0.391$$

$$N_{\text{RG 830}} = 0.307$$

$$N_{\text{RG 850}} = 0.264$$

Thus, the dc background currents using the RG 780, RG 830, and RG 850 filters, respectively, should be 39.1 percent, 30.7 percent, and 26.4 percent of the levels with no filters. Since the transmission at  $\lambda = 9040\text{\AA}$  (i.e., GaAs at  $+25^{\circ}\text{C}$ ), with allowance for reflection losses, is 90.6 percent, 89.6 percent, and 78.5 percent, respectively, (values from C-1 including reflection loss) then we may define a quality index as follows:

$$Q = \frac{T_{9040\text{\AA}}}{\sqrt{N}}$$

where  $T_{9040\text{\AA}}$  is the filter transmission at  $9040\text{\AA}$ . In effect,  $Q$  is directly proportional to signal-to-noise ratio since an increase in transmission at  $\lambda = 9040\text{\AA}$  will increase the signal, while an increase in  $N$  will increase the shot noise in a square-root fashion. Thus, upon substitution we find:

$$\text{No Filter:} \quad Q_{\text{No Filter}} = \frac{1.000}{\sqrt{1.000}} = 1.000$$

$$\text{RG 780:} \quad Q_{780} = \frac{0.906}{\sqrt{0.391}} = 1.449$$

$$\text{RG 830:} \quad Q_{830} = \frac{0.896}{\sqrt{0.307}} = 1.617$$

$$\text{RG 850:} \quad Q_{850} = \frac{0.785}{\sqrt{0.264}} = 1.528$$

thus it can be seen that the use of an RG 780 filter should increase S/N by about 45 percent relative to no filter at all. Further, the use of an RG 830 increases S/N by about 62 percent, but there is a small decrease to only 53 percent in going to the RG 850. Also, the RG 780 and RG 830 are identical in price while the RG 850 is about 50 percent more expensive than either the RG 780 or RG 830. Finally, the temperature coefficient of GaAs is about  $3\text{\AA}/^{\circ}\text{C}$ . At  $-25^{\circ}\text{C}$ , relative to  $+25^{\circ}\text{C}$ , the wavelength shift will be  $-150\text{\AA}$ . Since the GaAs laser center wavelength is  $9040 \pm 100\text{\AA}$ , then in a worst-case condition the laser output could occur at

$$\begin{aligned} \lambda &= 9040 - 100 - 150 \\ &= 8790\text{\AA} \end{aligned}$$

The transmission of the RG 830 at  $\lambda = 8790\text{\AA}$  is still 89 percent, including allowance for two surface reflection losses, while the comparable value for the RG 850 is only 6 percent. Hence at low temperature we find

$$\left. \begin{array}{ll} Q_{\text{No Filter}} & = 1.000 \\ Q_{\text{RG 780}} & \approx 1.440 \\ Q_{\text{RG 830}} & = 1.606 \\ Q_{\text{RG 850}} & = 1.187 \end{array} \right\} \text{ at } -25^{\circ}\text{C}$$

Thus, the low temperature performance of the RG-830 significantly exceeds that of the RG 850.

### C.3 EXPERIMENTAL RESULTS

A silicon cell supplied by sensor technology (a so-called "ultracell") was connected across a 1.0 ohm load resistance and the voltage drop read with a digital voltmeter. The silicon cell was positioned in direct sunlight on the roof of XEOS Building No. 101 on 28 June 1976, and a dc background of 21.0 mV was recorded with no filter present. The dc background was recorded on a Hewlett-Packard Model 3469-B digital voltmeter. The results were as follows:

| <u>Filter</u> | <u>dc Background<br/>(mV)</u> | <u>Normalized</u> |
|---------------|-------------------------------|-------------------|
| No Filter     | 21.0                          | 1.000             |
| RG 780        | 7.8                           | 0.375             |
| RG 830        | 6.1                           | 0.293             |
| RG 850        | 5.2                           | 0.248             |

Using the manufacturer's transmission data at 9040Å for the three filters,\* the experimental data result in the following quality factors:

$$\text{No Filter:} \quad Q = \frac{1.000}{\sqrt{1.00}} = 1.000$$

$$\text{RG 780:} \quad Q = \frac{0.906}{\sqrt{0.375}} = 1.479$$

$$\text{RG 830:} \quad Q = \frac{0.896}{\sqrt{0.293}} = 1.655$$

$$\text{RG 850} \quad Q = \frac{0.785}{\sqrt{0.248}} = 1.576$$

#### C.4 CONCLUSIONS

- a. Analysis of solar spectral irradiance data, silicon detector response data and spectral transmittance data for RG 780, RG 830, and RG 850 filters shows significant improvement in signal-to-noise ratio is possible with all three filters.
- b. At room temperature, the performance of the RG 830 and RG 850 filters for the detection of GaAs radiation by a silicon detector against a solar background in a shot noise dominated condition is almost the same, with a slight edge to the RG 830.
- c. At low temperatures (e.g., -25°C), the performance of the RG 830 filter will be superior to that of the RG 850 filter. This is the result of the wavelength shift of GaAs laser radiation toward the blue at reduced temperatures.
- d. Experimental tests at XEOS, in direct sunlight, directly confirm the analytical predictions and are in agreement with predicted values within 3 percent. This is considered excellent agreement and confirms the analysis.

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\* Figures C-2, C-3, and C-4 are copies of actual transmission curves for the three filters used.

### C.5 RECOMMENDATIONS

- a. From a performance standpoint, at room temperature, the RG 830 filter is slightly superior to the RG 850 although either filter would provide good MILES performance.
- b. At reduced temperatures, the RG 830 filter is definitely recommended.
- c. Since the RG 830 is less costly than the RG 850, has definitely superior low temperature performance, and slightly superior room temperature performance, the overall MILES systems analysis recommendation for a spectral filter is the RG 830.