Laser Terminal Homing Engagement Simulator (Eye Safe)

December 1975

RESEARCH
DEVELOPMENT
ENGINEERING

U.S. Army Materiel Command
HARRY DIAMOND LABORATORIES
Adelphi, Maryland 20783

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: HDL-TM-75-28
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): Laser Terminal Homing Engagement Simulator (Eye Safe)
5. TYPE OF REPORT & PERIOD COVERED: Technical Memorandum
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): Thomas J. Gleason, Melvin E. Sword
8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Harry Diamond Laboratories, 2800 Powder Mill Road, Adelphi, MD 20783
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
11. CONTROLLING OFFICE NAME AND ADDRESS: Commander, USAOTEA, 5600 Columbia Pike, Falls Church, VA 22041
12. REPORT DATE: December 1975
13. NUMBER OF PAGES: 30
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:
16. DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited.
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):
18. SUPPLEMENTARY NOTES: HDL Project No.: 329532; AMCMS Code: 697000.22.11370; Operation and Maintenance, Army, funds.
19. KEY WORDS (Continue on reverse side if necessary and identify by block number): Laser, Terminal Homing, Training Device, Instrumentation, Simulator
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Laser Terminal Homing Engagement Simulator (LATHES) (Eye Safe) was developed by the Harry Diamond Laboratories for the US Army Operational Test and Evaluation Agency. It allows realistic field exercises for tests or training relative to laser terminal homing systems to be conducted without the use of non-eye-safe lasers. The LATHES consists of a designator simulator, target simulator, and seeker simulator allowing simulation of the tactical engagement at realistic ranges. The designator and target

simulators are eye safe, and the target simulator is compatible with tactical laser receivers. The LATHES provides a means of testing tactical concepts or training troops in the operational use of laser guided weapons or laser designation and target hand-off procedures without requiring the extensive range safety provisions that are necessary when real target designators are used.

CONTENTS

FIGURES

1. INTRODUCTION

The Laser Terminal Homing Engagement Simulator (LATHES) was developed for the US Army Operational Test and Evaluation Agency by the Harry Diamond Laboratories (US Army Materiel Command) for use in test and training exercises involving laser terminal homing systems.[1] The most important feature of the LATHES is that it makes it possible to conduct a realistic field simulation of a tactical laser terminal homing engagement without using any components that pose a hazard to the eyes of user or bystander personnel. All LATHES components are eye safe at zero range.

The basic concept of the LATHES system is to provide eye-safe equipment capable of realistically simulating the tactical characteristics of a laser terminal homing engagement. As such, the LATHES system allows test or training of tactical proficiency (command and control, tactical fire control, selection and utilization of tactical position, etc.) as opposed to technical proficiency (operator tracking capability, operation of the Ground Laser Locator/Designator (GLLD) controls for ranging, etc.). (Integration of both tactical and technical training on one system is feasible if desired.) The elements of the engagement that are simulated with the LATHES are target acquisition and identification, selection of target to be engaged, call for fire or close air support, coordination of laser code, initiation of designation, acquisition of coded target by the laser tracker or weapon seeker, and termination of designation.

The LATHES hardware is designed to allow simulation of the elements of the engagement that involve active interactions between the designator, target, and seeker (from initiation of designation to the end of the engagement). The LATHES designator simulator provides a visible light beam to cue the target when designation is initiated and to confirm the existence of a clear optical line of sight from the designator to the target. The LATHES target simulator, turned on upon the cue provided by the designator simulator, generates a coded laser target signature fully compatible with tactical seekers and search-track systems. The LATHES receiver provides a low-cost simulation of a seeker or search-track system with full Department of Defense (DOD) standard decoding capability.

---

[1] *In the US Army these systems include Cannon Launched Guided Projectile, HELLFIRE Missile System, Light Weight Laser Designator, Ground Laser Locator Designator, Airborne Target Acquisition and Fire Control System, and Airborne Laser Tracker.*

2. THE LATHES SUBSYSTEMS

The LATHES system consists of three major subsystems (fig. 1).

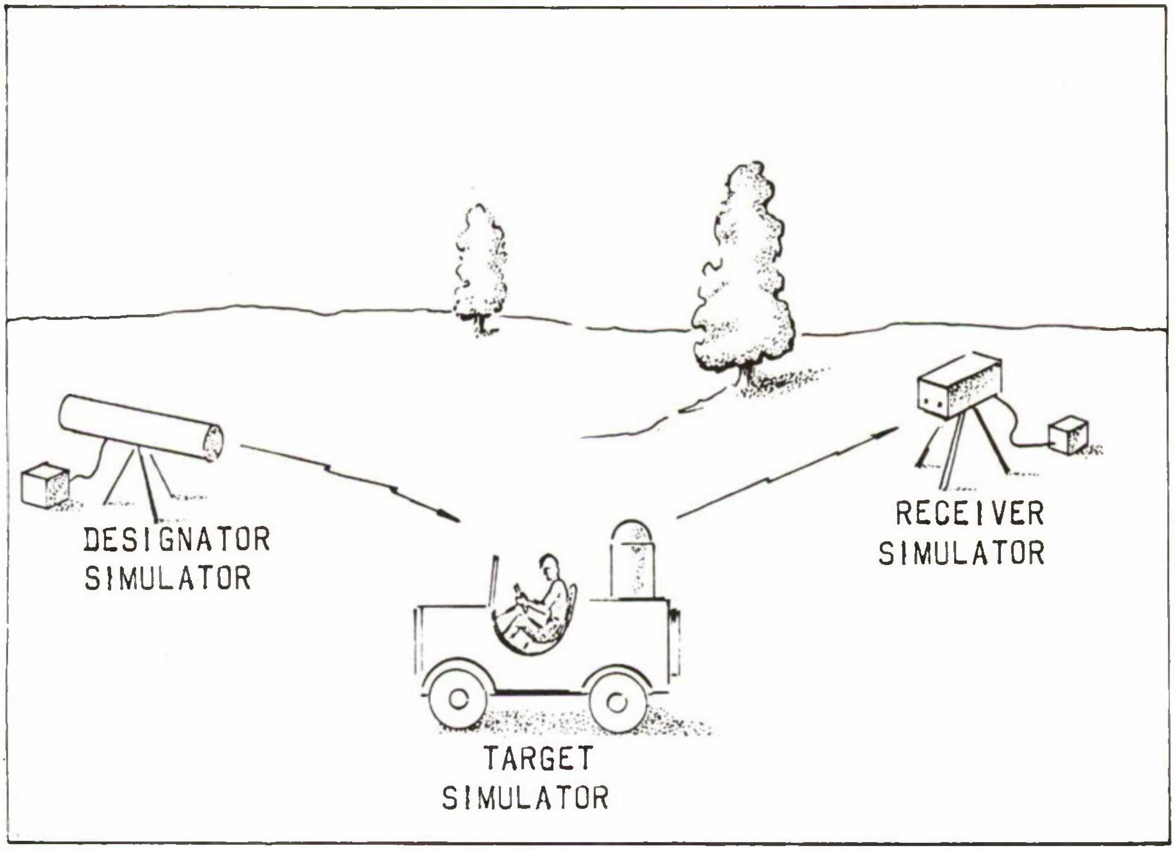


Figure 1. LATHES components.

2.1 Designator Simulator

The designator simulator (fig. 2) takes the place of a ground laser designator in the tactical engagement. It is primarily intended to simulate a precision designator such as the GLLD. The designator simulator consists of a color-coded, narrow-beam, visible light source provided with a tracking sight, telemetry interface, instrumentation camera mount, and battery power pack. The designator simulator mounts on a TOW (antitank guided missle system) traversing unit to provide full viscous damped manual target tracking. It is compatible with TOW tracking optics, including the TOW night sight.

Figure 2. Designator simulator.

2.2 Target Pallet

The target pallet (fig. 3) is designed for mounting on a 1/4-ton truck or armored personnel carrier (APC). It provides physical protection and shock mounting for a laser target simulator (International Laser Systems NC-10) that is capable of producing a valid laser-designated-target signature. The laser target simulator is a pulsed laser whose output is spread through somewhat more than a hemisphere. It is eye safe at zero range. The target simulator operates on vehicle power. In addition, a remote control unit is provided that allows a controller to set codes on the laser target simulator and to turn it on and off. A telemetry interface is provided, and a spare, manually operated, telemetry input is available on the remote control console.

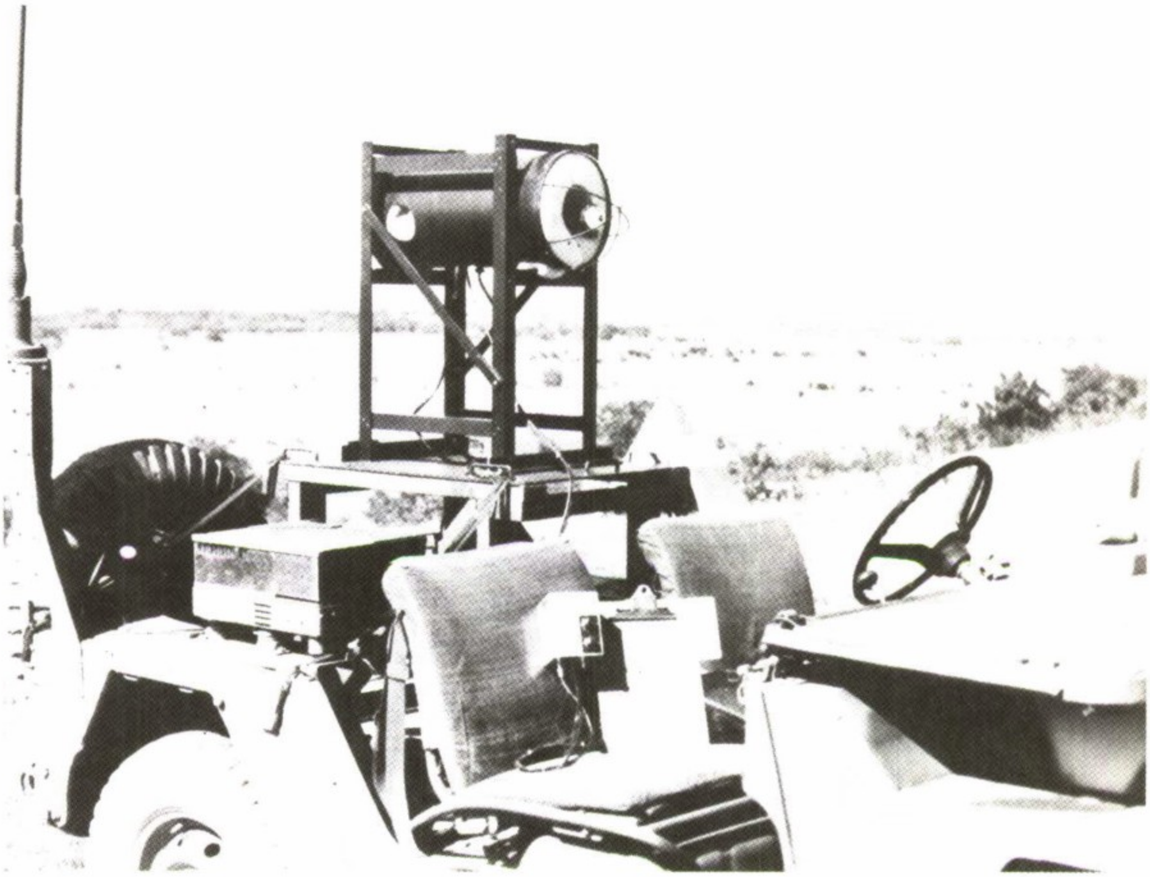


Figure 3. Target pallet on 1/4-ton truck.

2.3 Receiver

The LATHES receiver (fig. 4) performs the target acquisition functions of a laser terminal homing seeker. It is configured as a "box camera" with a simple viewfinder and may be used hand held, on a tripod, or mounted on a vehicle. The receiver detects the laser-designated-target signature from the laser target simulator or a real designated target. It has a decoder compatible with all standard DOD laser designators. When a properly coded target is present within the receiver field of view (FOV), visual and audible acquisition alarms are activated. The target acquisition criteria and "missing-pulse" logic capabilities of the receiver are identical to typical laser-guided weapons seekers. The receiver has two simultaneous FOV's, a wide FOV of 15 deg and a narrow FOV of 2 deg centered in the wide FOV. A distinct narrow FOV acquisition indication permits the operator to determine when he has centered the receiver on the target being "designated." The receiver has no automatic direction finding or tracking capability. A remote acquisition indicator can be located at the observer position when the receiver is vehicle or aircraft mounted.

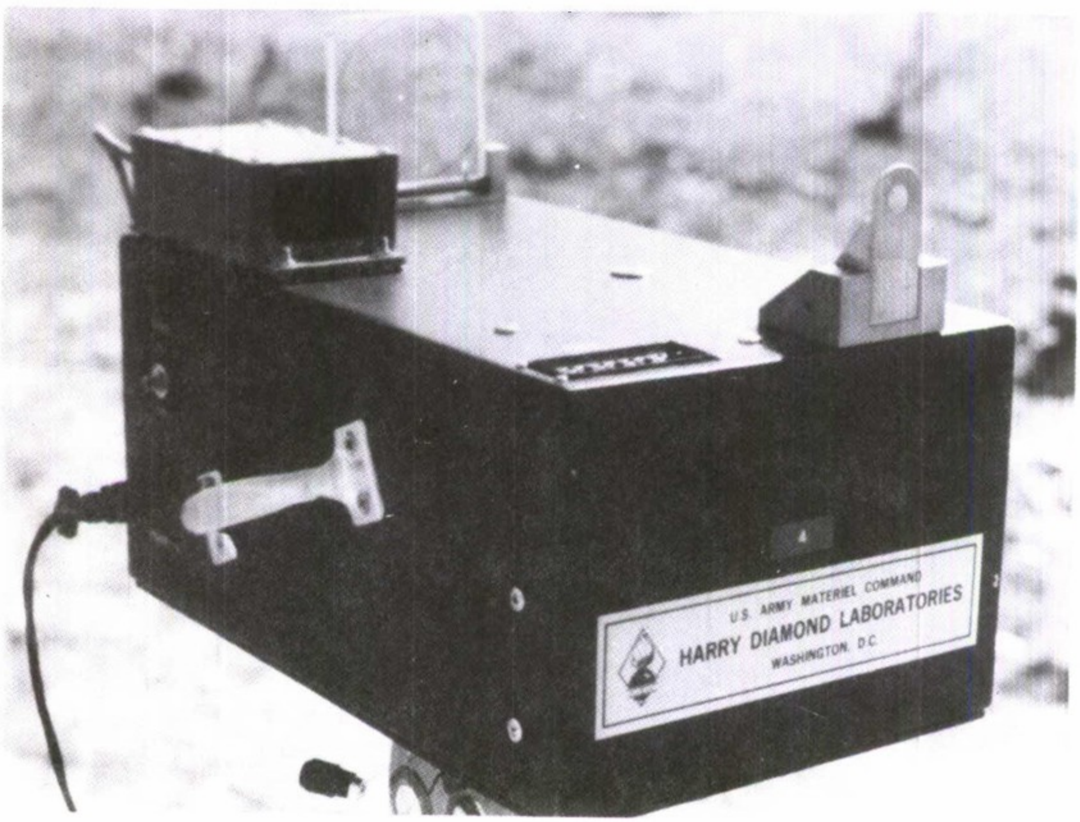


Figure 4. LATHES receiver.

3. THE LATHES OPERATIONAL CONCEPT

In operation, the designator simulator is used to cue the observer on the target vehicle when to turn on the target simulator and also to confirm the existence of designator-to-target line of sight. Color coding of the designator simulator can be used to indicate which code to set into the target simulator. The receiver can be operated either at a ground position (perhaps a hilltop to simulate a helicopter just breaking mask) or on an aircraft. If the proper code has been set into the receiver and the target is in its FOV with unobstructed line of sight, the receiver signals acquisition of the target. All elements of the system are usable at ranges of at least 2 km and will significantly exceed this range under most conditions.

4. EXAMPLES OF POTENTIAL LATHES USAGE

4.1 Cannon Launched Guided Projectile Engagement

The forward observer (FO) team equipped with the LATHES designator simulator occupies a tactical observation point (OP) and performs its assigned role in target acquisition and fire control. Upon command from the fire direction center (FDC), the designator operator initiates designation using the color code indicated by the code coordination procedure in use. A controller on the target vehicle, cued by the timing and color of the designator beam, sets the target's code and turns it on. He continuously monitors designator-to-target inter-visibility by watching for obscuration of the designator beam. A controller on an overwatching position sets the LATHES receiver to the code specified by the firing unit and reports acquisition of a properly coded target, thus confirming that the code coordination between the FO and firing unit has been successfully accomplished.

4.2 Close Air Support (All Services)

The ground unit occupies a tactical position and performs its target acquisition function. Close air support is requested, and target and code information are processed through the command and control system. Upon command, the designator operator initiates designation and the target is turned on (coded). If all functions have been successfully performed, the tactical laser acquisition devices of the aircraft acquire a properly coded target within their search pattern, and weapons release is simulated.

5. DESIGNATOR SIMULATOR DESIGN

The designator simulator, shown in a cutaway view in figure 5, is designed to project a bright visible light beam for several kilometers. It utilizes a 24-V aircraft landing lamp with a 5-in. diam sealed-beam reflector. The landing lamp output is baffled to about 2-deg total beam spread by being passed through 10 in. of aluminum honeycomb. Interchangeable plastic color filters provide red, green, amber, and white beams.

The lamp is turned on and off by a push-button trigger in a pistol grip handle that attaches to the right-hand elevating knob of the TOW traversing unit. A switch-closure telemetry output from the designator simulator indicates when the lamp is turned on and off.

A mounting platform is provided for an instrumentation camera. Camera on-off control is provided by a relay in the designator simulator that switches the camera power on and off. Normally, the camera is switched on when the lamp is turned on. However, a camera override switch located on the pistol grip allows independent operation of the camera.

A flasher circuit in the designator simulator can be activated to cause the lamp to blink with a period of 2 s. This optional mode of operation can be used either to expand the code set provided by the color filters or to increase the subjective visibility of the light beam.

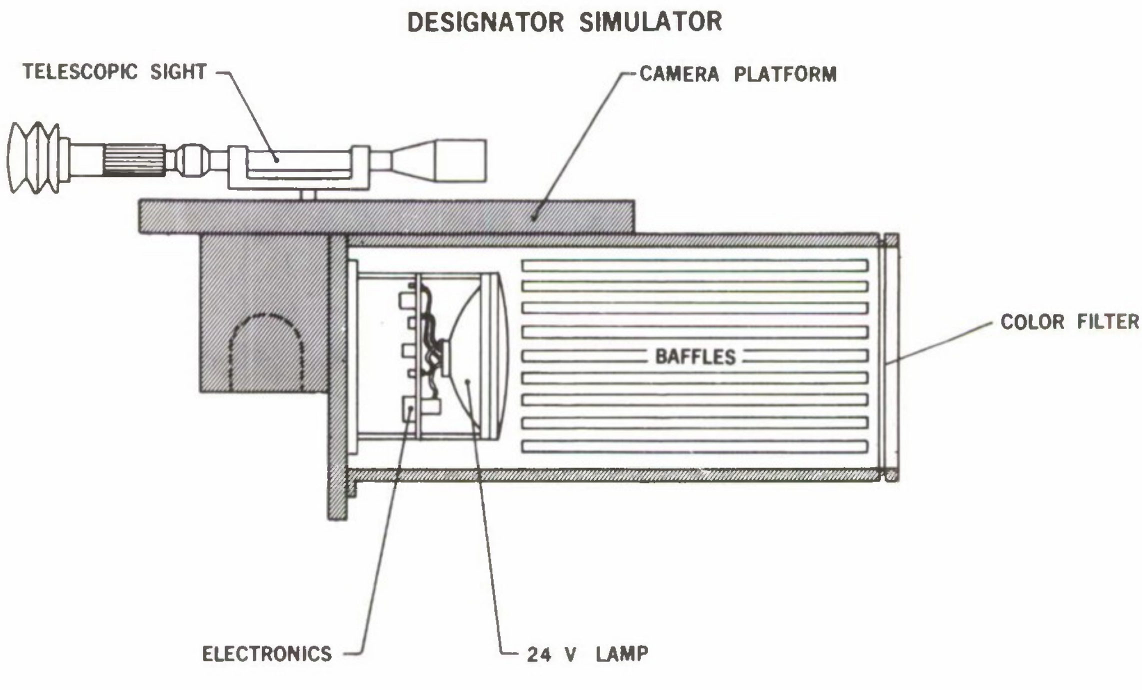


Figure 5. Designator simulator cutaway view.

The designator simulator is powered by two 12-V motorcycle batteries (fig. 6) that are packaged in a separate aluminum battery case. They provide about 1 hr of "on" time between recharging. A battery charging console capable of charging up to five battery packs simultaneously is part of the LATHES support equipment.

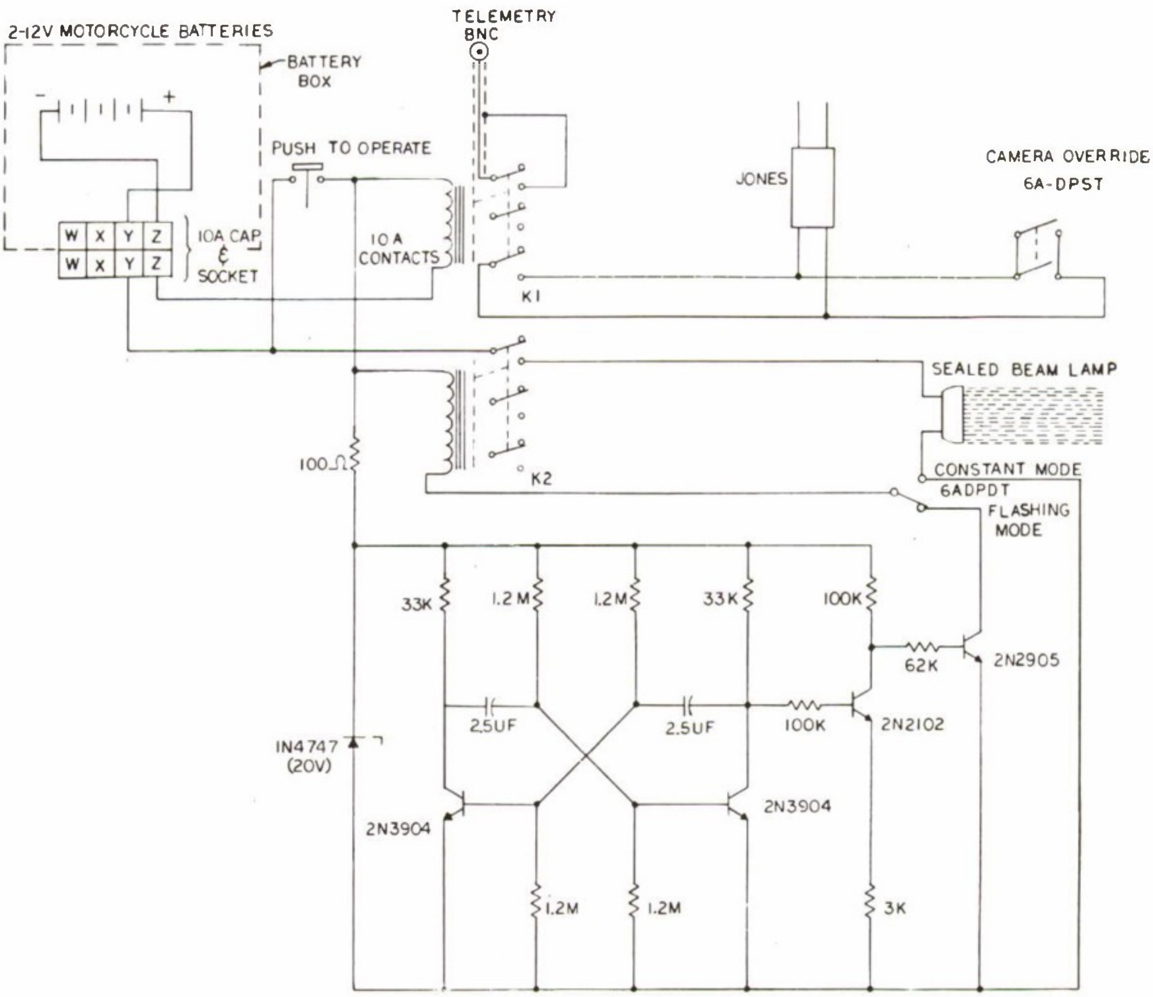


Figure 6. Schematic diagram of LATHES designator simulator.

6. TARGET PALLET DESIGN

The LATHES target pallet provides a mount for the target simulator laser on a 1/4-ton truck or APC. It provides shock mounting and enough physical protection for the laser to allow off-road movement with reasonable care. The target simulator laser, an ILS NC-10 provided by the Precision Laser Designator Product Office of the US Army Missile Command, has at its output a diffuser that spreads the laser pulse energy out into approximately a hemisphere. The resultant diffused output is eye safe at zero range (app A). The laser is powered directly from 28-Vdc vehicle power and controlled remotely by the LATHES remote control console.

Figure 7 shows the target pallet design, while figure 3 shows the target pallet installed on a 1/4-ton truck. The wooden platform, when installed on the truck, raises the laser output diffuser above the driver's head. For APC installation, the wooden platform is omitted and

TARGET SIMULATOR

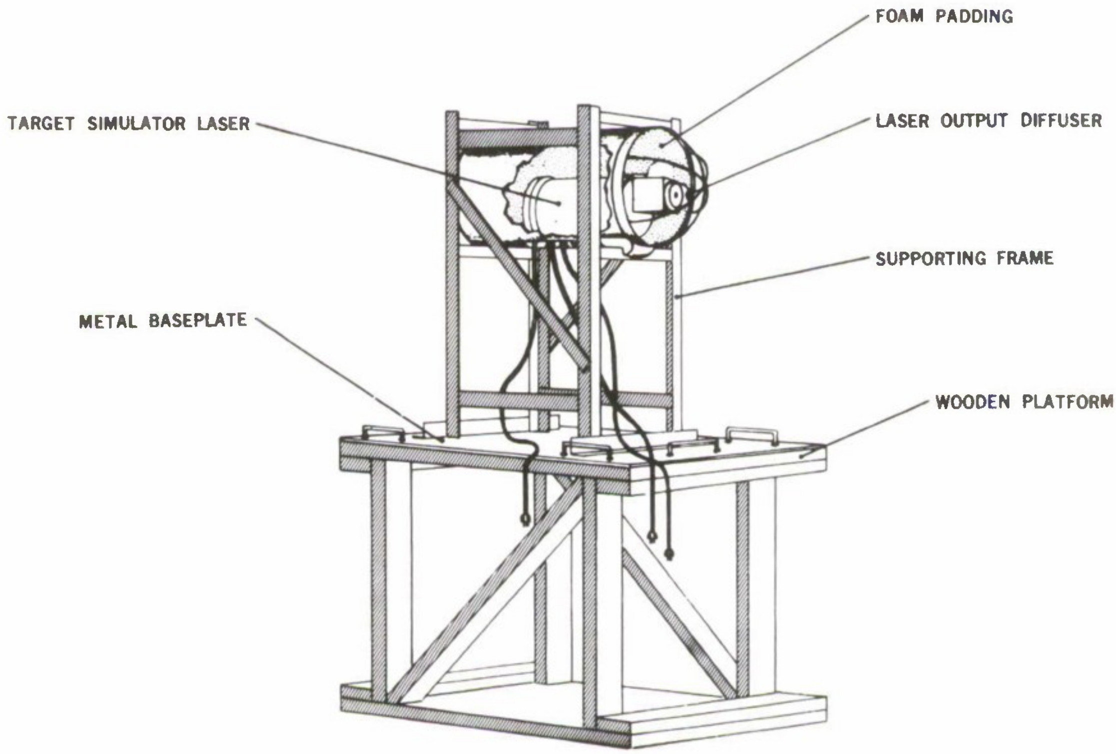


Figure 7. Target pallet design.

the metal base-plate is mounted directly on the top surface of the crew compartment hatch of the APC. In this configuration, the diffuser height is designed to be just above the head of a crew member exposed from the thorax up out of the driver's or vehicle commander's hatch.

The remote control console is mounted on a clipboard to facilitate use by a data recorder or test controller. It provides remote on-off and code setting for the NC-10 by use of an extender cable harness. The remote control module is visible in the passenger seat of the 1/4-ton truck in figure 3.

The target pallet is lashed to the vehicle with nylon tie-down straps. In the field, the pallet is left on the vehicle during overnight breaks in the test, while the laser, in its cylindrical housing, is removed and placed in covered storage. Removing or replacing the laser takes less than 5 min and is performed by the vehicle crew.

7. RECEIVER DESIGN

The LATHES receiver consists of two component parts, the power supply and the receiver, joined by an interconnecting cable (fig 4).

The power supply contains two PRC 77 field radio batteries wired in series and center tapped to provide ±14 Vdc, a +45-Vdc battery to provide bias voltage for the photodiodes, and a switch and meter for checking all of the batteries. An interconnection wiring diagram is shown in figure 8.

The receiver has two analog channels, one for the wide-FOV detector and the other for the narrow-FOV detector, a decoder, and aural and visual acquisition indicators. A block diagram of the receiver is shown in figure 9.

A schematic diagram of an analog channel is shown in figure 10. The detector used in both analog channels is a Schottky barrier silicon PIN photodiode with an active area of 1.0 cm^2 and an average responsivity of 0.3 mA/mW at 8500 Å. Light energy entering the receiver passes through an optical filter with a spectral bandwidth of 250 Å centered at 1.07 μm before striking the photodiode. The photodiodes are reverse biased at 45 Vdc which produces an average junction capacitance of 45 pF. Each photodiode is followed by an analog channel having a voltage gain of 58 dB and bandwidth of 35 MHz. The first stage of the analog channel is a transimpedance amplifier to convert the low-level output current of the photodiode to a manageable voltage level. The gain of this stage is 34 dB. The following two stages provide the bandpass characteristics of the channel and an additional voltage gain of 24 dB. The three stages combine to provide a signal-to-noise ratio of 8 at the input to the SN52106 comparator under worst-case conditions (with the receiver looking directly into the sun and the minimum calculated signal being received).

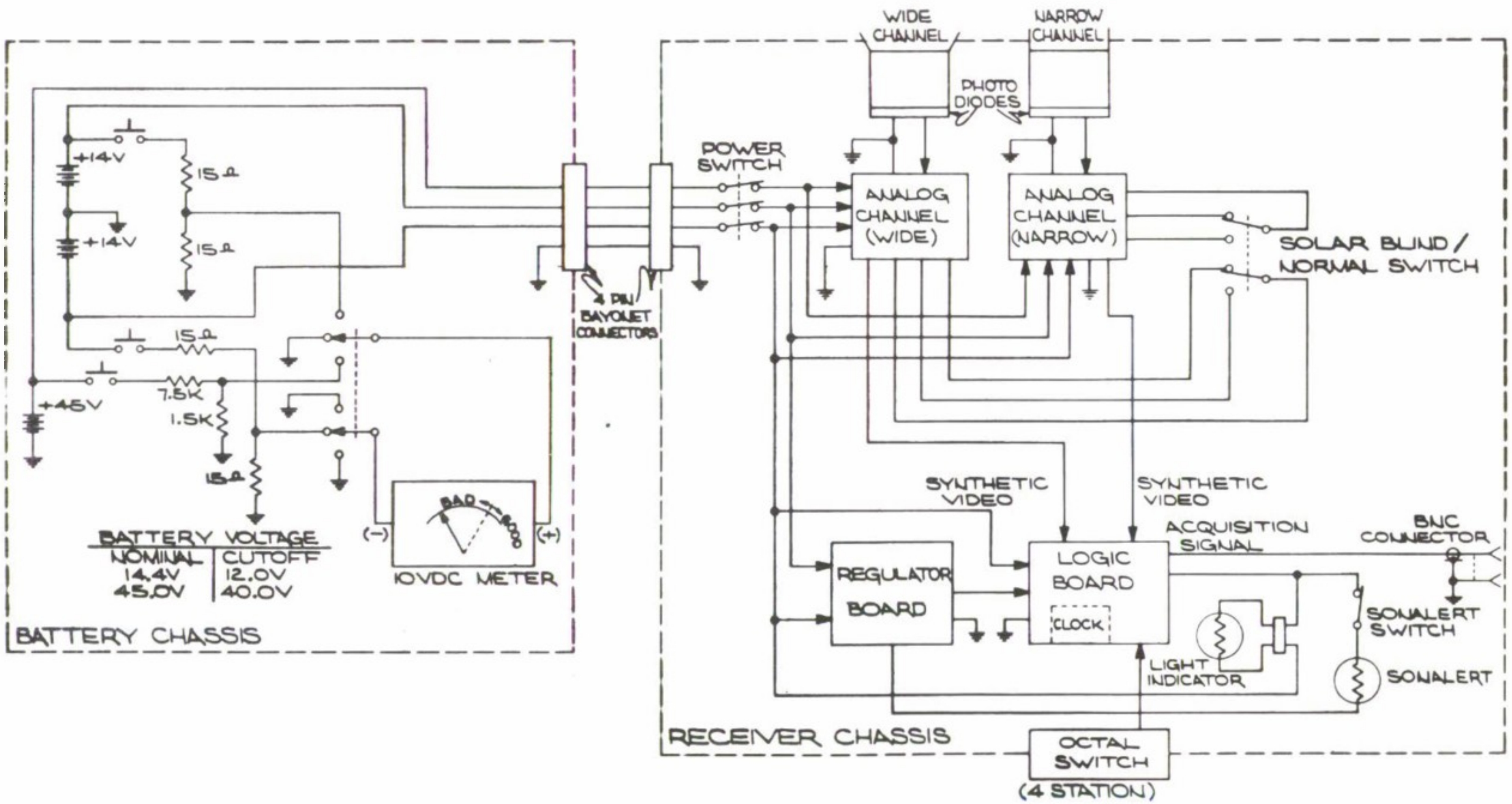


Figure 8. Interconnection diagram of receiver system.

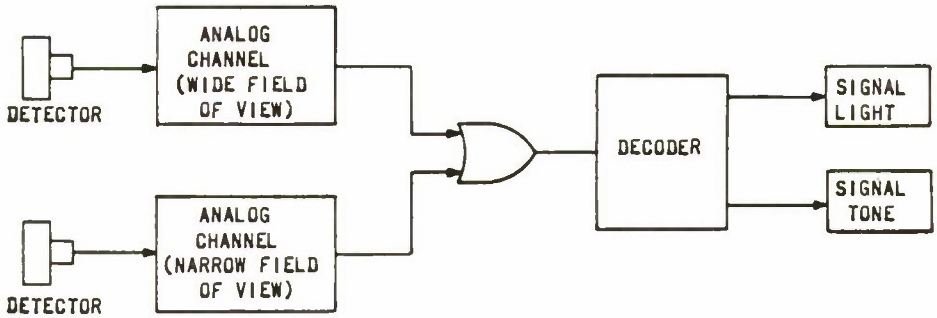


Figure 9. Block diagram of receiver.

The SN52106 has two threshold settings, which are switch selectable. One threshold setting, designated as "normal," is for use when the receiver is being operated in a normal bright background environment. The other threshold, designated as "solar blind," is for use when the receiver is being operated with the sun directly in the FOV.

Voltage regulation and proper operating voltages for the analog channel are provided by two appropriately wired uA723 regulators.

The outputs from the analog channels are fed to the decoder, which is shown schematically in figure 11, where they pass through a NAND gate and set a 20-ms one-shot. The pulse repetition frequency (PRF) code that the decoder is to accept is entered by setting a count-down circuit driven by the 10.250-MHz clock, and it produces output pulses that are properly spaced in time for the code selected. The output pulses from the count-down circuit shift the two shift registers providing the inputs to the SN74H52, which is composed of four AND gates and an OR gate. When three pulses in a row with the proper interpulse spacings have been received, the SN74H52 produces an output pulse, which, at the end of another interpulse interval, produces a signal to drive the acquisition light and the Sonalert aural signal and provides a telemetry output signal. After acquisition of a properly coded signal, the decoder continues to produce an output signal as long as no more than three successive properly spaced received pulses are missing. This feature constitutes the so called "missing pulse" logic of the decoder. If the received signals are arriving in the wide FOV analog channel only, the acquisition light is on continuously and the Sonalert produces a solid sound. If the received signals are in both the wide FOV and the narrow FOV or from the narrow FOV only, the acquisition light operates in a blinking mode and the Sonalert produces a beeping sound. Provisions are incorporated in the receiver to switch the Sonalert off if desired. However, to preclude the possibility of the receiver detecting a properly coded signal but producing no indication of its presence, the acquisition light cannot be disabled.

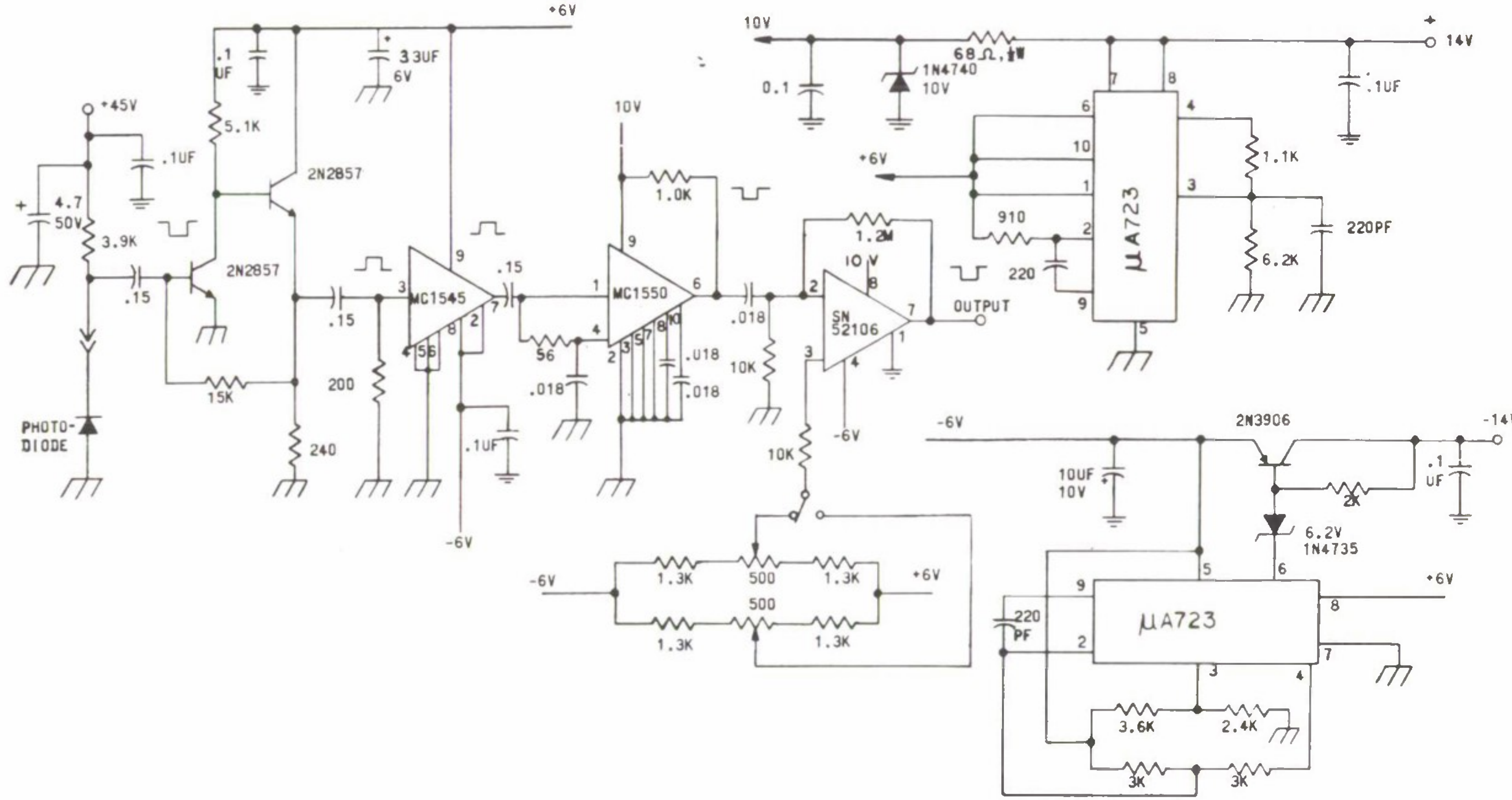


Figure 10. Receiver analog channel schematic diagram.

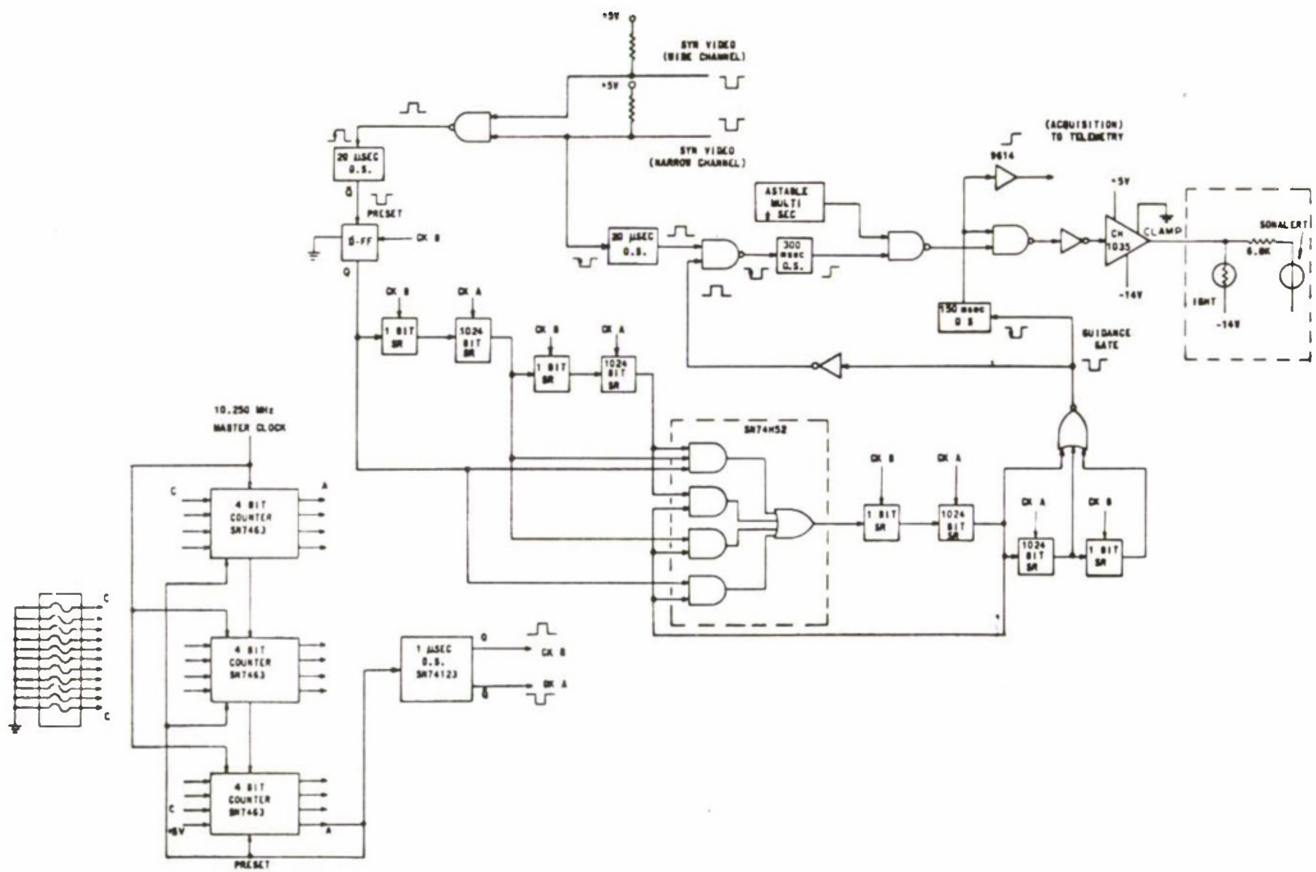


Figure 11. Decoder schematic diagram.

The decoder requires -14 Vdc, which it receives directly from the -14-Vdc supply, and +5 Vdc, which it receives through a regulator from the +14-Vdc supply.

8. PERFORMANCE OF THE LATHES IN THE FIELD

The LATHES system was delivered to Fort Hood, TX, on 2 March 1975 for use in the Joint Service Test of Laser Guided Weapons in Close Air Support. The system met all specifications, with a demonstrated receiver acquisition range of 2 km when the target simulator was used on the LATHES target pallet and up to 4 km when real targets were designated. As a side benefit, the LATHES receiver proved extremely valuable as a test and diagnostic tool for checking the performance of the many laser designators being used in the test. No maintenance problems were encountered with the LATHES hardware during a total of about 5 wk in the field, and routine preventive maintenance was sufficient to insure a nearly 100-percent availability record for the laser target simulators.[2] Six designator simulators, four target pallets, and four receivers (plus one spare) were deployed.

9. MODIFICATIONS TO THE LATHES

9.1 Increased Target Output Energy

From experience gained during the initial phases of the Joint Service Test at Fort Hood, it was decided to modify the LATHES target pallet to provide increased output energy and thus increased detection range. This was accomplished by replacing the NC-10 target simulator lasers with "MPT" model laser designators, provided by the Precision Laser Designator Product Office.

The MPT designator is larger than the NC-10, has a 100- to 120-mJ output pulse (compared with 6 to 10 mJ for the NC-10), and has a highly collimated output beam about 10 cm in diam. The size and output beam characteristics of the MPT laser required changes in the mounting arrangements on the pallet and in the diffuser. The MPT laser with its diffuser is shown in figure 12.

---

[2]*With the exception of one unit that was inoperative and awaiting repair parts during the first 3 wk in the field.*

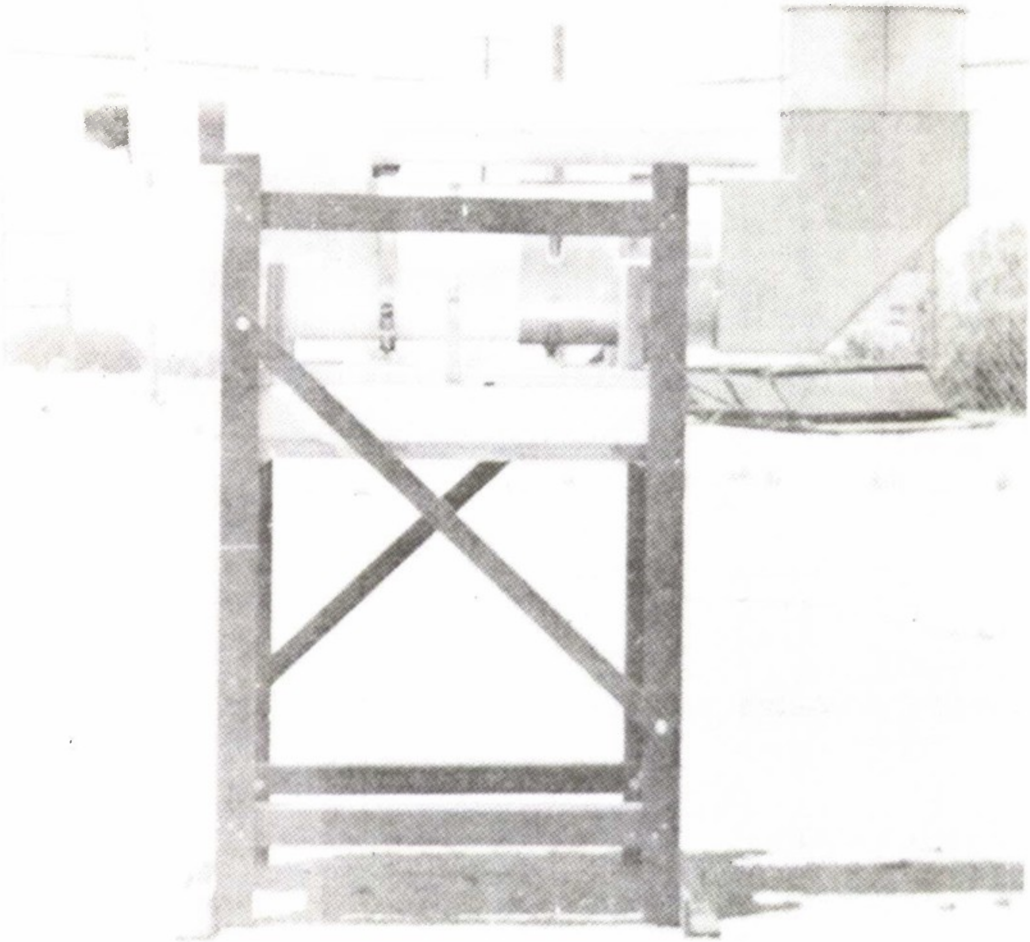


Figure 12. MPT laser and diffuser.

Figure 13 shows the main features of the MPT diffuser. The plane mirror changes the beam direction 90 deg and is adjustable to permit alignment of the beam uniformly over the inside of the diffuser. The effective diffuser area is 265 cm^2 (see app A for eye-safety analysis). With this target, the LATHES receiver has demonstrated target acquisition at 7.0 km.

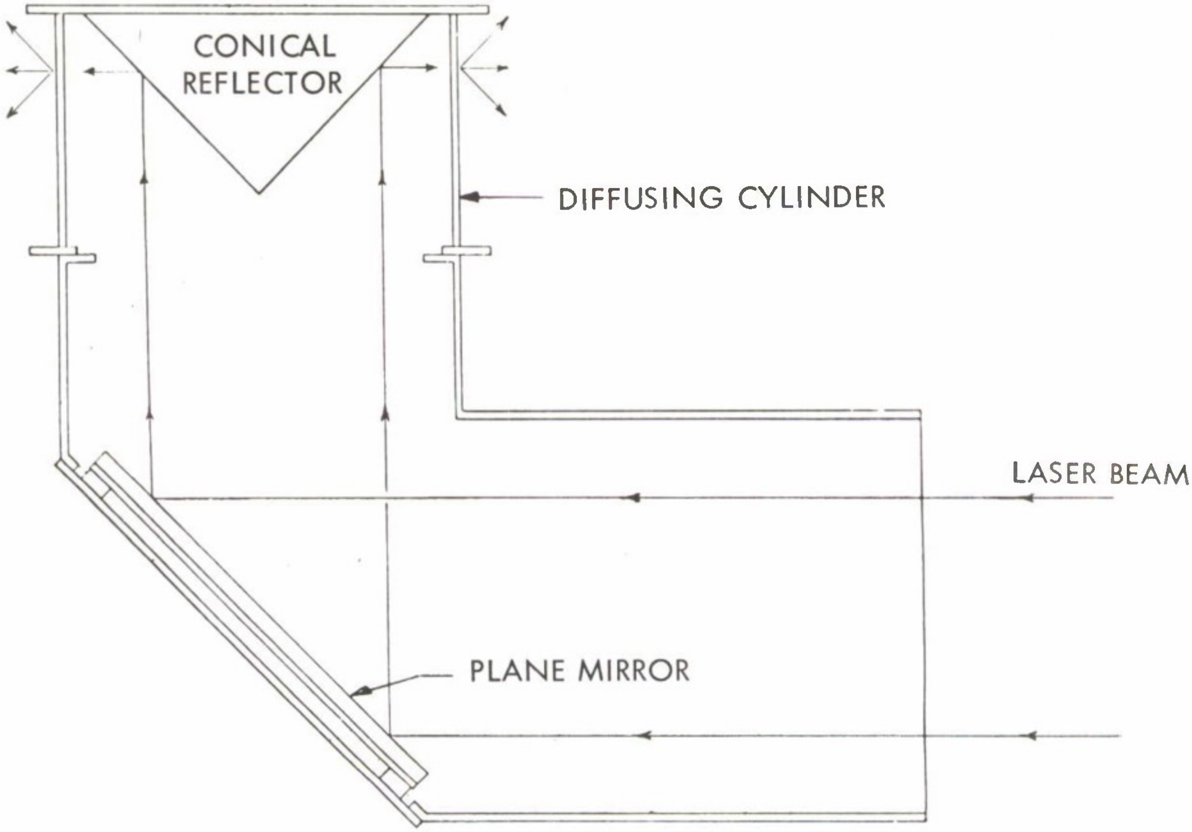
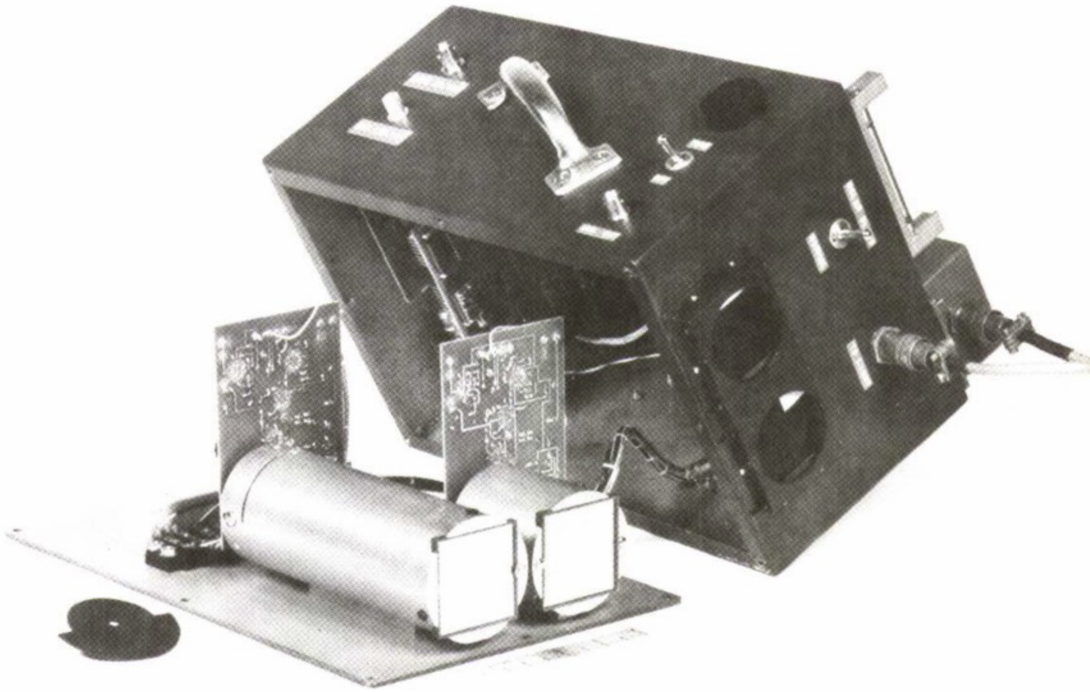


Figure 13. Diffuser for MPT laser.

9.2 Additional Signal Outputs from Receiver

The fringe-benefit usefulness of the LATHES receiver for test and monitoring of laser designator performance at the Joint Service Test was sufficient to create a demand for additional receivers to be used in this role. As a first step in this direction, a LATHES receiver has been prepared with additional signal output suited to laser monitoring. The amplified video signal at the output of the MC-1550 amplifier (fig. 10) and the synthetic video at the output of the SN52106 comparator (through a one-shot buffer) are available at coaxial connectors on the modified receiver. The amplified video can be used to monitor pulse amplitude. The synthetic video can be used to trigger timers to monitor the pulse-to-pulse timing of the laser being tested. The modified receiver has been delivered to the Precision Laser Designator Product Office for use in development tests. Figure 14 is a photograph of the modified receiver, opened up to show the internal arrangement.



475-75

Figure 14. Receiver opened to show internal parts.

10. FUTURE LATHES CONFIGURATIONS

The LATHES system has demonstrated its ability to simulate the operational aspects of a laser terminal homing engagement from the standpoint of troop procedures and command and control. Future use of the system may include troop training, as well as further operational tests. The existing system was built in a very short time to support a specific test. There are several areas in which major improvements might be made.

The visible beam from the designator simulator can be made narrower by the use of an imaging optical system, probably utilizing inexpensive Fresnel lenses. This system would increase the selectivity of the designator in specifying a target, particularly at long range.

A more significant improvement would be to replace the visible designator simulator beam with a coded infrared beam, at eye-safe levels, that could be detected at the target and automatically turn on the laser on the target pallet. Elimination of the manual link in the system, represented by the observer/operator at the target, should increase the realism of the simulation. This upgrading is feasible with a galium-arsenide injection laser, appropriate optics at the designator simulator, and simple detectors at the target.[3]

The LATHES receiver might, in the future, be equipped with a four-quadrant detector system to more nearly simulate operational receivers. In a future training system, the LATHES receiver might be replaced by operational search/track sets.

The physical packaging of the LATHES designator simulator was dictated by the availability of TOW traversing units and the non-availability of GLLD traversing units. Once the GLLD enters the inventory, the LATHES designator simulator should be repackaged to match its form and use its traversing unit.

11. SUMMARY

The LATHES system allows field simulation of a tactical laser terminal homing engagement without introducing any eye-safety hazards. It allows test or training of tactical proficiency without the extensive range safety requirements associated with the use of laser designators. The LATHES has demonstrated its potential as a training system that is associated with the generation of laser terminal homing systems now under development.

ACKNOWLEDGEMENTS

T. F. Geiger, C. Boykin, R. N. Curnutt, D. L. Chambers, D. G. Green, O. Edwards, and N. Disario all made important contributions to the design and fabrication of the LATHES hardware described in this report. Their ingenuity in use of available components and diligence in completing fabrication of the hardware were critical in completing the LATHES system on schedule and in its successful performance in the field.

---

[3]*A limited range demonstration of a GaAs system was conducted at NWC, China Lake, CA, using the LATHES and a GaAs transmitter and receiver from the Advanced Development Program for Multiple Integrated Laser Engagement Simulator.*

APPENDIX A.--EYE-SAFETY CRITERIA FOR DIFFUSE SOURCES

In this appendix, each Protection Standard (PS) is taken from Department of the Army TB MED 279 (18 September 1974) and referenced with a paragraph, table, or figure number.

The PS for a given optical exposure is the maximum exposure that will not create a hazard to unwarned, unprotected personnel. For a diffuse reflection of a Q-switched laser with pulse duration of 20 ns, wavelength of 1.06 μm, and pulse rate of 20/s,

$$PS = PS(700\text{-}1400\ nm) \cdot (C_A) \cdot (C_P),$$

where PS(700-1400 nm) is taken from figure B-2 using an exposure duration of 20×10^{-9} s, C_A from figure B-4 at 1060 nm, and C_P from figure B-5 at 20 Hz. These values are

$$PS(700\text{-}1400\ nm) = 0.027\ J \cdot cm^{-2} \cdot sr^{-1}$$
$$C_A = 5$$
$$C_P = 0.2.$$

This gives a value of

$$(C_A) \cdot (C_P) = 1$$

or

$$PS = 0.027\ J \cdot cm^{-2} \cdot sr^{-1}.$$

To convert to $J \cdot cm^{-2}$ at the diffusing surface, one can multiply by π, assuming the worst case (from a safety standpoint) of 100-percent (diffuse) reflectivity (example 9, p 49). This is strictly true only for a flat surface, but gives conservative (low PS) results for a convex surface. This yields a value

$$PS = 85 \times 10^{-3}\ J \cdot cm^{-2}$$

incident energy per pulse on the diffusing surface.

A second PS must be calculated, based on an integrated exposure to the pulse train (para B-5, -6 and example 4, p 48). Following this procedure, the single-pulse PS is

$$PS' = (10\ s) \cdot PS\ (cw,\ 10\ s)/(\text{number of pulses per second})\ (10\ s)$$

$$PS' = (10\ s) \cdot (15\ J \cdot s^{-1} \cdot cm^{-2} \cdot sr^{-1})/(20)(10)$$

$$PS' = 0.75\ J \cdot cm^{-2} \cdot sr^{-1}$$

or

$$PS' = 2.4\ J \cdot cm^{-2}\ ,$$

where PS (cw, 10 s) is taken from figure B-2.

Clearly, the single-pulse PS of $85 \times 10^{-3}\ J \cdot cm^{-2}$ per pulse is controlling. The minimum permissible area of the diffuser over which the beam must be spread is given by

$$A(min) = E(pulse)/PS$$

which gives

$$E(pulse,\ NC\text{-}10) = 0.01\ J$$

then

$$A(min,\ NC\text{-}10) = 0.12\ cm^2$$

which gives

$$E(pulse,\ MPT) = 0.100\ J$$

then

$$A(min,\ MPT) = 1.20\ cm^2.$$

In both cases, these minimum areas were exceeded by at least a factor of 10.

APPENDIX A

While the calculations above are an excellent guide to the design of a LATHES system free from eye hazard, it is necessary to confirm the design by actual measurements on final hardware. These measurements were performed by the US Army Environmental Hygiene Agency, Edgewood Arsenal, MD. Their findings are reported in Radiation Protection Special Study Number 42-161-75 and Radiation Protection Special Study Number 42-143-75. In both cases, the LATHES target simulator with its diffuser in place was determined to present no ocular hazard to the unaided eye.

DISTRIBUTION

DEFENSE DOCUMENTATION CENTER
CAMERON STATION, BUILDING 5
ALEXANDRIA, VA 22314
ATTN DDC-TCA (12 COPIES)

OFC, CHIEF OF RESEARCH & DEVELOPMENT
USA RSCH & DEV GROUP (EUROPE)
BOX 15
FPR NEW YORK 09510
ATTN LTC EDWARD E. CHICK
CHIEF, MATERIALS BRANCH

COMMANDER
US ARMY MATERIEL COMMAND
5001 EISENHOWER AVENUE
ALEXANDRIA, VA 22333
ATTN AMCRD, RES, DEV, & ENGR
DIRECTORATE

COMMANDER
USA ARMAMENT COMMAND
ROCK ISLAND, IL 61201
ATTN AMSAR-ASF, FUZE DIV
ATTN AMSAR-RDF, SYS DEV DIV - FUZES
ATTN AMCPM-CAWS, BARRETT

COMMANDER
USA MISSILE & MUNITIONS CENTER
& SCHOOL
REDSTONE ARSENAL, AL 35809
ATTN ATSK-CTD-F

COMMANDER
US ARMY COMBAT DEVELOPMENTS
EXPERIMENTATION COMMAND
FORT ORD, CA 93941
ATTN DCSI, ENGINEERING DIV (10 COPIES)
ATTN DCSI-ED, MR. CHURCH
ATTN DCSI-ED, CPT SWARZ
ATTN DCSI-ED, CPT RICE (4 COPIES)

HEADQUARTERS
US ARMY MASSTER
FORT HOOD, TX 76544
ATTN AMC FIELD SUPPORT ACTIVITY
ATTN MAJ T. BROWN (2 COPIES)

HEADQUARTERS
US ARMY TRAINING AND DOCTRINE COMMAND
FORT MONROE, VA 23351
ATTN DEPUTY FOR TRAINING

COMMANDER
US ARMY OPERATIONAL TEST AND
EVALUATION COMMAND
FALLS CHURCH, VA 22041
ATTN DACS-TEZ-A
ATTN DACS-TES-I, MR. MICHELSEN
(10 COPIES)
ATTN DACS-TEM-LG, COL WILLIAMS
(2 COPIES)

COMMANDER
US ARMY MISSILE COMMAND
REDSTONE ARSENAL, AL 35809
ATTN AMCPM-LDE, MR. STARKEY (2 COPIES)
ATTN AMCPM-HFE
ATTN AMSMI-REO, WIDENHOFER/EMMONS
ATTN AMCPM-CAWS-FO

COMMANDER
OFFICE OF MISSILE ELECTRONIC WARFARE
WHITE SANDS MISSILE RANGE, NM 88002
ATTN AMSEL-WLM-ST

COMMANDER
NAVAL AIR SYSTEMS COMMAND
DEPARTMENT OF THE NAVY
WASHINGTON, DC 20361
ATTN AIR-03P23, DR. HABAYEB (2 COPIES)
ATTN AIR-53352B, MR. KLEIN

COMMANDER
AIR FORCE SYSTEMS COMMAND
WASHINGTON, DC 20334
ATTN AFSC/XRLW, LTC SEUFERT (2 COPIES)

COMMANDER
US ARMY AVSCOM
PO BOX 209
ST. LOUIS, MO 63166
ATTN AMSAV-EVW, MR. COLEMAN

DIRECTOR
OFFICE OF THE TEST DIRECTOR, LGWCCM
WHITE SANDS MISSILE RANGE, NM 88002
ATTN AMSEL-WL-TD, (4 COPIES)

COMMANDER
US ARMY ELECTRONICS COMMAND
FT. MONMOUTH, NJ 09703
ATTN AMSEL-CT-L, MR. MIRARCHI
ATTN AMSEL-CT-L, DR. BUSER

COMMANDER
USATDA
ORLANDO, FL 32813
ATTN AMCPM-TND-2A, DR. RASHIS

COMMANDER
AMCPM-TND
PO BOX 2147
FT. BENNING, GA 31905
ATTN MAJ SCHMIDT (3 COPIES)

COMMANDER
TRADOC-TRADOR
FT. BENNING, GA 31905
ATTN ATTNG-TD-R, CPT BELL (2 COPIES)

COMMANDER
MARINE CORPS DEVELOPMENT CENTER
MCB QUANTICO, VA 22134
ATTN AIR OPS DIV MC, MAJ EDWARDS (2 COPIES)

COMMANDER
AFTEC/JT
KIRTLAND AFB, NM 87115
ATTN COL DENT

COMMANDER
TAC
LANGLEY AFB, VA 23665
ATTN DRAV, CPT CRUMPLER

COMMANDER
ARMAMENT DEVELOPMENT & TEST CENTER
EGLIN AFB, FL 32542
ATTN SD9, MR. TODD

COMMANDER
AERONAUTICAL SYSTEMS DIV, AFSC
WRIGHT PATTERSON AFB, OH 45433
ATTN ASD/SD65M, CPT CLARK

HARRY DIAMOND LABORATORIES
ATTN MCGREGOR, THOMAS, COL, COMMANDING OFFICER/FLYER, I.N./LANDIS, P.E./SOMMER, H./CONRAD, E.E.
ATTN CARTER, W.W., DR., ACTING TECHNICAL DIRECTOR/MARCUS, S.M.
ATTN KIMMEL, S., PIO
ATTN CHIEF, 0021
ATTN CHIEF, 0022
ATTN CHIEF, LAB 100
ATTN CHIEF, LAB 200
ATTN CHIEF, LAB 300
ATTN CHIEF, LAB 400
ATTN CHIEF, LAB 500
ATTN CHIEF, LAB 600
ATTN CHIEF, DIV 700
ATTN CHIEF, DIV 800
ATTN CHIEF, LAB 900
ATTN CHIEF, LAB 1000
ATTN RECORD COPY, BR 041
ATTN HDL LIBRARY (3 COPIES)
ATTN CHAIRMAN, EDITORIAL COMMITTEE (4 COPIES)
ATTN CHIEF, 047
ATTN TECH REPORTS, 013
ATTN PATENT LAW BRANCH, 071
ATTN MCLAUGHLIN, P.W., 741
ATTN CURNUTT, R. M., 540
ATTN GIBSON, H. F., 540
ATTN MORRISON, C. A., 320
ATTN NEMARICH, J., 320
ATTN SCALES, J. T., 540
ATTN SHREVE, J. T., 540
ATTN GEIGER, T. F., 540
ATTN HUMPHREY, R., 930
ATTN EDWARDS, O., 430
ATTN CHAMBERS, D. L., 540 (2 COPIES)
ATTN DISARIO, N., 540
ATTN BOYKIN, C., 540
ATTN GREEN, D. G., 540
ATTN GLEASON, T. J., 540, (40 COPIES)
ATTN SWORD, M. E., 540, (5 COPIES)