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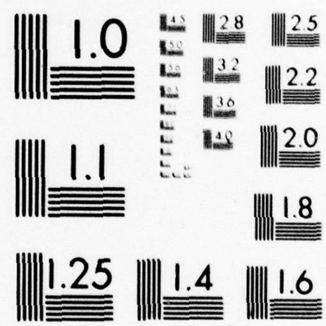

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TECHNICAL REPORT T-79-38

MINICOMPUTER APPLICATIONS IN AUTOMATED TESTING OF ELECTRO-OPTICAL GUIDANCE SYSTEMS

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Advanced Sensors Directorate
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19 March 1979

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U.S. ARMY MISSILE RESEARCH AND DEVELOPMENT COMMAND

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Nd: YAG Laser
Pulse Repetition Frequency (prf)
AUTOMATED TESTING
MINICOMPUTER APPLICATIONS

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An Automated Laser Seeker Performance Evaluation System (ALSPES) has been developed at the US Army Missile Research and Development Command (USAMIRAD-COM) which utilizes a minicomputer to implement the control functions required to test electro-optical (E/O) guidance systems. These tests are used by the Government to identify problem areas in the guidance system design and to validate subsequent design changes. Software programs have been written for a series of tests which fully evaluate E/O seeker performance. Test conditions

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are fed into a CRT terminal and the minicomputer conducts a fully automated, "hands-off" test by varying such parameters as laser energy, target position and velocity, seeker position and angular rate, and time separation between targets. This report discusses the types of automated tests performed, the electro-optical test equipment utilized and the layout of the test facility, the minicomputer to test equipment interface, and the cost savings resulting from the development of this automated test facility.

ACKNOWLEDGMENTS

The Author wishes to thank Mr. E. Doug Crosswhite for helpful discussions in the planning and operation of the ALSPES facility, and the local Sperry Support Services group for timely delivery of critical components which they fabricated as required by Contract DAAK40-77-C-0034.

CONTENTS

ILLUSTRATIONS

1. INTRODUCTION

Since the early development (about 10 years ago) of laser seekers for missile and projectile terminal guidance applications, the US Army Missile Research and Development Command (USAMIRADCOM) has been involved in the performance evaluation of these seekers using laboratory test facilities. The Advanced Sensors Directorate (AdSeD) of USAMIRADCOM is responsible for evaluating the seeker design of major terminal guidance missile and projectile systems, identifying seeker problem areas, and making recommendations for their solution. Until the development of the Automated Laser Seeker Performance Evaluation System (ALSPES) described herein, conducting the series of tests required to fully evaluate the seeker performance, specification compliance, and identification of problem areas was a time-consuming task requiring about three days with two people full-time. The types of tests required to fully characterize the seeker are shown in *Table I* with typical times required for completion by both old test techniques and ALSPES. Listed below is a test report* describing in detail the procedures and test results on a semi-active laser seeker tested according to the conventional, pre-ALSPES test techniques. The user times listed for ASLPES are based on our experience with the facility during the past several months since its completion.

2. FACILITY DESCRIPTION

Figure 1 shows the conventional facility used to conduct seeker performance evaluations. It consists of a laser with means of varying the laser energy (neutral density filter box), a set of mirrors to simulate laser target motion on the diffusing screen, and a three degree-of-freedom table on which the seeker is mounted. From the list of tests shown in *Table 1*, one can see that the control functions which have to be driven in order to conduct the performance evaluation are, as minimum, variation in laser energy, x/y mirror position, pitch/yaw table position, laser turn on/turn off, seeker input/output (I/O) functions, and time separations between multiple laser pulses. Before development of ALSPES, these functions had to be independently controlled by hand from control consoles during each test. The use of a minicomputer to implement these control functions in the construction of the ALSPES facility has greatly reduced the amount of time consumed to generate the required test data.

A. DATA PROCESSING SYSTEM

Figure 2 shows a block diagram of the HP2174A general purpose and expandable

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* *Test Report, Laboratory Performance Evaluation of Army SM712* Copperhead B016/2 Laser Seeker (U), Technical Report T-78-68 dated 21 July 1978, MIRADCOM (confidential).

TABLE 1. LASER SEEKER PERFORMANCE TESTS AND TIME SAVINGS ACHIEVABLE WITH AUTOMATED TEST FACILITY (ALSPES)

Test	Time Conventional	Time ALSPES
Sensitivity	1 hr	1/2 hr
Boresight Shift with Range Closure	1 hr	1/2 hr
Proportional Zone	2 hrs	1/2 hr
Instantaneous Field-of-View (IFOV)	2 hrs	1/2 hr
Optical Gimbal Coupling (OGC)	2 hrs	1 hr
Maximum Gyro Slew Rate	2 hrs	1 hr
Gyro Dynamics with Target Step LOS Change	2 hrs	1 hr
Gimbal Angle Output Linearity	1 hr	1/2 hr
Correlation/Decorrelation Logic	1 hr	1/2 hr
False Target Ambiguity Discrimination	10 hrs	4 hrs
Total	24 hrs	10 hrs

control and data acquisition system being provided for the ALSPES project. The 20-kHz analog-to-digital (A/D) interface subsystem provides for up to 16 analog inputs, and the HP91063A digital I/O subsystem provides sufficient interfaces to all instruments, mounts, and seekers.

The ALSPES data and control flow diagram in *Figure 3* illustrates the flow of test data and feedback data and the manual and computer signal flow to the test equipment.

The digital I/O subsystem and analog input options interface to the various seekers through "personality" modules. The digital I/O also operates control electronics for the variable optical filters, pulse delay *generators, mirror* galvanometers, and table position. Radiation measurements are input to the computer through the analog inputs.

The 2113 CPU contains a real-time clock which is used to time-annotate data measurements. The flexible disc is used both for data storage and program storage. The 2645A display station is used to select the test being run and to specify the test parameters and sampling times.

For complete stand-alone operation of the data processing system, a Tektronix Model 4012 Graphics Terminal with Model 4631 Hard Copy Unit is included. These units provide high-speed, computer-generated plots with 1024 by 780 viewable points on a 6.375 x 8.250 in. storage screen. The hard copy unit can then produce plots of maximum complexity in not more than 18 sec. The HP2174A is designed to interface these Tektronix units through its 12531C interface board in conjunction with the Tektronix Option 06 computer port.

The HP2174A minicomputer, digital I/0 subsystem, and control electronics outside the seeker test enclosure are shown in *Figure 4*.

B. DARKROOM

The laser seeker test enclosure is a prefabricated structure with wall and ceiling panels of honeycomb construction. The room measures 12 x 28 ft with 8-ft walls. The inside surfaces have been covered with ECCOSORB CV-3 black anechoic foam material which has been measured to have a reflectance of 1.5% or less at the laser wavelength. The floor is covered with black corrugated rubber matting. The layout of the ALSPES darkroom is shown in *Figure 5*. Three low energy (5 - 10 mJ) Nd:YAG lasers are mounted on top of an air-suspension isolation table with their associated neutral density filter boxes, solenoid activated (NDF/SA). Three lasers in conjunction with a time delay generator system are used to simulate three targets spatially and temporally displaced with respect to each other. In this way a true target, a foreground false target, and a background false target are simulated during a test of the seeker's false target ambiguity discrimination logic. The lasers, NDF/SA boxes, and scanning mirror on the isolation table are shown in *Figure 6*, and a top view of the isolation table assembly and diffusing screen is shown in *Figure 7*. An HE-NE laser is used to optically align the lasers, NDF/SA boxes, and mirror assembly and to visually display target motion on the screen. *Figure 8* shows construction details of the NDF/SA box. This filter box has a dynamic range of attenuation of 62.5 dBP and is programmed via the minicomputer to simulate missile or projectile range closure by moving discrete ND filters out of the laser beam as a function of flight time. Eight discrete ND filters are used in the box, the filters having optical densities of 3.2, 1.6, 0.8, 0.4, 0.2, 0.1, 0.05, and 0.025, respectively. Using this combination of filters, the 62.5 dBP range closure can be covered in steps of 0.25 dBP on a pulse-to-pulse basis.

The IR scanner is a galvanometer-type beam deflector utilizing 1 X 1 in. mirrors on each axis. The scanner-to-screen distance is set for a 4 x 4 ft screen scan with a beam deflection of ±15 deg. Maximum response of the scanner is 300 deg/sec (15 deg in 5 msec). The mirror servomechanism electronics and Control and Data Acquisition Module (CDAM) to scanner interface package are rack mounted. Specifications for the laser beam scanner are shown in *Table 2*.

The two-axis rotary table consists of a universal single-axis, mechanical-bearing drive assembly for the yaw axis and a fabricated single-axis, mechanical-bearing slew assembly for the pitch axis. The two-axis rate table inside the seeker test enclosure is shown in *Figure 9*. The drive system for both axes is contained in a single rack mount which accepts a five-digit parallel word command for each axis and generates the serial data necesssary to move the drive from its present position to the position specified by the parallel words.

Each axis is capable of 90 ft-lb of peak torque. Reflected inertia is minimized for maximum efficiency. A selectable manual rate and position switch and a 0.1% precision tachometer are included so the yaw axis has full rate table capability. The yaw axis can support up to 2000 lb.

The time delay generator system uses a sync pulse coded to the required laser pulse repetition frequency (prf) to trigger the firings of laser flashlamps and pockels cells for the three lasers. Time delays between the spatially separated lasers are set by delays in flashlamp firings. The pockels cell firing delay from the onset of the flashlamp pulse for each respective laser, is triggered off the flashlamp. In this way each laser's pockels cell is fired at the optimum point during the flashlamp pump.

3. SOFTWARE

User programs have been written to exercise the laser beam scanner, two-axis rate table, time delay generators, and solenoid-activated neutral density filter boxes. Missile and projectile range closure programs driving the NDF/SA boxes are completed; they have the flexibility of simulating any tactical scenario. Software routines have been written and documented for the tests described in *Table 1*.** Updates of these tests along with routines for additional tests are continuing.

4. CONCLUSIONS

The Advanced Sensors Directorate (AdSeD) of MIRADCOM is responsible for evaluating the seeker design of major terminal guidance missile and projectile systems, identifying seeker problem areas, and making recommendations for their solution. The Automated Laser Seeker Performance Evaluation System (ALSPES) facility described in this paper has given MIRADCOM the capability to conduct comprehensive performance evaluations of laser seekers in a laboratory environment in a fraction of the time required by old test procedures. The use of a minicomputer in ALSPES to implement control functions such as laser energy variation, seeker position, and target location coupled with the automated printout and plotting of the seeker I/O test parameters during the particular test run has resulted in a "hands-off" environment such that total test time is now approximately 40% of the previously required time. In addition, the facility has enabled AdSeD to conduct a more complete and comprehensive identification of potential seeker problem areas than has been possible heretofore, resulting in an increase in the number of electro-optical terminal guidance seeker design change recommendations to the system developer.

****COPPERHEAD Test Programs Operations Manual*, SP-220-1046, Sperry Support Services, 30 September 1978.

TABLE 2. SPECIFICATIONS FOR TAI 2-AXIS LASER BEAM SCANNER

Beam Deflection	±20 Degrees
Response to 40-Deg Step	6mS, X-Axis, 7mS, Y-Axis
Input	±10 Volts
Input Impedance	60K Ohms
Beam Deflection Gain Factor	2 Degrees/Volt
Linearity	0.1% Peak-to-Peak Excursion
Optical Transmittance at Laser Wavelength	TBD
Intensity Variation at Scanned Spot	63.75 dBP
Power Amplifier Fuses	1A 3AG

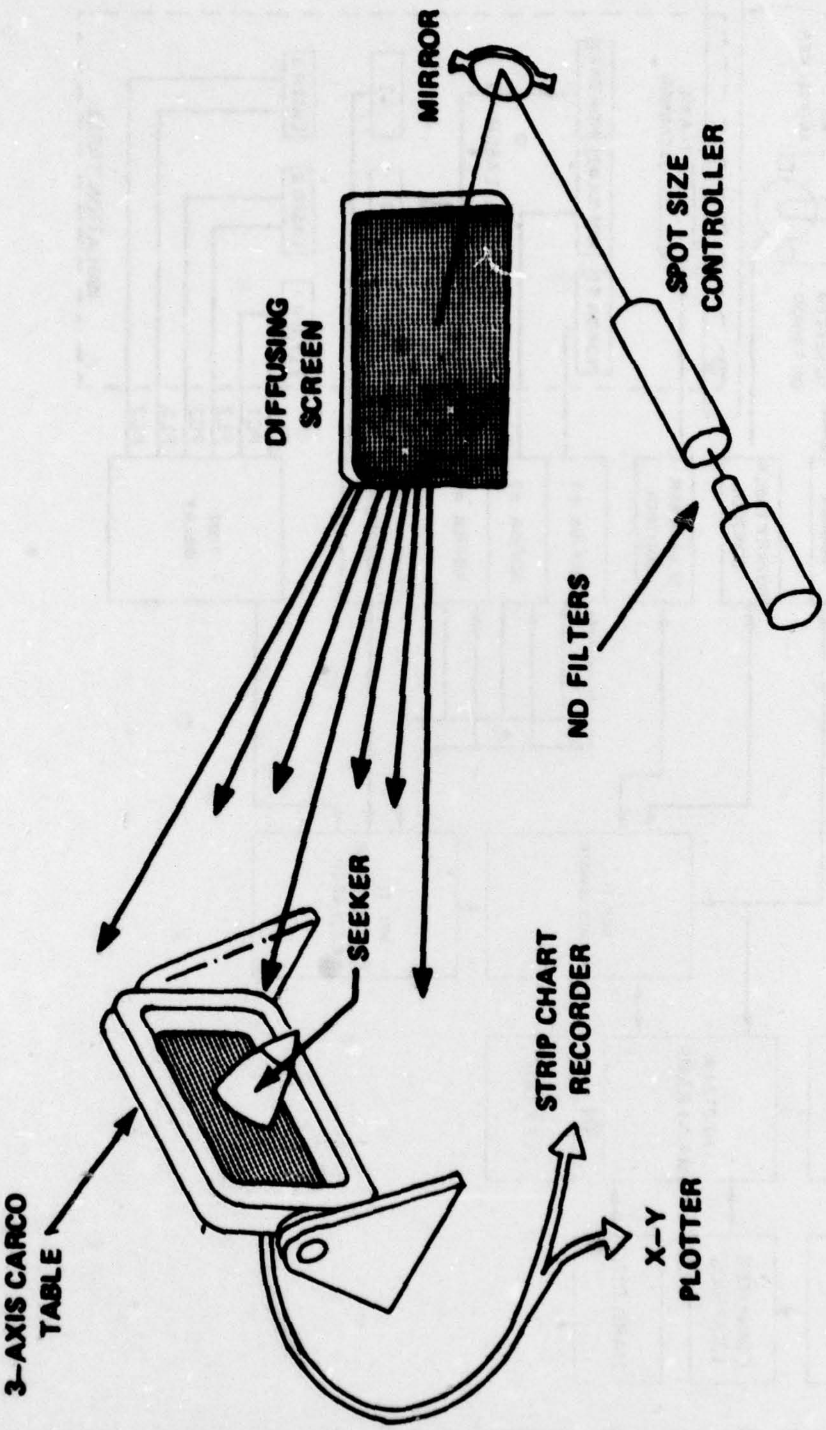

Figure 1. Laser dynamic range simulation facility.

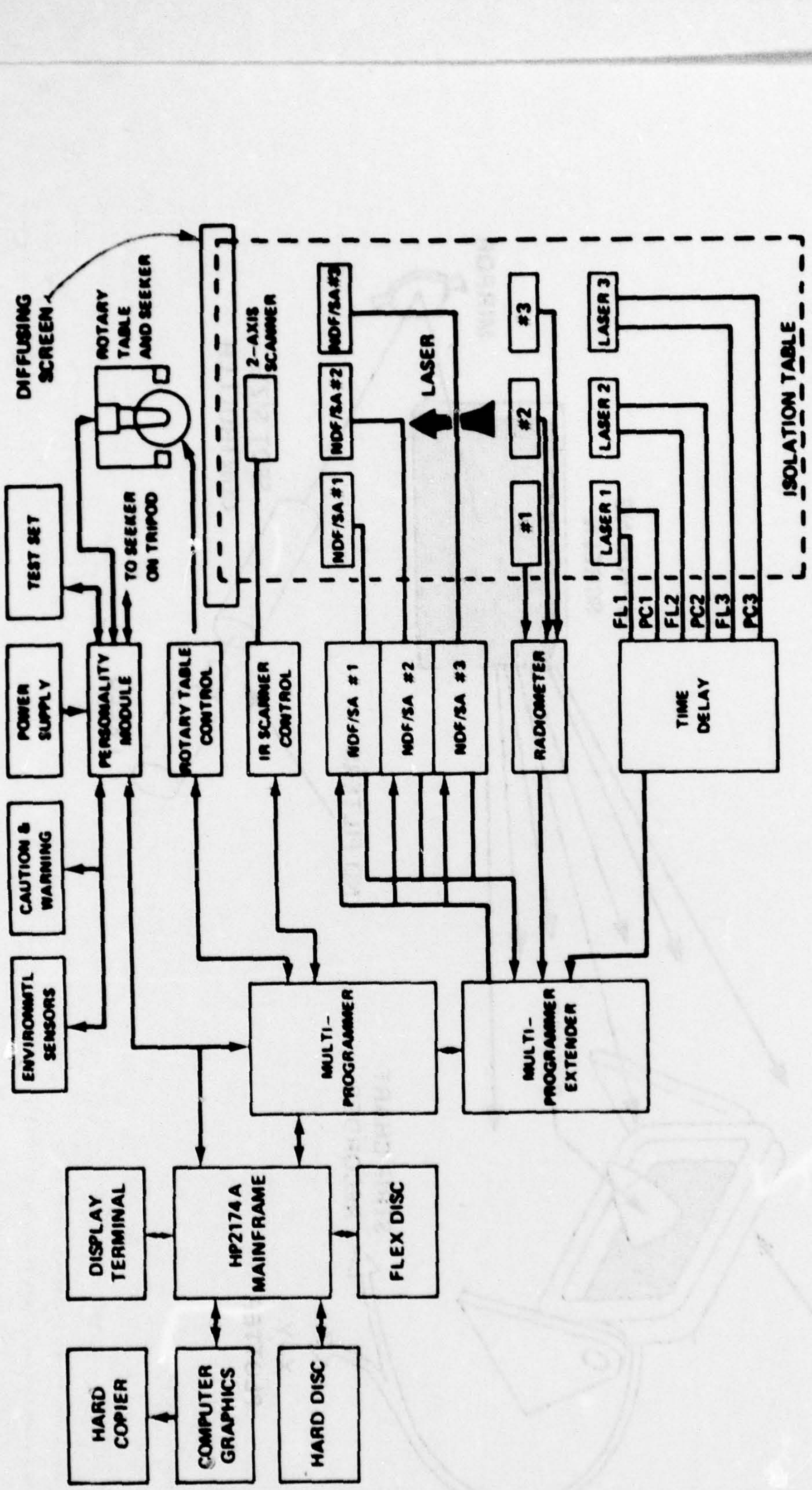

Figure 2. Block diagram of minicomputer to control function interface for Automated Laser Seeker Performance Evaluation System (ALSPES).

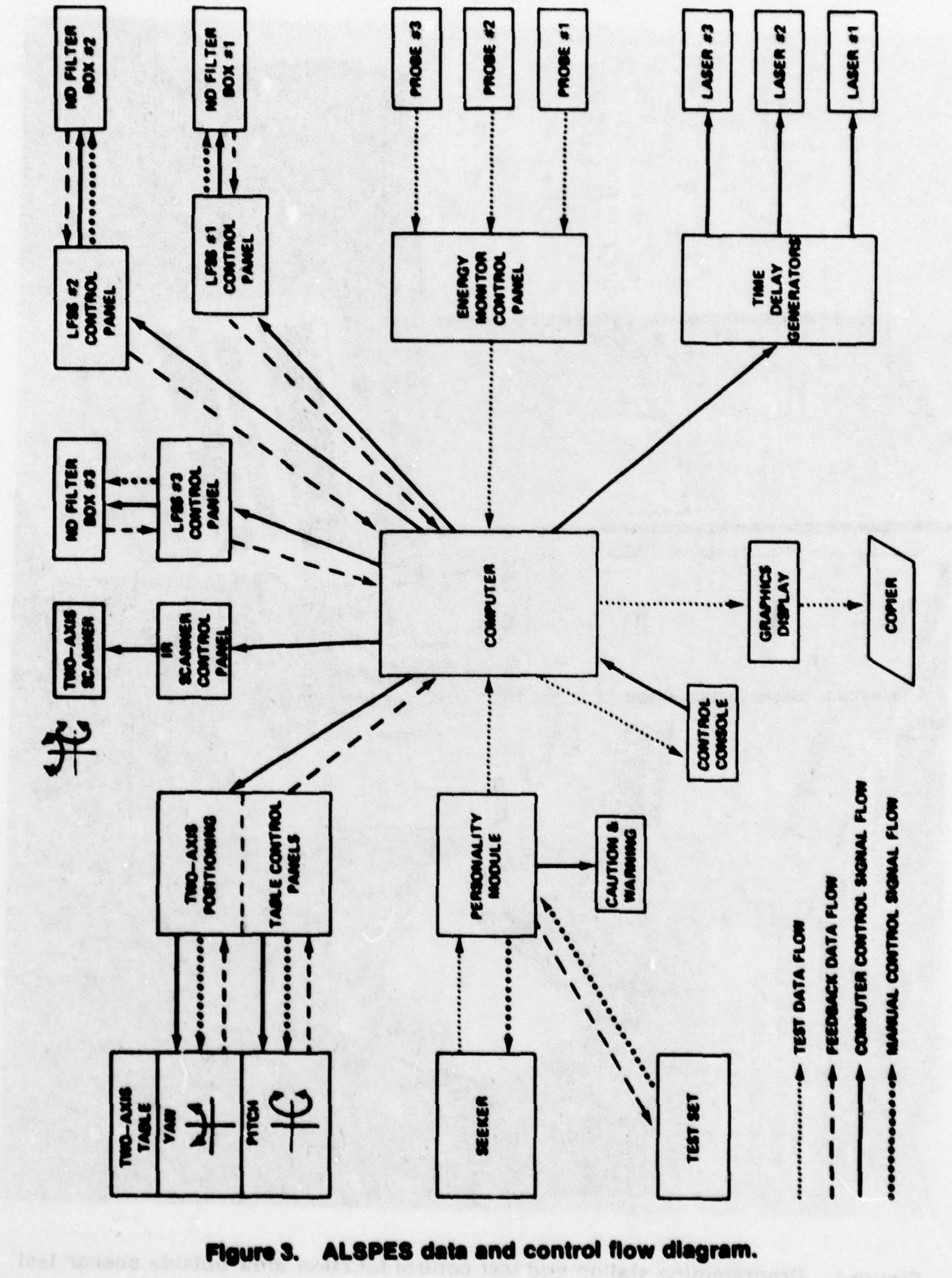

Figure 3. ALSPES data and control flow diagram.

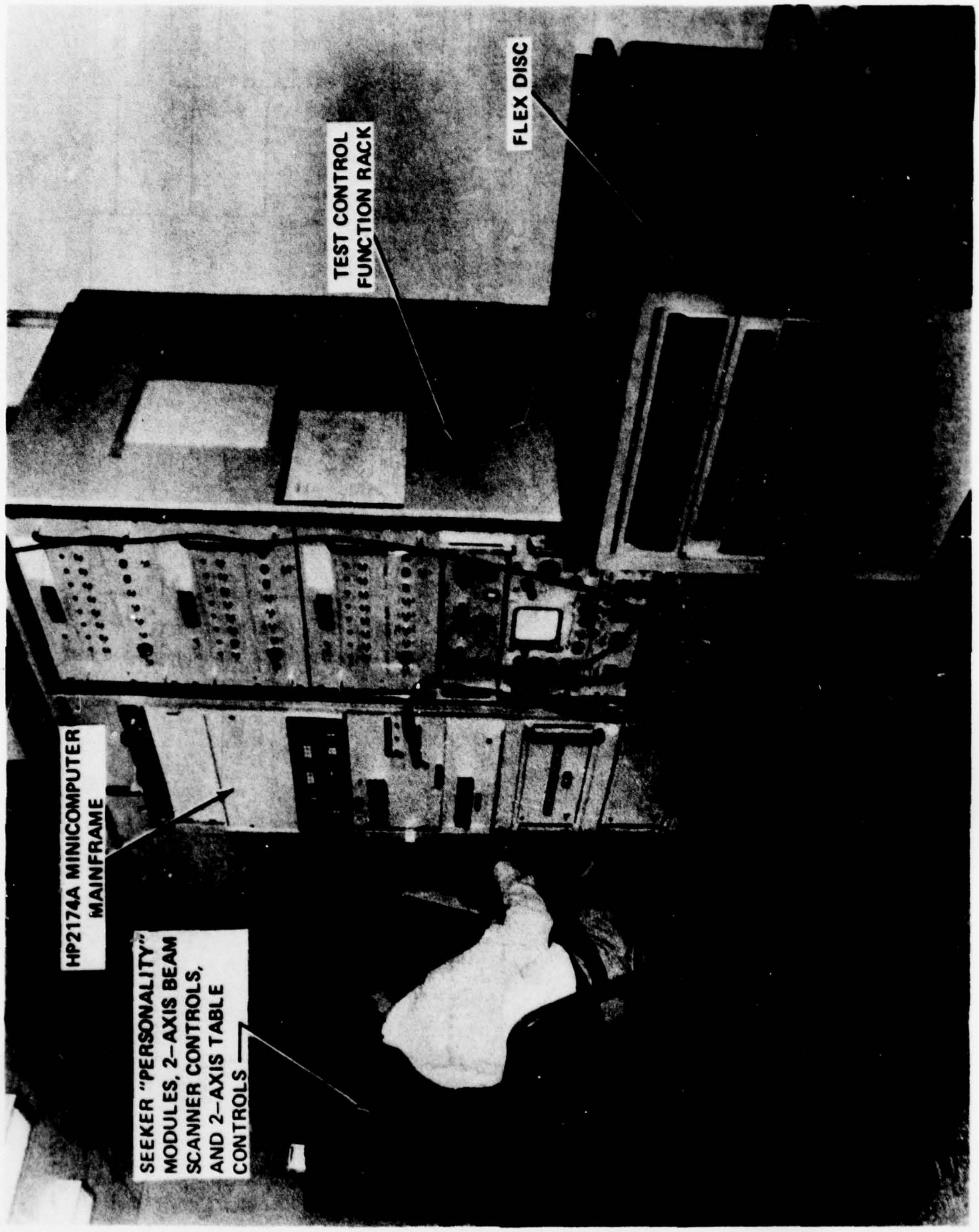

Figure 4. Programming station and test control function area outside seeker test enclosure.

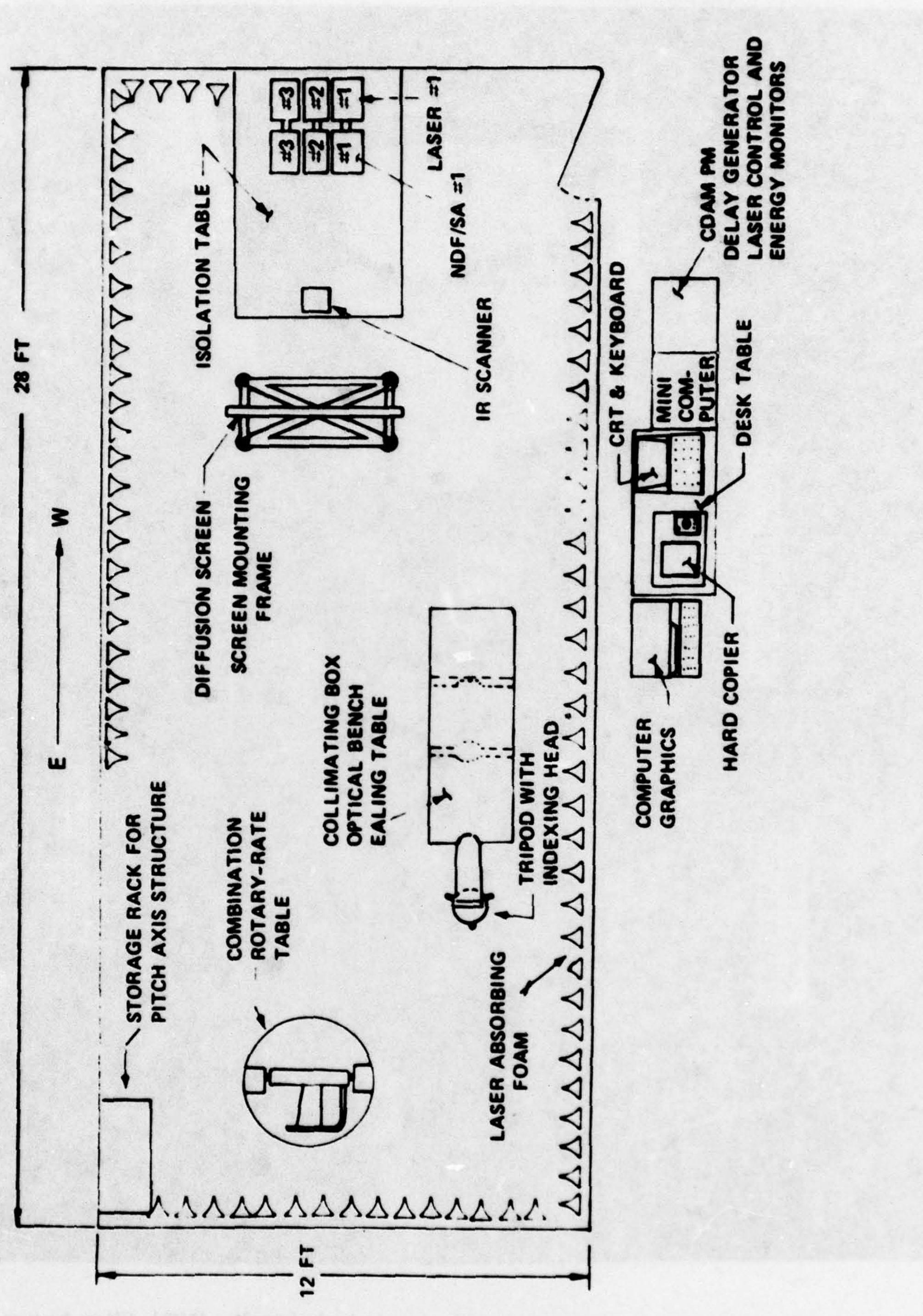

Figure 5. Room layout of MIRADCOM ALSPES facility.

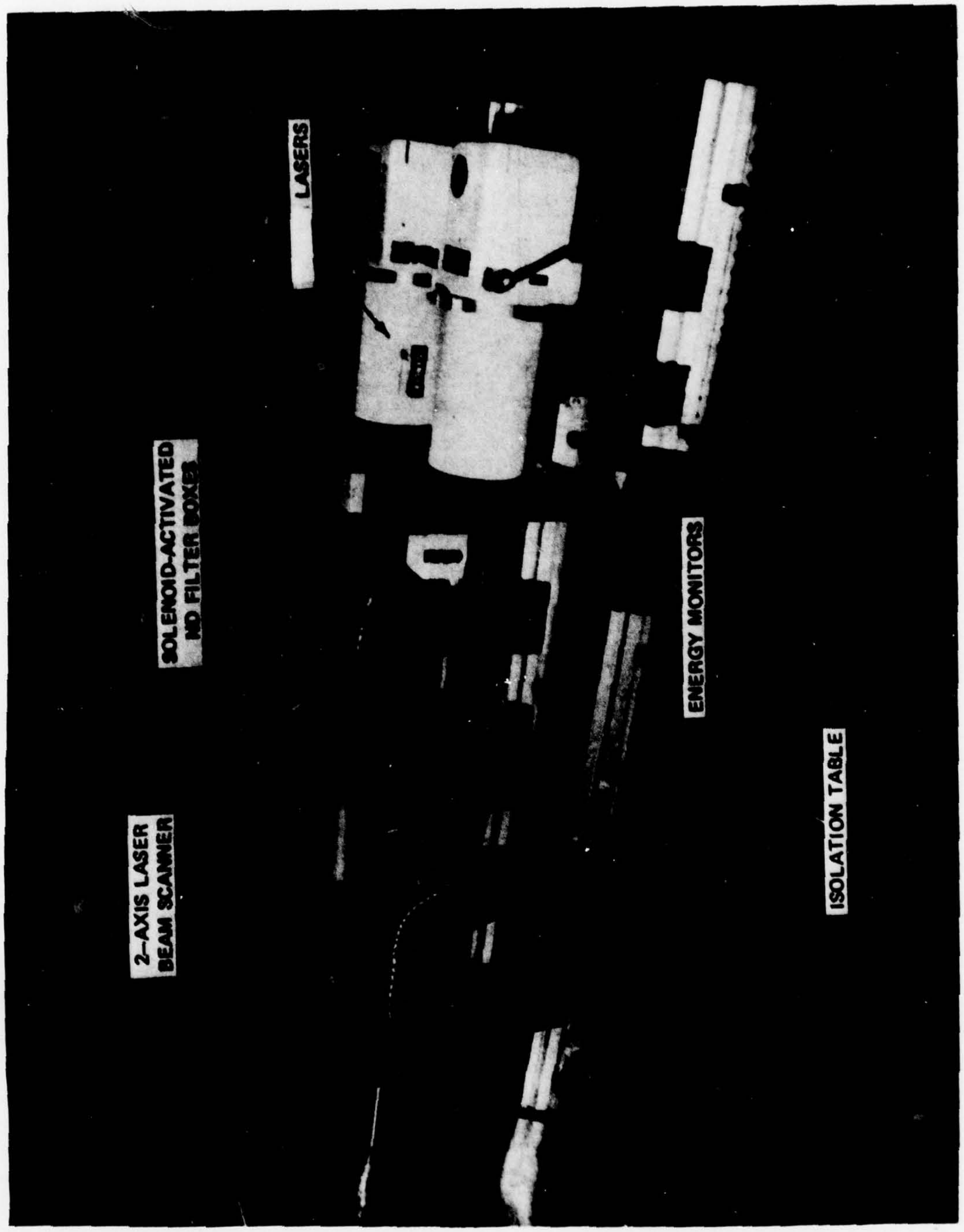

Figure 6. Laser sources, energy monitor, neutral density (ND) filter boxes, and two-axis beam scanner mounted on isolation table.

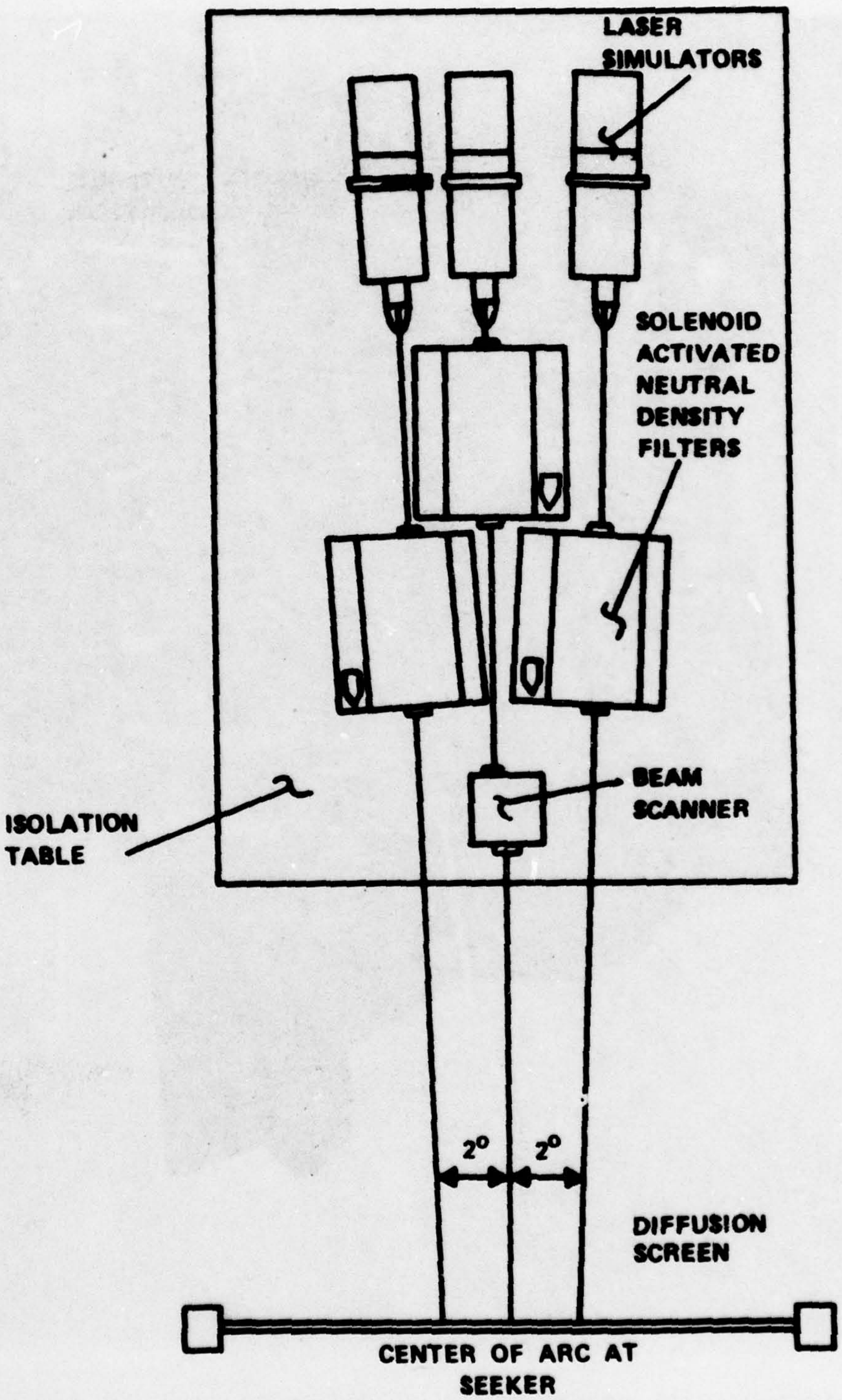

Figure 7. Laser, filter box, scanning mirror, and diffusing screen layout.

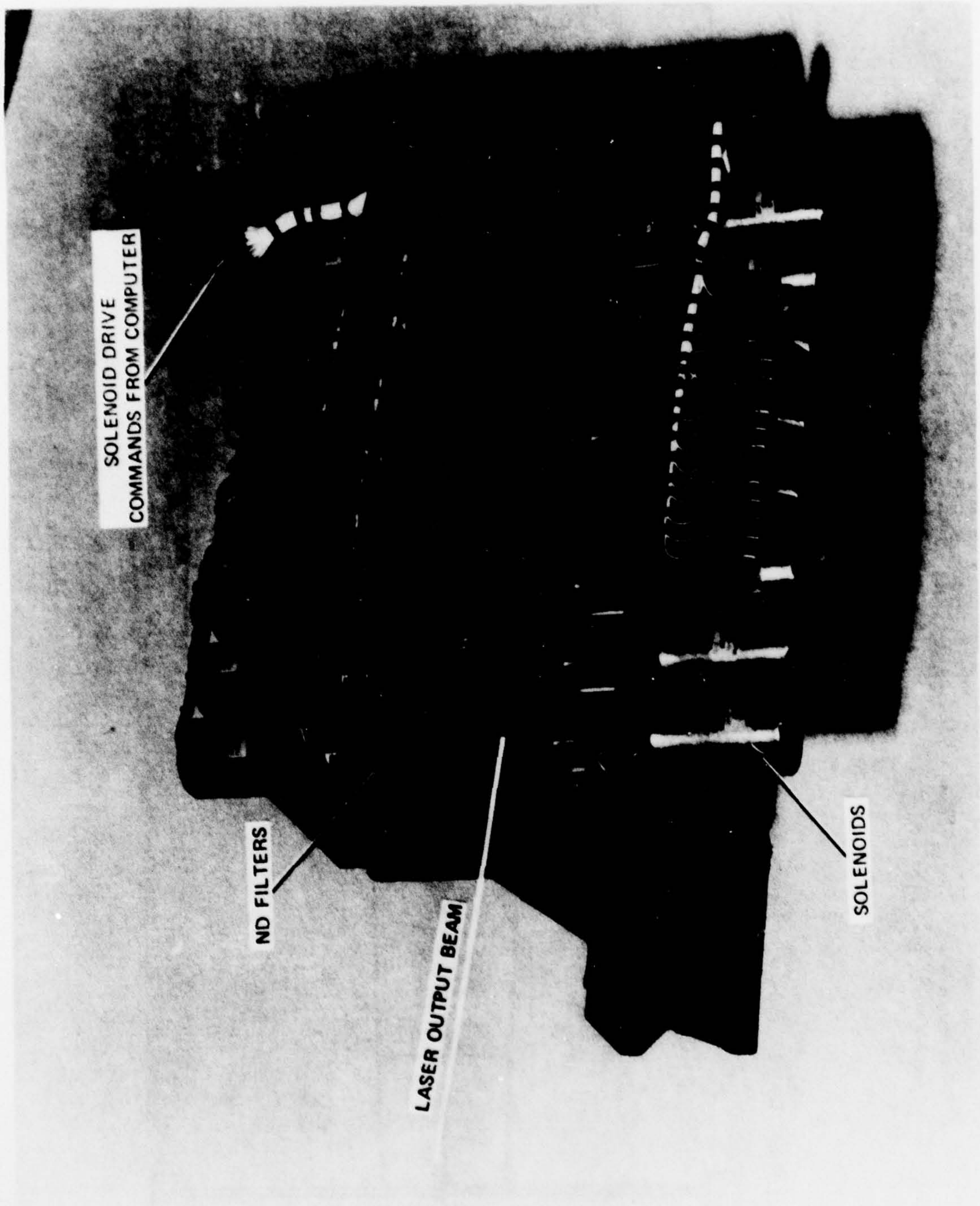

Figure 8. Solenoid activated ND filter box.

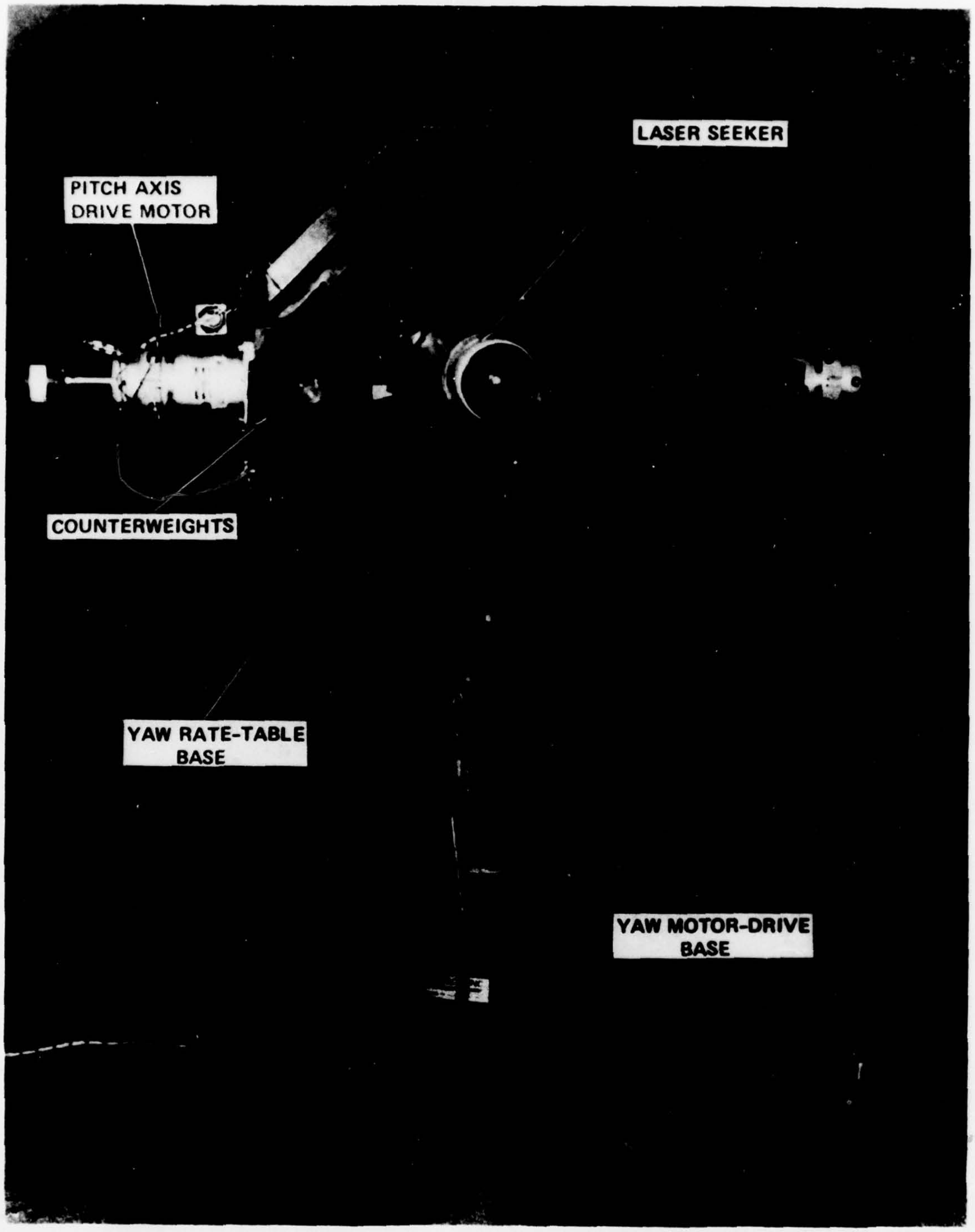

Figure 9. Seeker two-axis rate table.

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