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JUN 78 S J KRUPSKI, F J AUDINO

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LASER SCAN INSPECTION SYSTEM

S. J. KRUPSKI
F. J. AUDINO

JUNE 1978

US ARMY ARMAMENT COMMAND

PRODUCT ASSURANCE DIRECTORATE
WATERVLIET ARSENAL
WATERVLIET, N.Y. 12189

TECHNICAL REPORT

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BLACK-LIGHT BORESCOPE
LASER SCAN

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

The present magnetic particle method of inspection using a black light borescope for the detection of cannon bore indications such as cracks, inclusions and discontinuities is time consuming and requires constant operator control. The inspector is highly susceptible to fatigue from prolonged staring into the scope which increases the possibility of overlooking a defect.

(see reverse side)

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20. ABSTRACT (cont'd)

Cont

A new method employing a recently developed laser scan inspection system automatically scans, detects and records indications. In doing so, it provides a faster and more reliable inspection method to replace the method using a black light borescope.

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MATERIALS TESTING TECHNOLOGY PROGRAM (AMS 4931)

Report No.: WVT-QA-7801

Title: Laser Scan Inspection System

THIS PROJECT HAS BEEN ACCOMPLISHED AS PART OF THE US ARMY MATERIALS TESTING TECHNOLOGY PROGRAM, WHICH HAS FOR ITS OBJECTIVE THE TIMELY ESTABLISHMENT OF TESTING TECHNIQUES, PROCEDURES OR PROTOTYPE EQUIPMENT (IN MECHANICAL, CHEMICAL, OR NONDESTRUCTIVE TESTING) TO INSURE EFFICIENT INSPECTION METHODS FOR MATERIEL/MATERIAL PROCURED OR MAINTAINED BY AMC.

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ABSTRACT

The present magnetic particle method of inspection using a black light borescope for the detection of cannon bore indications such as cracks, inclusions and discontinuities is time consuming and requires constant operator control. The inspector is highly susceptible to fatigue from prolonged staring into the scope which increases the possibility of overlooking a defect.

A new method employing a recently developed laser scan inspection system automatically scans, detects and records indications. In doing so, it provides a faster and more reliable inspection method to replace the method using a black light borescope

CROSS-REFERENCE DATA

Indications
Magnetic Particle
Black-light borescope
Laser Scan

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1. INTRODUCTION

Prior to acceptance, all cannon tube bores are inspected for indications such as cracks which requires the application of magnetic particle inspection using a black light borescope. (see figure 1). The borescope method is a time-consuming process and requires constant operator control. The operator is highly susceptible to fatigue (from prolonged staring into the scope) which increases the chances of overlooking a defect. Also, some operators are able to easily pick-up indications in the cannon tube while some find it very difficult to pick out fluorescent particles that collect in an indication.

The danger in not detecting a crack in a cannon tube is obvious. Also if a crack is detected after leaving the manufacturing facility, additional costs are incurred for transportation back to the facility for additional inspection. A more positive, faster and reliable method with the capability of recording indications to reduce the present dependency on the human element was required to better assure materiel integrity in cannon tubes.

2. THEORY OF MAGNETIC PARTICLE INSPECTION

The fluorescent magnetic particle process is used for the inspection of cannon tubes. It consists of establishing a magnetic field in the tube to be inspected. The degree of magnetization depends on size, shape and material composition of each tube. When the field cuts across a crack or discontinuity in the cannon tube, the two sides effectively form new magnetic poles.

A special fluorescent material mixed in a suitable solution to form a suspension of fluorescent particles is then applied to the cannon tube being inspected. The magnetic field around the defect attracts and holds the fluorescent magnetic particles forming a brilliant fluorescent pattern of the defect when illuminated and observed under a black light (near ultraviolet) source such as the black light borescope. The fluorescent material will show the defect as a bright color contrasting to the dull purple of the reflected radiation from the rest of the area free of surface anomalies.

3. DESCRIPTION OF THE LASER SCAN SYSTEM

In 1976, an MTT project was initiated to develop an automatic magnetic particle cannon bore inspection system. The objective of the project was to develop a faster and more reliable inspection system.

As a result, a laser scan inspection system was developed for the automatic scanning and detection of cannon bore indications such as cracks, inclusions and discontinuities throughout the bores of 105mm. M68 and 155mm. M185 cannon tubes. (see figures 2 & 3). The cannon tubes are presented to the scanning system after they have been properly magnetized and the fluorescent particle solution applied to the bore surfaces.

The laser scan inspection system uses blue light from a Helium-Cadmium laser to excite the pigment in the fluorescent particles. When the laser light strikes an indication (a collection of fluorescent particles) in the bore, yellow-green light is produced that is detected by a photodiode pointed at the spot the laser is striking. An optical filter removes all the reflected blue light from the laser leaving only the induced fluorescent light. This photodiode converts the light into an electrical signal that is amplified and, after some processing displayed on the facsimile recorder.

The laser is pointed down a long pushtube that goes into the cannon bore. At the end of the cannon tube is a head assembly consisting of a hollow-shafted motor through which the laser beam passes. This motor rotates a mirror which reflects the beam 90 degrees to the bore of the cannon tube. As it rotates, the beam traces a circle on the bore. Slip rings carry the signal from the rotating photodiode to the remaining electronics.

This system uses a scanning technique commonly known as a "flying spot" scanner. The operation is very similar to the way pictures and documents are transmitted by wirephoto. A laser beam scans the bore of the cannon tube in a spiral fashion. The scanning is done at two revolutions per second while moving forward at 1/8 inch per second. This produces a spiral scan with a pitch of 1/16 inch. The laser beam is 1/8 inch wide so the entire tube is covered with overlap between scans. Synchronized to the rotation of the head is a drum on the recorder. This drum has mounted just above its surface a wire wrapped around it in a spiral fashion. The spiral begins and ends at the same angular position on the drum, and makes one revolution in the length of the drum. The recording paper (see figure 4) is sandwiched between this wire and a knife edge running the width of the paper. As the drum spins the intersection of the helix wire and the knife edge moves in a straight line from left to right. Electric current passing through the paper darkens it producing the permanent record. (see figure 5).

An oscilloscope is also included as a part of the readout system. The scope displays a constant signal level which is adjusted as the "threshold" level. Just below this level is the background noise of the rifling and electronics. If an indication is found, the signal shoots upwards and is displayed as a spike above the threshold level. A buzzer sounds and a light flashes at the same time the indication is being printed out. The print out scaling size is either 1:1 or 1:5 by selection.

Once a print out is obtained for each cannon tube, indications on the print out may be evaluated. If any remain questionable, the cannon bore is borescoped in the areas shown to contain indications.

4. TESTING RESULTS

The purpose of the testing was to determine the systems capability of detecting cracks of a known size in a cannon tube with a number of known defects as required by the specification for the system and also to determine its reliability. The defects or cracks were of various sizes in length and width.

As the testing began, impressions of the rifling lands were being shown on the facsimile recording at the 6 o'clock position of the tube. It was discovered that improper draining of the magnetic particle solution caused puddling at the bottom of the tube which in turn caused reflections of the laser beam to be picked up and printed as it would with a defect. This condition was not acceptable because an actual defect could be hidden in the same area. With modifications to the wetting and draining procedures, the condition was corrected.

Another problem discovered was the difficulty in establishing the level of sensitivity. That is, adjustment of the system so as to be capable of detecting defects and yet eliminate the extraneous electrical noises being picked-up and shown as defects.

With changes in some of the electrical components and other adjustments, the level of sensitivity was established for inspection of production tubes. Occasionally when there is doubt about the validity of an indication, inspection by the borescope is used.

Although the system as procured does have a method to insure proper operation prior to entering the tube, it was decided additional assurances were required to insure its continued operation during the entire inspection cycle. Briefly, the system has a machined defect located in a position so that the head assembly scans the defect prior to entering the tube. The system proceeds automatically if the defect is detected; if not the system is shut off automatically until the problem is corrected.

To insure the system is calibrated and functioning properly after entering the tube, actual cracks from a scrapped cannon tube were machined into small specimens (see figure 6). These specimens are now placed at both ends of each cannon tube inspected. The positioning of these specimens assures continued proper operation of the system after the head assembly enters the tube and also that there is proper operation during the entire inspection cycle. The print out showing all three defects in their proper location assures calibration.

The evaluation of the testing results was satisfactory and the system was accepted.

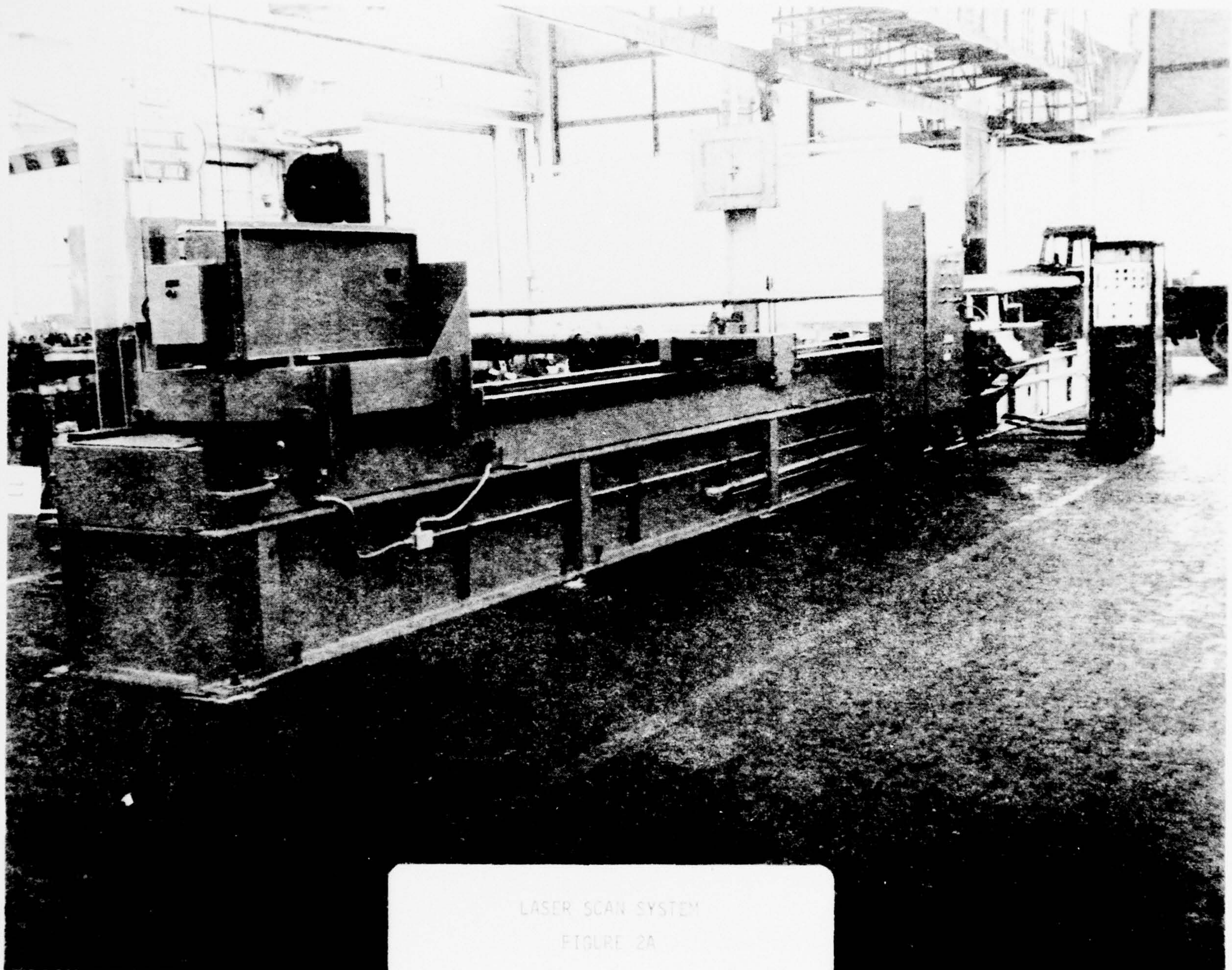
5. CONCLUSION

The use of the automatic laser scan inspection system has reduced inspection time by 20 min/tube or approximately fifty (50) percent and has increased inspection reliability by the elimination of the human element. The substantially increased probability of detecting critical defects will reflect directly on increased field reliability and safety.

6. IMPLEMENTATION

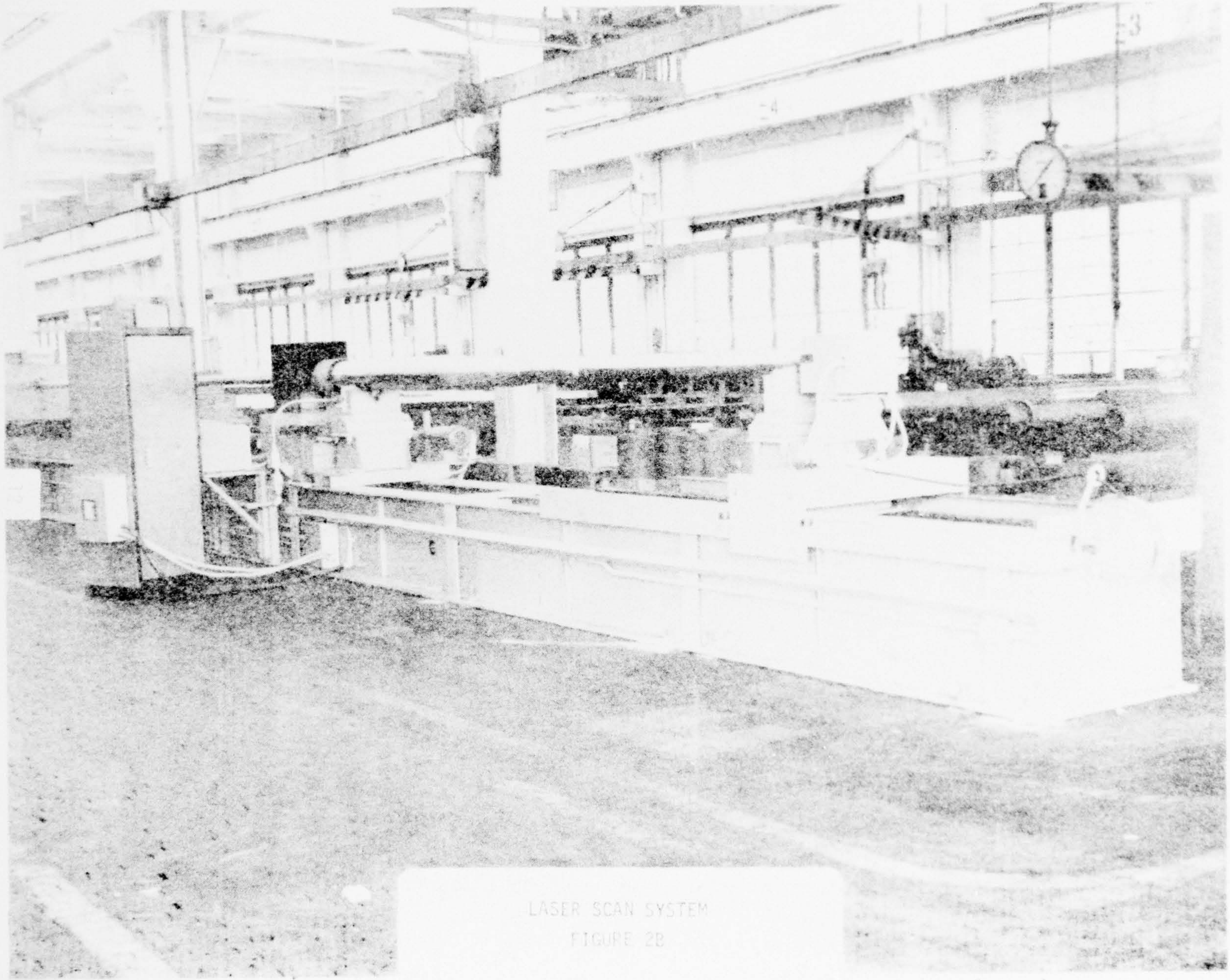
The laser scan inspection system has been implemented on production 105mm., M68 cannon tubes.

FIGURE 1: OPERATION OF BLACK-LIGHT BORESCOPE



LASER SCAN SYSTEM

FIGURE 2A



LASER SCAN SYSTEM

FIGURE 2B

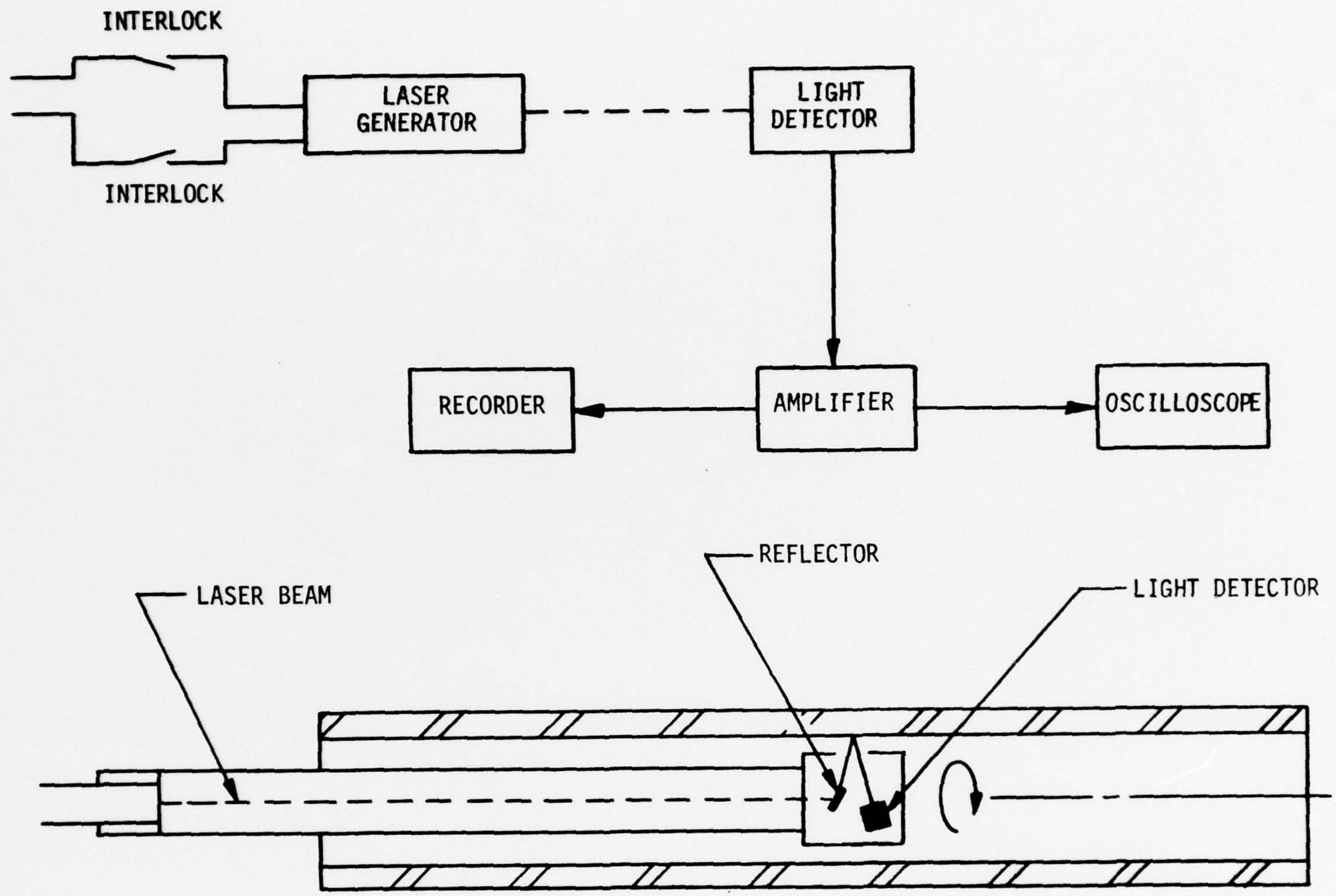
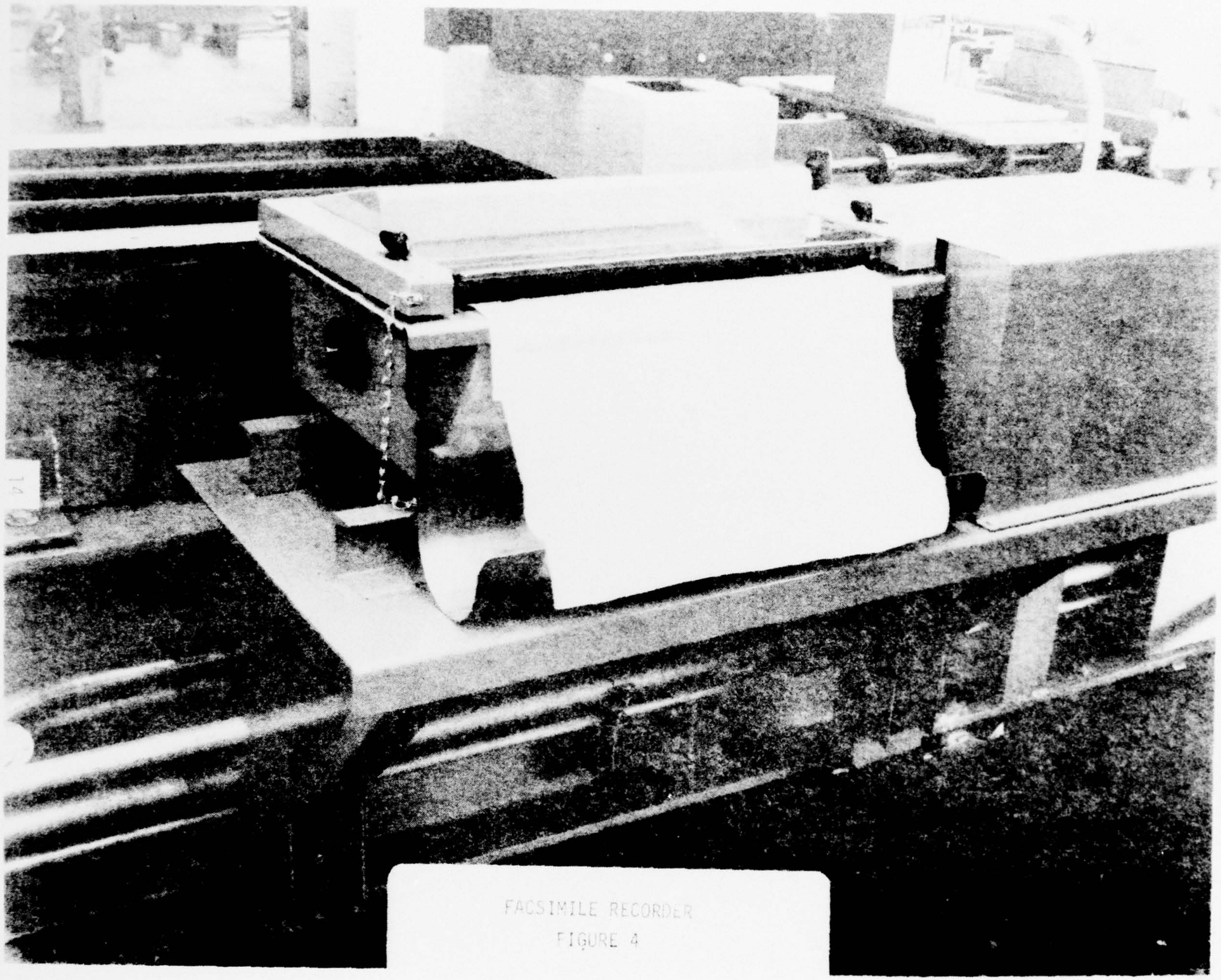


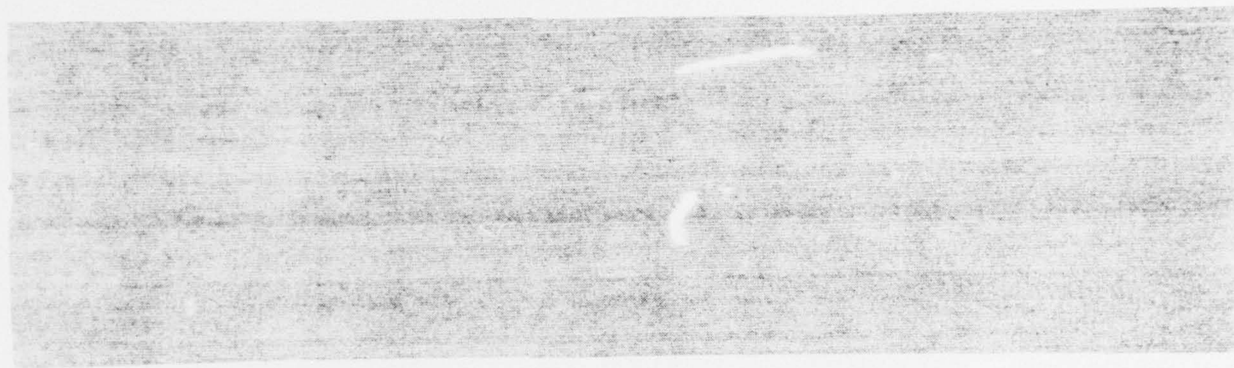
FIGURE 3: LASER SCAN SCHEMATIC



FACSIMILE RECORDER

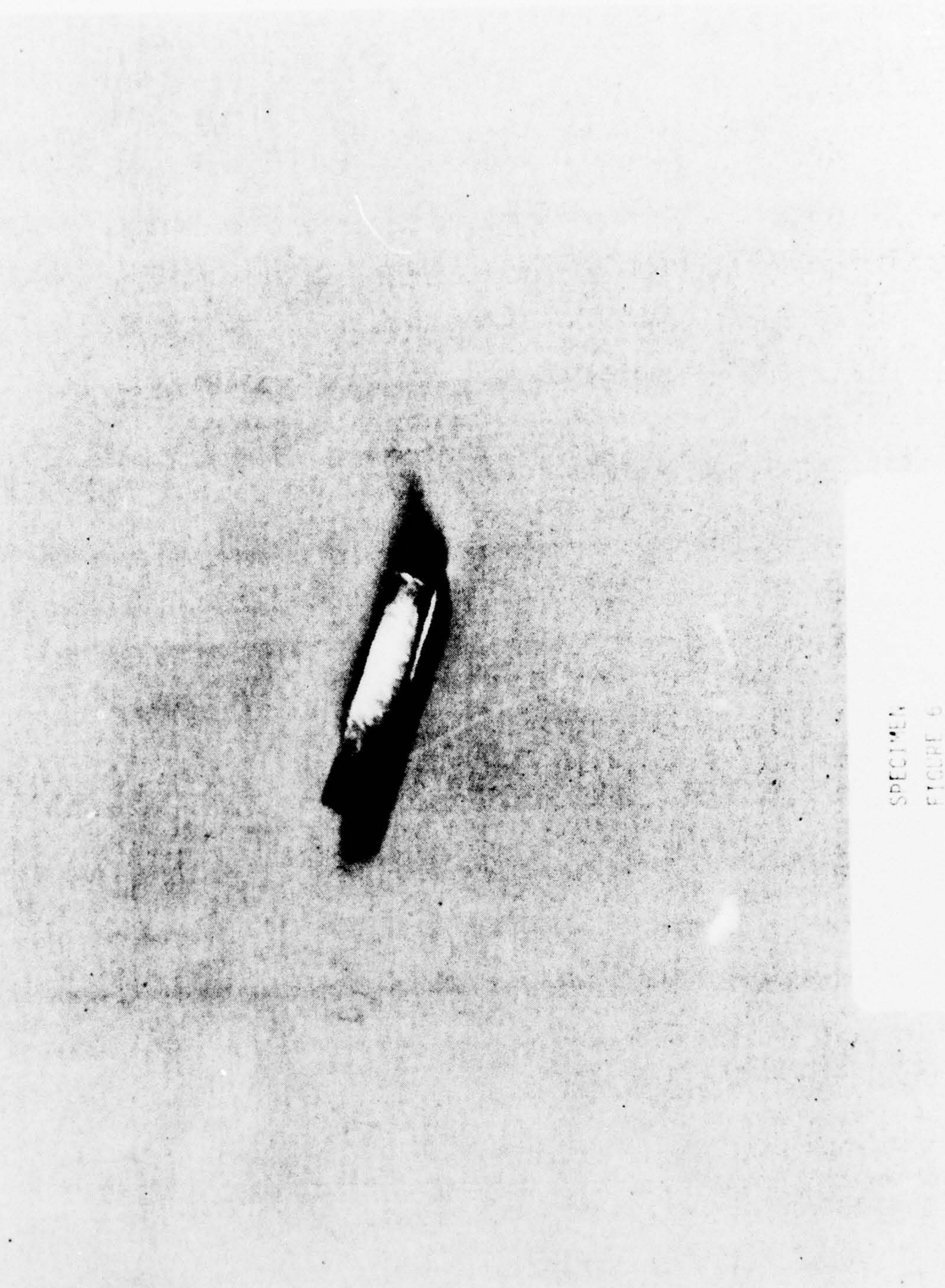
FIGURE 4

WHITE AREAS ARE SURFACE INDICATIONS

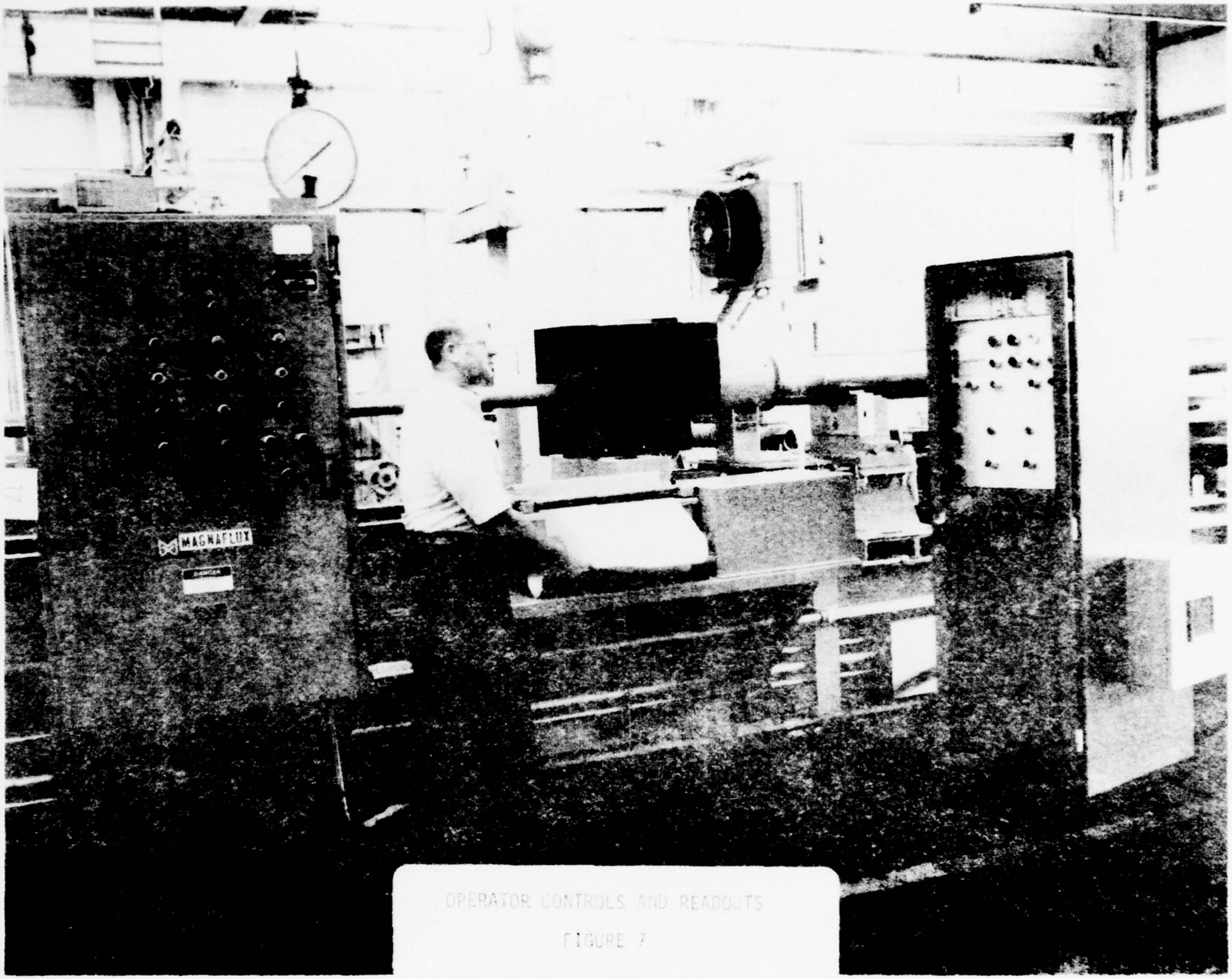


INSPECTION RECORDING

FIGURE 5



SPECIMEN
FIGURE 6



OPERATOR CONTROLS AND READOUTS

FIGURE 7

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