AD-A035 248 HARRY DIAMOND LABS ADELPHI MD F/G 19/1
RADIOGRAPHIC EVALUATION OF POTTING VOIDS FOR ELECTRONIC FUZE PR--ETC(U)
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1. REPORT NUMBER (14) HDL-TM-76-29	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER (9)
4. TITLE (and Subtitle) (6) Radiographic Evaluation of Potting Voids for Electronic Fuze Procurement Program: Phase II.		5. TYPE OF REPORT & PERIOD COVERED Technical Memorandum 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) Edward W. Burke		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 (12) 23p.
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Materiel Development & Readiness Command, ATTN: DRCMS Alexandria, VA 22333	(11)	12. REPORT DATE Dec [redacted] 76 13. NUMBER OF PAGES 27
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE NA

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)

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18. SUPPLEMENTARY NOTES

DRCMS Code: 5397.0M.6350
HDL Project: 789577

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Radiography
Scintillography
Nondestructive testing
Automated radiography
Automated Scintillography

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

An x-ray scintillographic scanning technique was found to be a good method for detecting voids in light-density potting foam encased in steel and for determining whether the electrolyte ampules in fuze batteries are broken or intact.

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FIGURES

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1. INTRODUCTION

Based on the findings of Phase I of this project,[1] an x-ray scintillographic scanning method of evaluation was further explored and refined to continue the development of techniques for detecting voids in light-density (18 ± 2 lb/ft^3) (288 ± 32 kg/m^3) potting foam in electronic fuzes.

The existing scintillographic system's stability was increased, allowing a resolution of better than 1-percent change in transmission of x rays. This resolution permits detection of 0.106-in. (0.27-cm) voids in 1.5 in. (3.81 cm) of potting foam through 1/4 in. (0.64 cm) of steel in our gages. Known 1/8-in. (0.32 cm) voids under the oscillator board assembly were successfully detected also in control samples of XM732 fuzes.

An automatic sequencing fixture and control circuit was designed and built. Further work in this area could produce a fully automated test facility that would accept, reject, and classify fuzes (or other items) according to their scintillographic signatures.

2. DISCUSSION

The goal of this project was to formulate cost-effective and reliable techniques to identify debilitating potting voids in fuzes containing foamed-in-place electronic subassemblies. These techniques would be used in 100-percent testing of fuzes prior to their entry into the stockpile--thus, the necessity of speed in testing. Orthodox x-ray radiographic techniques using wet film (which is expensive and must be chemically processed) results in costly manual film evaluation after the fact. Furthermore, wet films are limited to a resolution of about 2-percent change in transmission of x rays, far less than the sensitivity required to resolve small voids through 1/3-in. (0.85-cm) thickness of cadmium-plated steel found in present electronic fuzes.

Neutron radiography was found to be extremely slow to image test items on film, and, using film, it suffers the same film limitations as orthodox x-ray techniques. Also, setting up a neutron source is an expensive project in itself.

A preliminary study[1] that surveyed these and other radiographic and radiological state-of-the-art systems showed the most promising

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[1] *Ruth E. Chaddick, Radiographic Evaluation of Potting Voids for Electronic Fuze Procurement Program: Phase I, Harry Diamond Laboratories TR-1767 (November 1976).*

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immediate solution of this problem to be inspection by using x rays with a scanning detector (x-ray scintillography).

An x-ray scintillographic inspection station requires the following basic items:

a. X-ray source

b. Test fixture

c. X-ray detector

d. Recording device

For inspection, the item under test is placed in a fixture that holds it in an x-ray beam generated by the source. The detector unit monitors the flux of x rays transmitted through the item and, hence, its density. The detector unit converts the transmitted x rays into an analog voltage proportional to the x-ray flux, which is, in turn, recorded on paper. Then the item under test is moved, and the changing x-ray flux is recorded describing the section of the item in the beam. By moving the areas of interest in the item through the beam, we can get a full description of the item.

To get very good resolution and high sensitivity, additions to the basic system described must be made. Such a system was built and operated at the Harry Diamond Laboratories (HDL).

3. SCINTILLOGRAPHIC SYSTEM DESCRIPTION

The scintillographic system (fig. 1) consists of the following major elements:

a. X-ray source

b. X-ray collimator

c. Motorized fixture

d. X-ray detector

e. Amplifier unit

f. Chart recorder

g. Automatic sequencing circuit

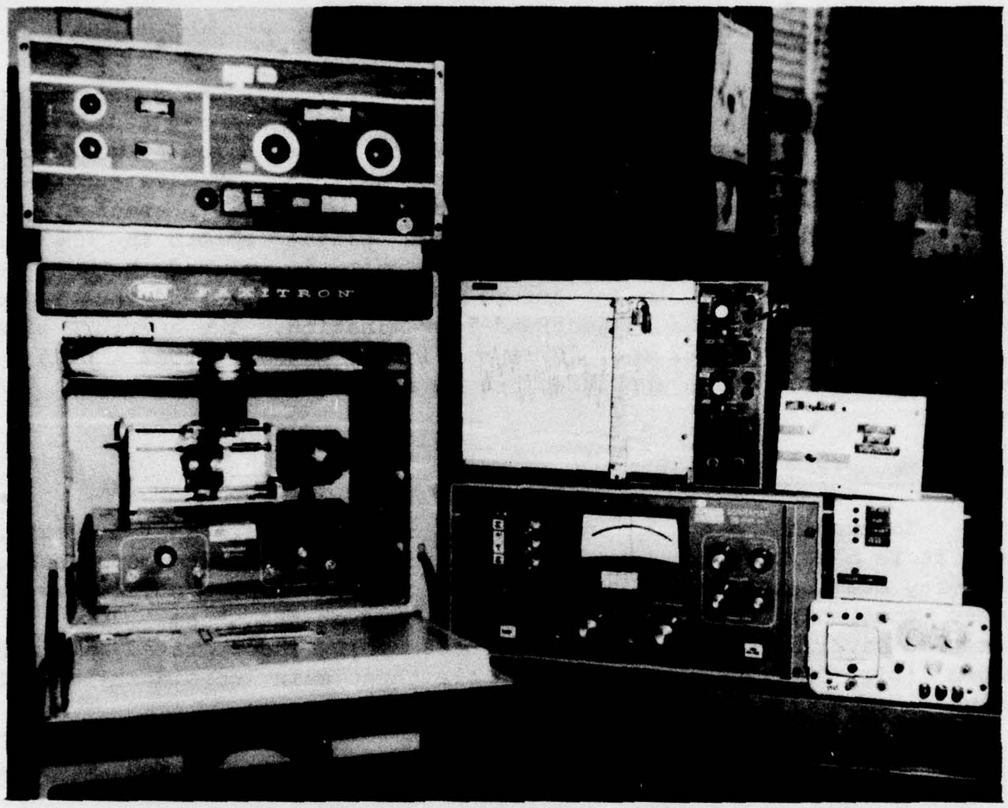

Figure 1. Scintillographic system.

3.1 X-Ray Source

The x-ray source used in this system is a Faxitron 805 radiation inspection unit manufactured by Hewlett-Packard, McMinnville Division. This unit has a power output to the x-ray tube of 10 to 110 kV at 3 mA and is self rectified at 60 Hz. The x-ray source stability (approximately 3 percent) was worse than the desired 1 percent, so a 500-VA Sola constant voltage transformer (part No. 23-22-150) was added, which enhanced the stability of the unit to approximately 0.75 percent. The Faxitron 805 conforms to the exempt protective installation classification as defined in Section 3.1 of the National Bureau of Standards Handbook 93.[2]

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[2] *National Bureau of Standards Handbook 93, American Standards Association (3 January 1964).*

3.2 X-Ray Collimator

To help rid the system of unwanted x-ray scatter, a collimation unit was built and placed between the subject and the x-ray source. The unit consists of a steel tube fitted with three holed lead plates (fig. 2). By placing the collimator on the axis of the wanted x-ray beam, the beam size is reduced at our working distance to about 0.5 in. (1.27 cm) in diameter. The three lead plates absorb the unwanted x rays. A second collimation aperture unit is placed between the subject and the detector to further reduce the beam size and thus reduce the effective area of the subject under examination. The aperture sizes used are 0.062 × 0.062 in. (0.16 × 0.16 cm) and 0.062 × 0.25 in. (0.16 × 0.64 cm). These apertures are in a 0.5-in (1.27-cm) thick lead plate.

3.3 Motorized Fixtures

To examine more than one area of comparable size to the aperture used, it is necessary to have the sample under examination move through the x-ray beam being monitored. Two methods of implementing this are linear movements and rotating movements through the beam. Two such fixtures have been designed and successfully incorporated into the system (fig. 3, 4 and app A). There are three main considerations in designing such fixtures:

a. Minimizing subject-to-detector distance to reduce x-ray scatter

b. True linear or on-axis rotation of sample

c. Precise positioning to produce repeatable results

Position sensors were installed on the rotating fixture to permit automatic sequencing of the examination procedures. The design details of this fixture are recorded on HDL drawings No. 11730155 and 11730162.

3.4 X-Ray Detector

The x-ray detection unit was purchased as part of an off-the-shelf radiological scanning system from Xetex, Inc. The detectors themselves are two NaI(Ti) crystals of 1-1/2-in. (3.81-cm) diam and 1-in. (2.54-cm) thickness optically coupled to RCA 6342A photomultiplier tubes. Dynode switching allows three decades of incident radiation intensity. Allowed radiation-source duty cycles are from dc to 2×10^{-4}.

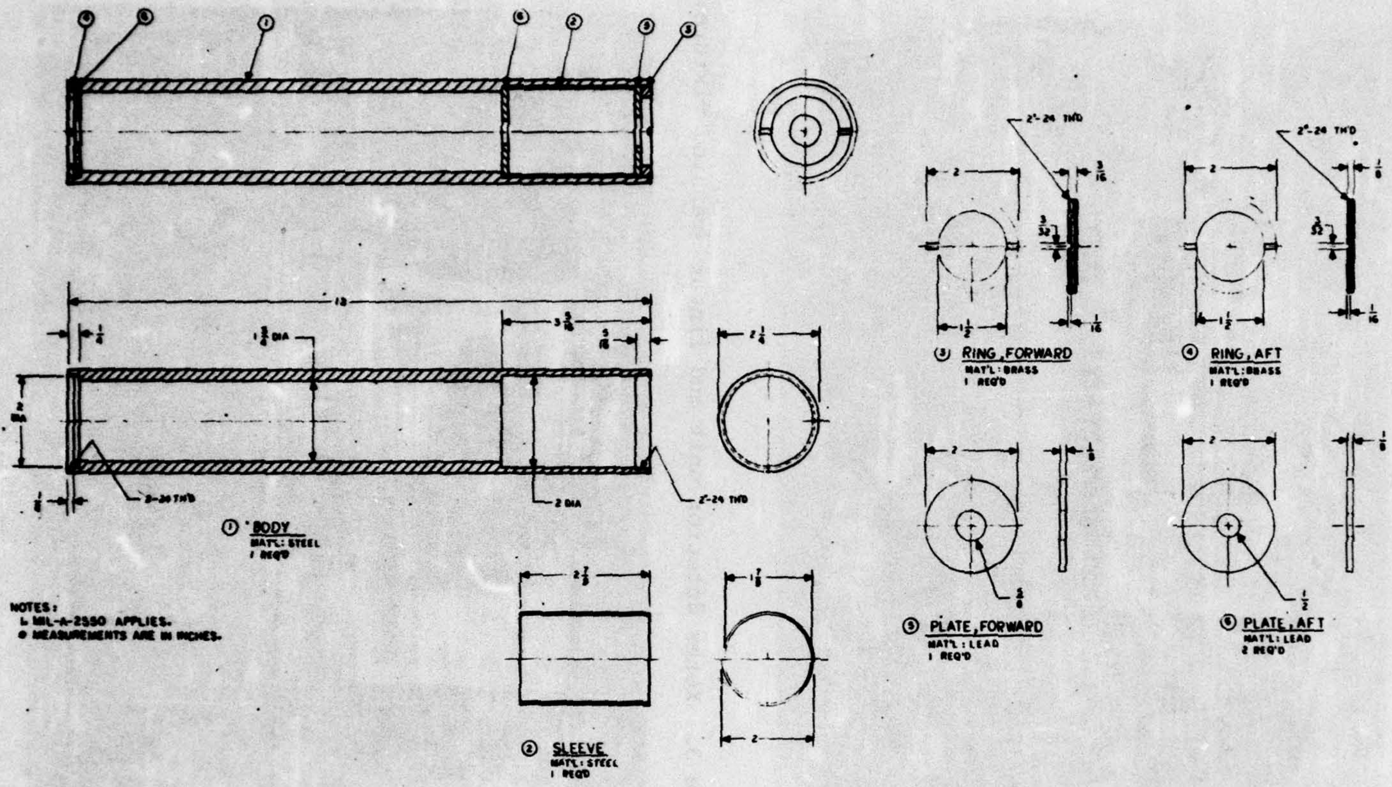

Figure 2. X-ray collimator.

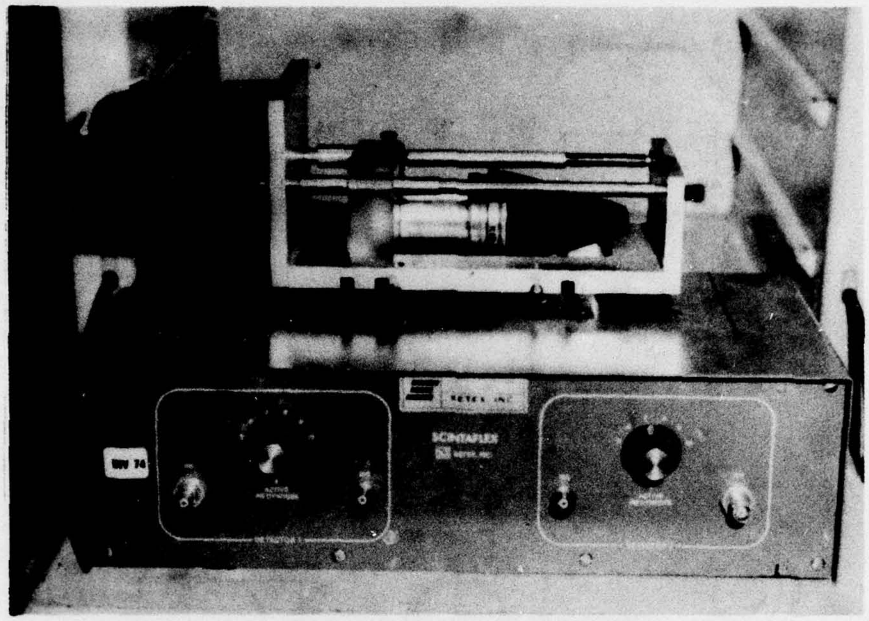

Figure 3. Xetex detector unit and linear scanning fixture.

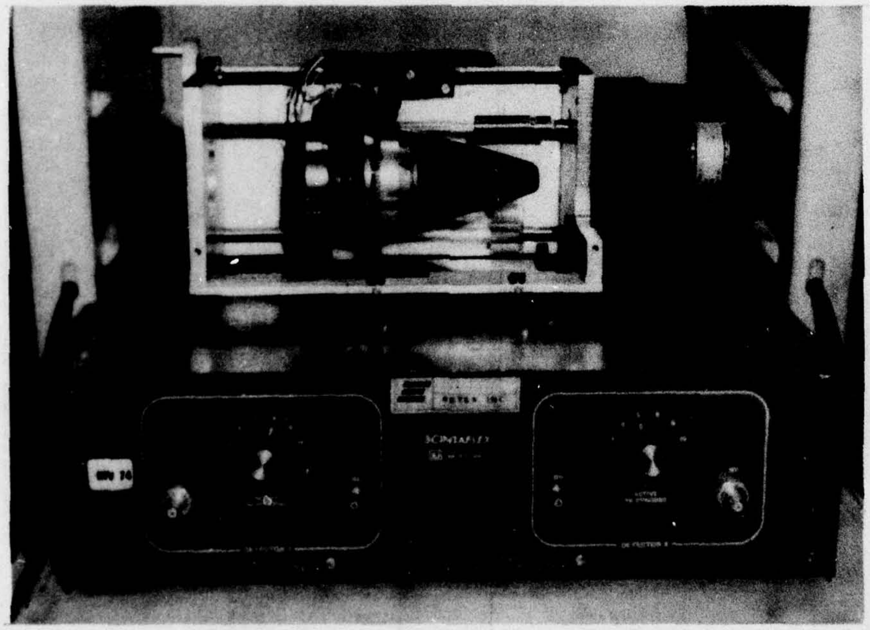

Figure 4. Xetex detector unit and rotative scanning fixture.

3.5 Amplifier Unit

The amplifier unit also was part of the Xetex radiological scanning unit. It has Delta Transmission sensitivities of ±5-percent full scale, 0.2-percent least reading; ±10-percent full scale; and ±50-percent full scale. It has push-button control with extra switch contacts available for external system synchronization. An integrator set allows selection of a time constant suitable to most applications, and a precise, stable, internal voltage reference also is provided. The amplifier unit was found to be susceptible to radio-frequency interference due primarily to unshielded wiring on internal high-impedance input circuitry. The problem was corrected by an in-house reworking of the amplifier (rewiring high-impedance signal lines with shielded wire). This correction helped greatly, but the amplifier still picks up some noise (primarily from fluorescent lighting).

3.6 Chart Recorder

The system uses a Hewlett-Packard Mosely X-Y recorder 135A, which has a voltage range from 0.5 mV/in. (0.20 mV/cm) to 50 V/in. (19.69 V/cm) and time range from 0.5 s/in. (0.20 s/cm) to 50 s/in. (19.69 s/cm) on the axes. A static chart hold mechanism allows use of paper up to 8-1/2 × 11 in. (21.59 × 27.94 cm). An external pen control circuit also is included.

3.7 Automatic Sequencing Circuit

To allow automatic operation of the inspection system, a special sequencing circuit was designed (fig. 5). The circuit implemented is a sequential machine operated according to the state diagram in figure 6. The states are defined as follows:

State 1. Rewind--reposition fixture to starting position.

State 2. Ready--fixture is in starting position.

State 3. Run--fixture starts rotating.

State 4. Chart 1--chart recorder is on in first revolution.

State 5. Chart 2--chart recorder is on in second revolution.

Five events can cause a state change:

A. Start scan--A signal from the amplifier unit is created by pressing the start scan button. This tells the system to start (STRTSCN-).

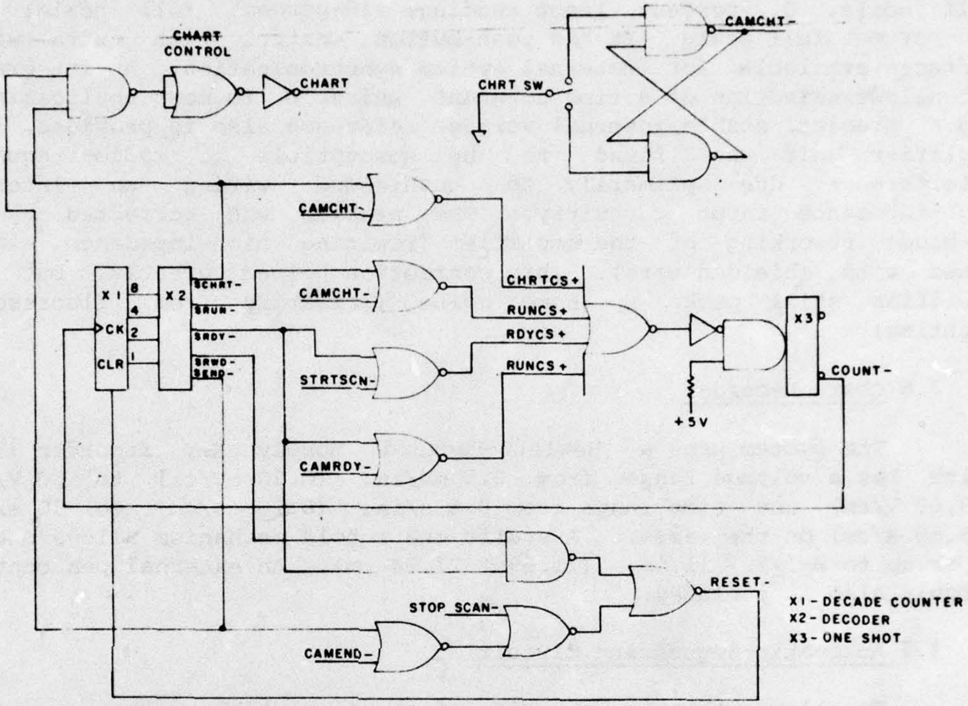

Figure 5. Sequencing circuit.

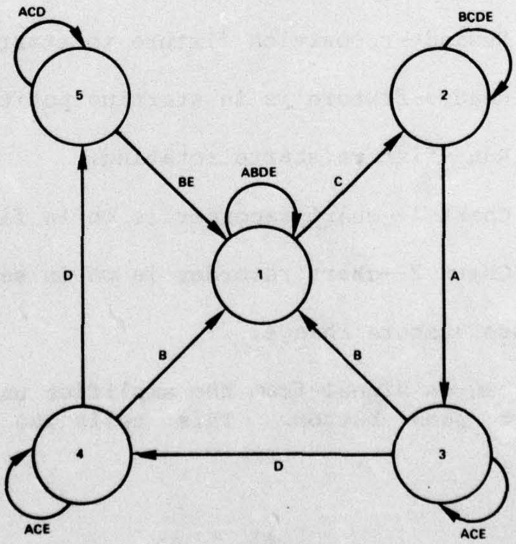

Figure 6. Sequencing circuit state diagram.

B. Stop scan--A signal from the amplifier unit is created by pressing the stop scan button. It tells the system to reset to a ready position (STOP SCAN-)

C. Cam ready--A signal from the fixture indicates a ready position (CAMRDY-).

D. Cam chart--A signal from the fixture indicates to turn on the chart recorder (CAMCHT-).

E. Cam end--A signal from the fixture indicates the end of the scan position (CAMEND-).

4. SYSTEM OPERATION

The procedure for producing a graphic description of an item under test is generally the same for all items. In this case, the item is an XM732 fuze, and the area of the fuze to be inspected is immediately beneath the oscillator board (fig. 7). For the desired resolution, an aperture 0.62 × 0.62 in. (0.16 × 0.16 cm) is used and mounted beneath the holding fixture. The fixture is then adjusted to position the area of interest directly above the aperture. After the equipment is allowed its warm-up period, the fuze is placed in the fixture, and the system is calibrated according to instructions supplied by the scanning-system manufacturer. These calibrations basically amount to setting the amplifier gain and offset voltage to provide maximum sensitivity and linearity at the desired magnitude of x-ray transmission. Rotation speed and signal filtration are then adjusted to allow the best combination of rotational speed or signal-to-noise ratio. Noise (compared to x-ray level drift) was found to be the biggest problem. The noise was filtered out, and the fixture speed was appropriately slowed to allow the desired signal response. Tests at HDL using these methods yielded the following results:

a. At 100 kV, 1 in. (2.54 cm) of potting foam was found to be the equivalent of approximately 0.012 in. (0.030 cm) of steel (fig. 8).

b. In a rotated test gage, 0.106-in. (0.27-cm) diam voids in 1.5 in. (3.81 cm) of potting foam were visible through 1/4 in. (0.64 cm) of steel (fig. 9).

c. Under the oscillator board of XM732 fuzes, 1/8-in.(0.32-cm) diam voids were visible (fig. 10 to 12).

d. Because of limited tube voltage on the Faxitron 805, no result was obtained through the steel sleeve of the XM732 fuze.

e. A preliminary study on the PS116 power supply showed full or empty fluid ampules and allowed counting of the battery plates. In addition to detecting voids, we found the same equipment to be quite useful in determining whether the electrolyte ampules in fuze batteries are broken or intact. Figure 13 shows broken versus unbroken ampules, and figure 14 shows plates.

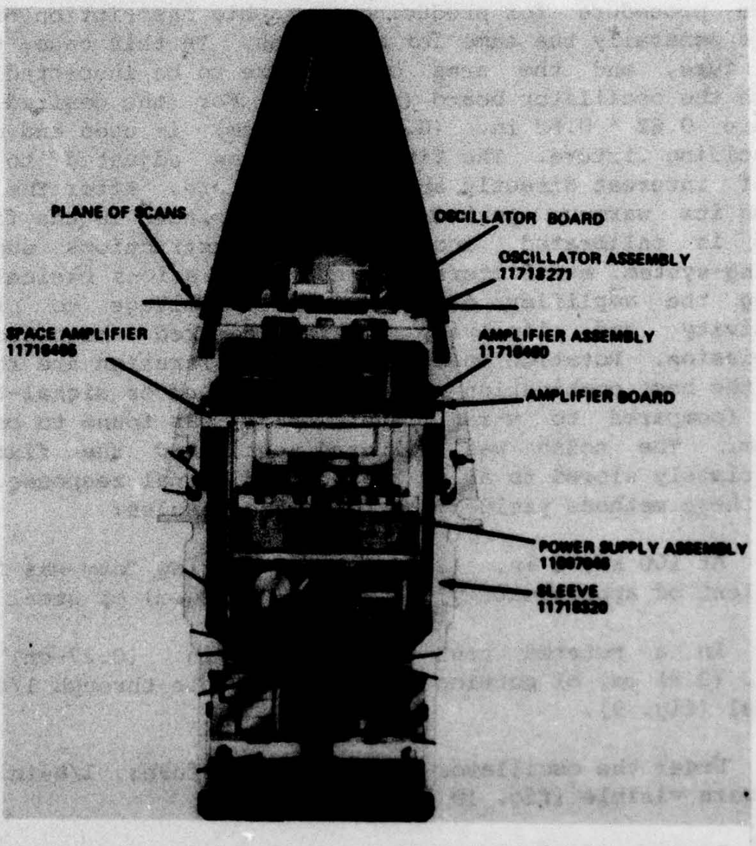

Figure 7. XM732 fuze configuration.

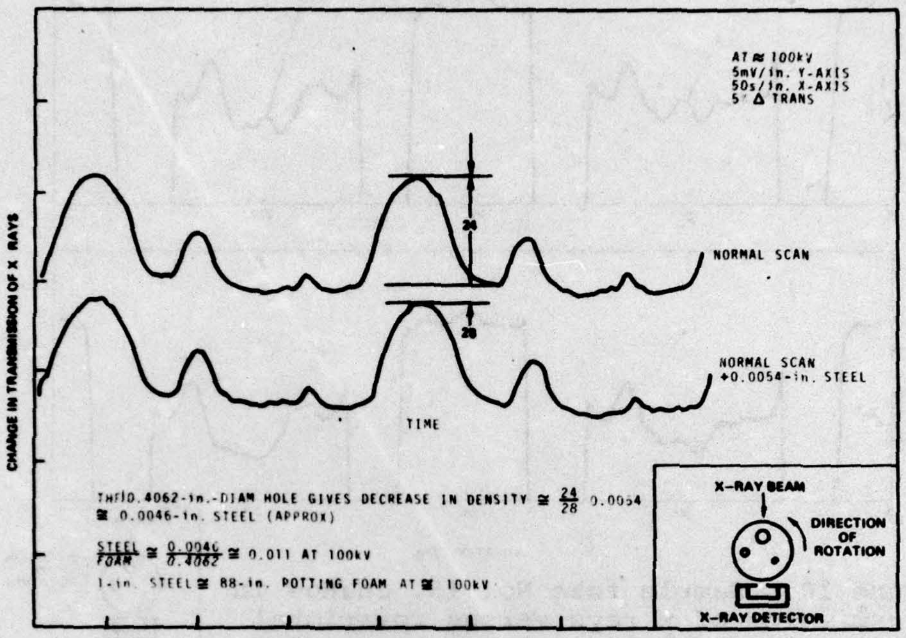

Figure 8. Potting foam/steel equivalence.

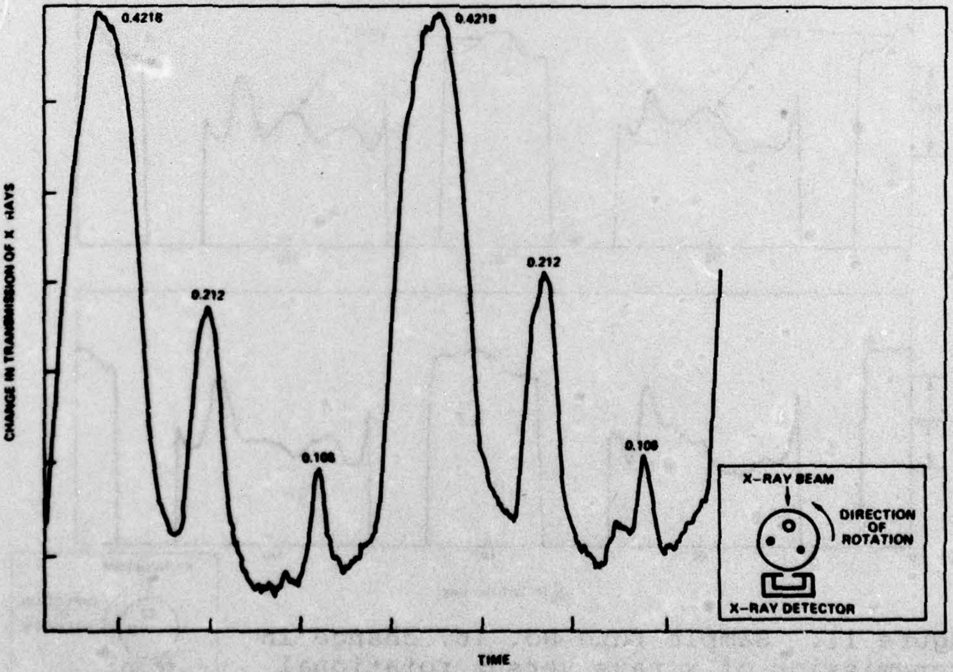

Figure 9. Voids 0.106, 0.212, and 0.4218 in. in 1.5 in. of foam through 1/4 in. of steel.

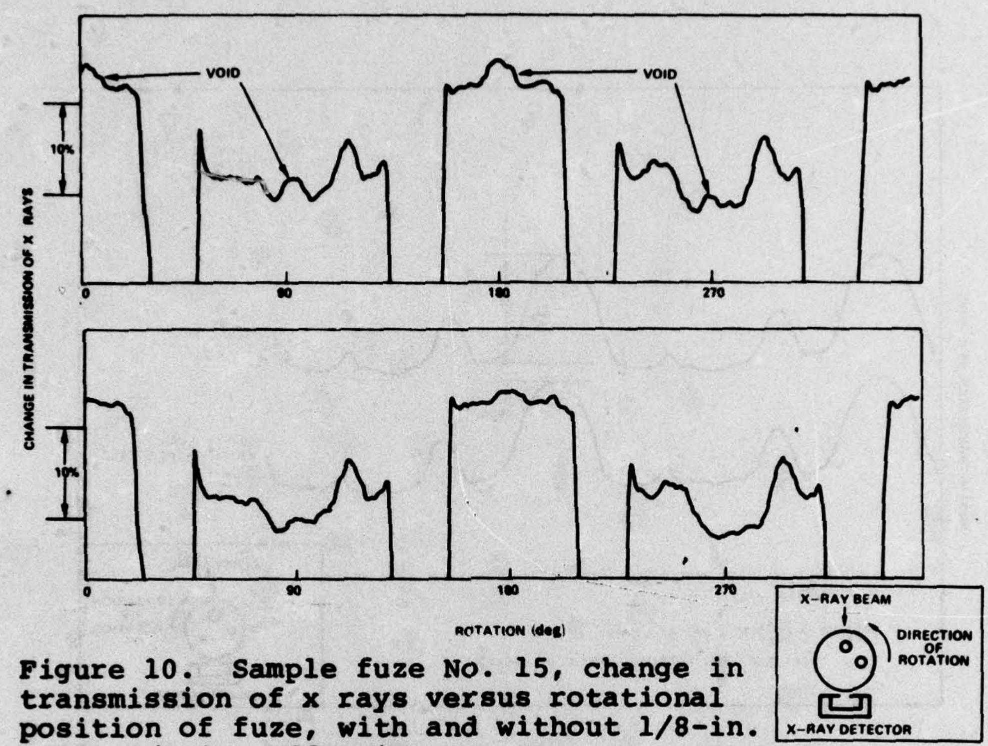

Figure 10. Sample fuze No. 15, change in transmission of x rays versus rotational position of fuze, with and without 1/8-in. voids 5/8-in. off axis.

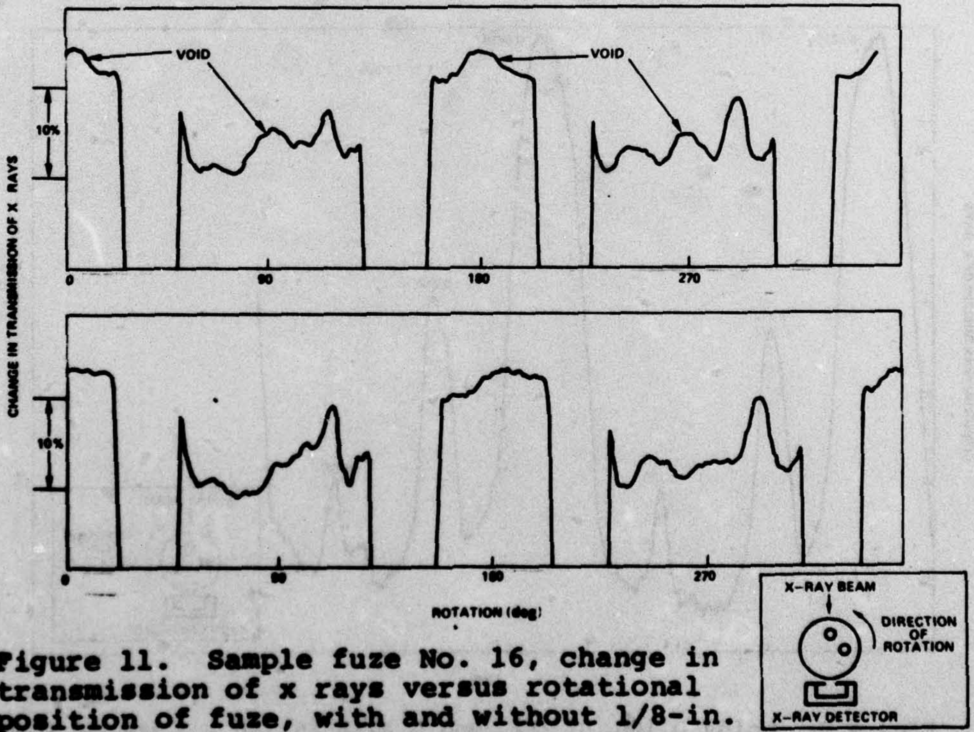

Figure 11. Sample fuze No. 16, change in transmission of x rays versus rotational position of fuze, with and without 1/8-in. voids 3/8-in. off axis.

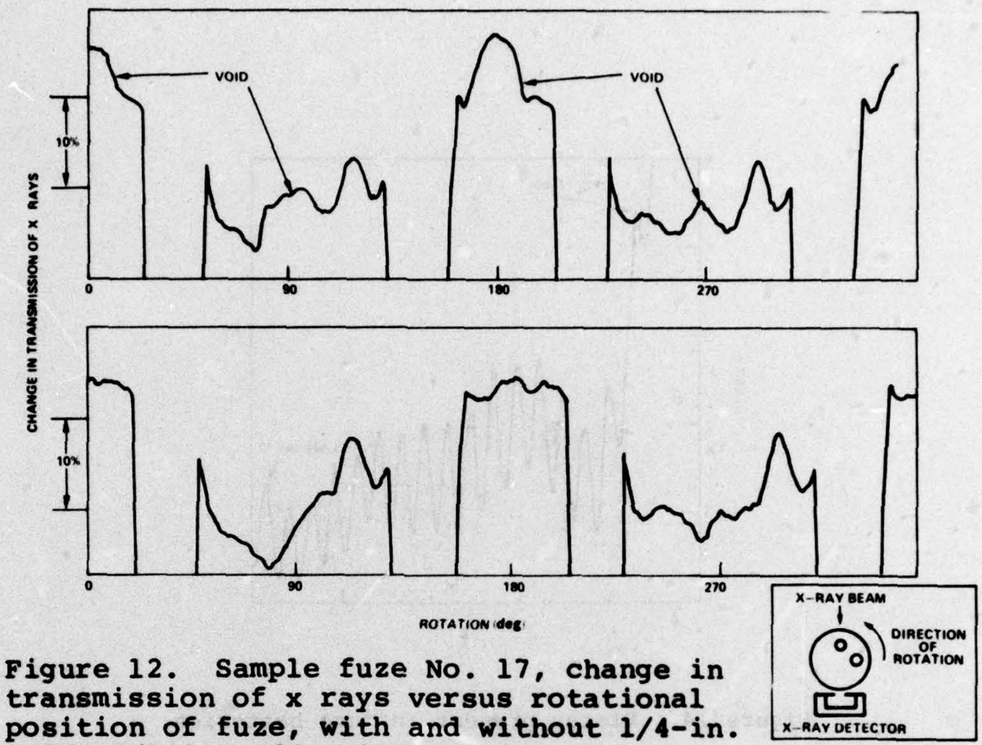

Figure 12. Sample fuze No. 17, change in transmission of x rays versus rotational position of fuze, with and without 1/4-in. voids 5/8-in. off axis.

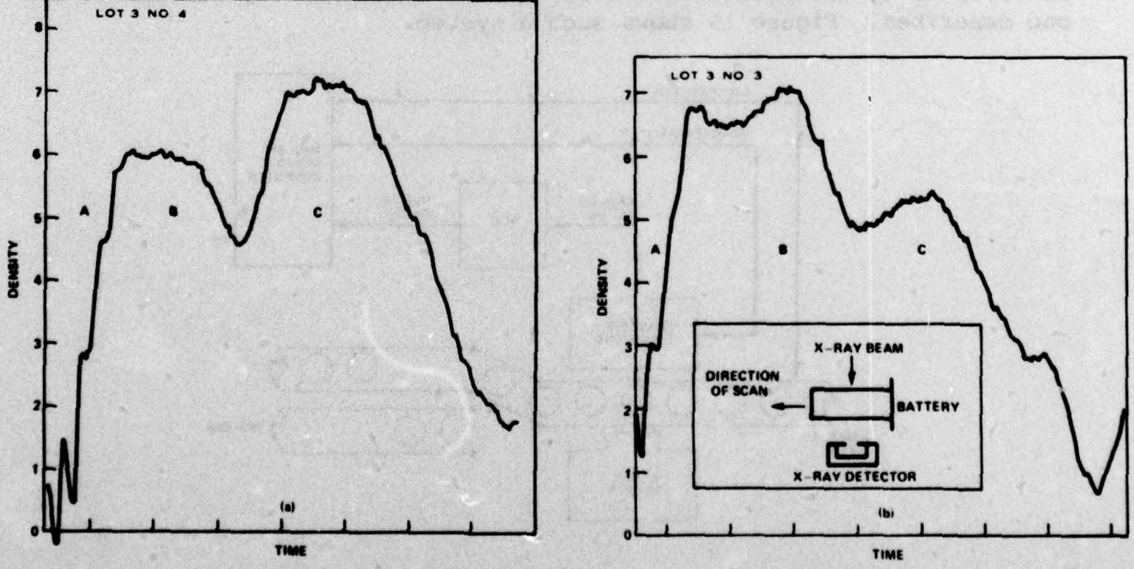

Figure 13. Electrolyte ampules: (a) unbroken and (b) broken.

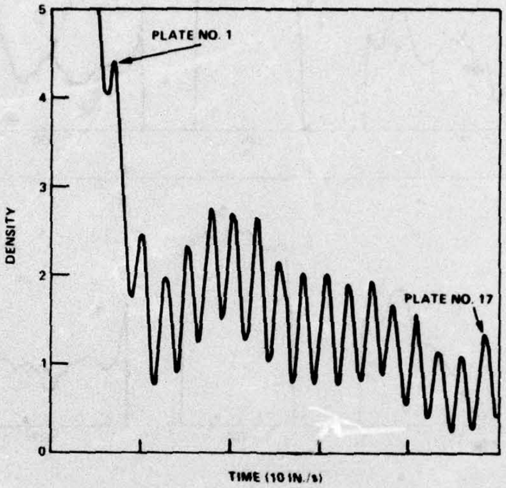

Figure 14. Plates present in fuze batteries.

5. *FUTURE WORK*

A scanning technique such as this lends itself very well to complete automation. Increased system throughput and improved data validity can be realized by automatic control of a test station very similar to the one described. Figure 15 shows such a system.

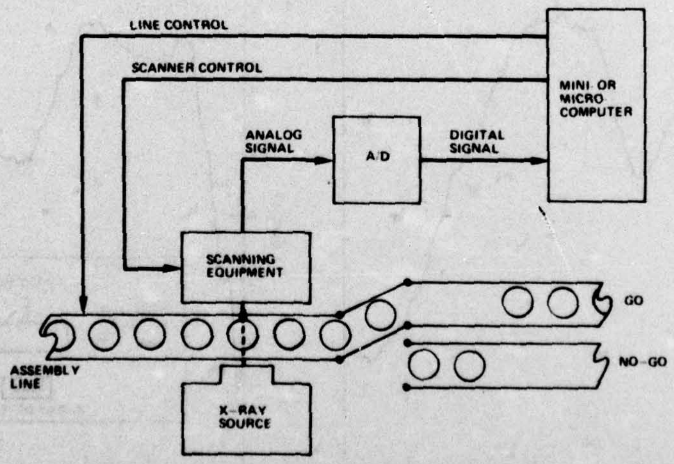

Figure 15. Completely automated scanning setup.

A setup like this would automatically load the test fixture and (under computer or other control-type mechanism) direct the test sequence and monitor the scintillographic output (this could include also automatic calibration of the equipment). By using pattern-recognition techniques, good and bad fuzes would be separated by their scintillographic signatures. The fuzes could be typed further by other signature characteristics.

Accurate logbooks, statistical data, and transportable data bases could be automatically maintained, even in real time, if deemed necessary. Classification errors due to human fatigue and differing inspection techniques would be eliminated. The necessary technology for this type of system exists.

6. CONCLUSIONS

X-ray scintillography is a feasible alternative to wet film x-ray techniques as a nondestructive testing method where the article of interest can be scanned. The running cost per item by using x-ray scintillography is significantly lower than radiographic inspection by wet film. Also, wet-film resolution is limited to about 2 percent, while the scintillographic resolution is limited to detector sensitivity (0.02 percent) or x-ray source stability (0.75 percent in our case). Detection of 1/8-in. (0.32-cm) and 1/4-in. (0.64-cm) voids in XM732 fuzes (fig. 10 to 12) and 0.106-in. (0.27-cm) voids through 1/4 in. (0.64 cm) of steel in gages (fig. 9) was realized by using the scintillographic techniques.

In addition, the complete automation of a scintillographic test station is straightforward and well within the limits of current technologies.

APPENDIX A.--DETAIL FIXTURE DRAWINGS

Figures A-1 and A-2 blueprint linear and rotational scanning fixtures to move potting samples through x-ray beams.

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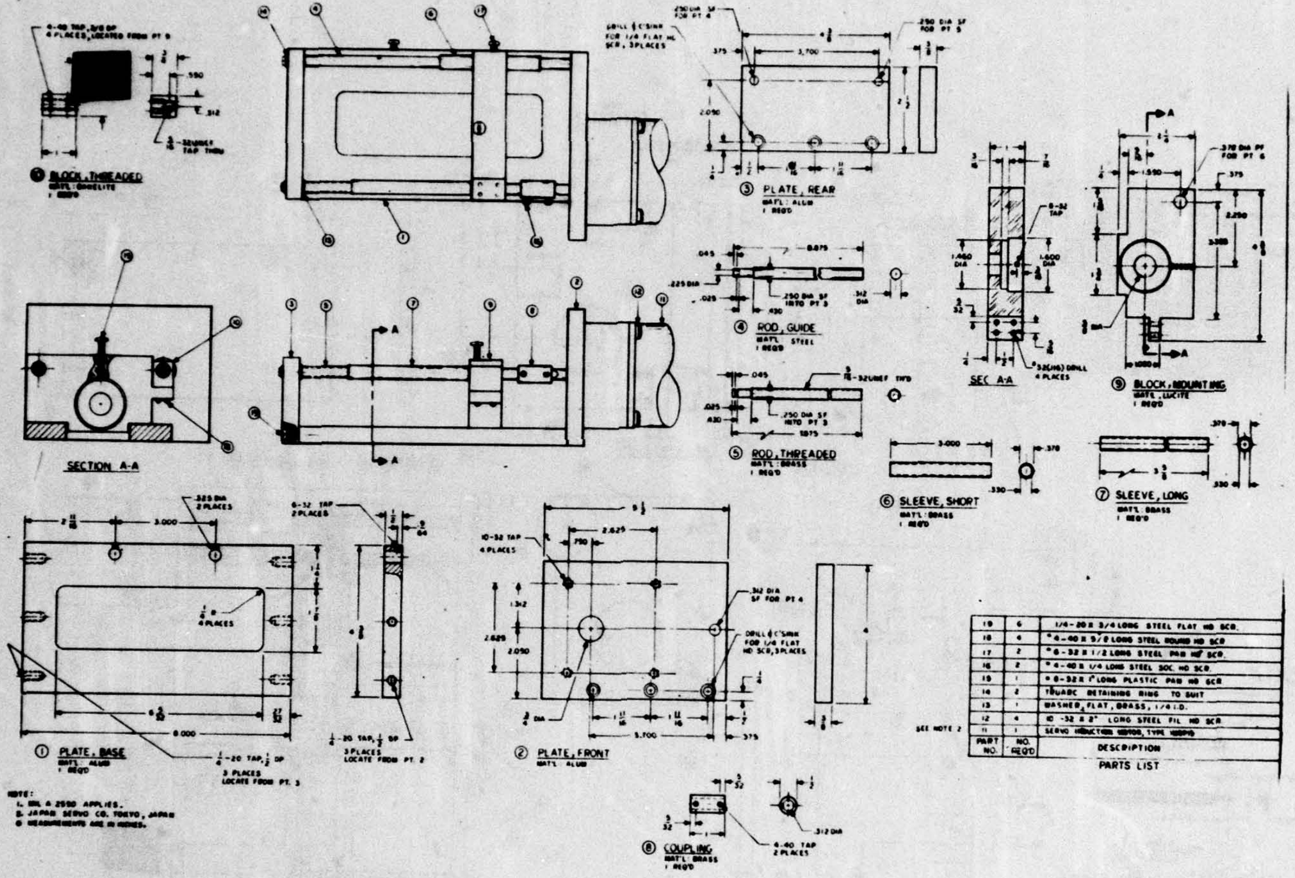

PART NO.	NO. REQ'D	DESCRIPTION
19	6	1/4-20 X 3/4 LONG STEEL FLAT HD SCR.
18	4	*4-40 X 5/8 LONG STEEL ROUND HD SCR
17	2	*6-32 X 1/2 LONG STEEL PAN HD SCR.
16	2	*4-40 X 1/4 LONG STEEL SOC. HD SCR.
15	1	*6-32 X 1" LONG PLASTIC PAN HD SCR
14	2	TRUARC RETAINING RING TO SUIT
13	1	WASHER, FLAT, BRASS, 1/4 I.D.
12	4	10-32 X 2" LONG STEEL FIL HD SCR
11	1	SERVO INDUCTION MOTOR, TYPE [illegible]

PARTS LIST

NOTE:
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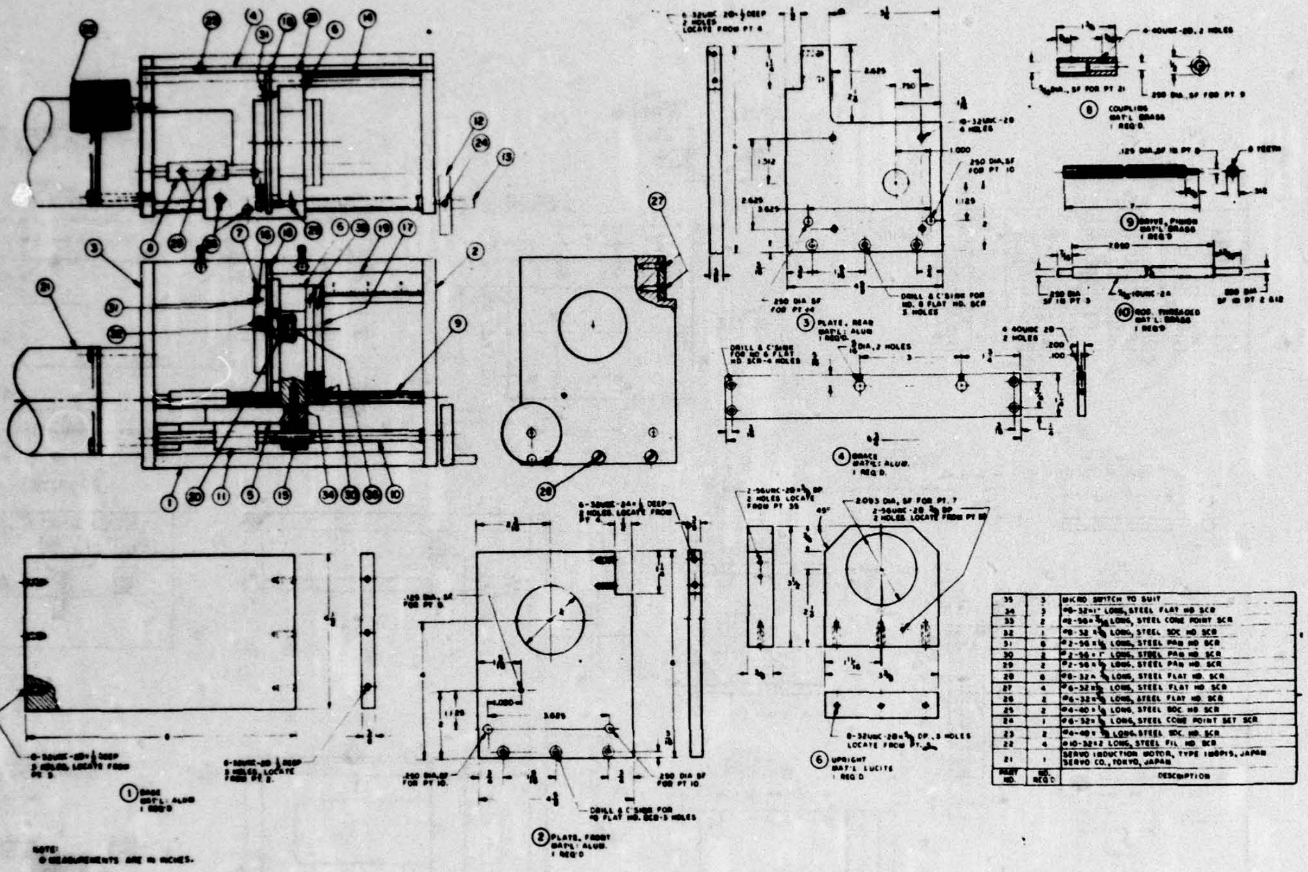

PART NO.	NO. REQ'D	DESCRIPTION
35	3	MICRO SWITCH TO SUIT
34	3	#8-32×1" LONG, STEEL FLAT HD SCR
33	2	#2-56×[illegible] LONG, STEEL CONE POINT SCR
32	1	#8-32×[illegible] LONG, STEEL SOC HD SCR
31	6	#2-56×[illegible] LONG, STEEL PAN HD SCR
30	2	#2-56×1" LONG, STEEL PAN HD SCR
29	2	#2-56×[illegible] LONG, STEEL PAN HD. SCR
28	6	#8-32×[illegible] LONG, STEEL FLAT HD. SCR
27	4	#6-32×[illegible] LONG, STEEL FLAT HD SCR
26	2	#6-32×[illegible] LONG, STEEL FLAT HD. SCR
25	2	#4-40×[illegible] LONG, STEEL SOC HD SCR
24	1	#6-32×[illegible] LONG, STEEL CONE POINT SET SCR
23	2	#4-40×[illegible] LONG, STEEL SOC. HD. SCR
22	4	#10-32×2 LONG, STEEL FIL HD SCR
21	1	SERVO INDUCTION MOTOR, TYPE IN8P15, JAPAN SERVO CO., TOKYO, JAPAN

Figure A-2. Rotational scanning fixture.

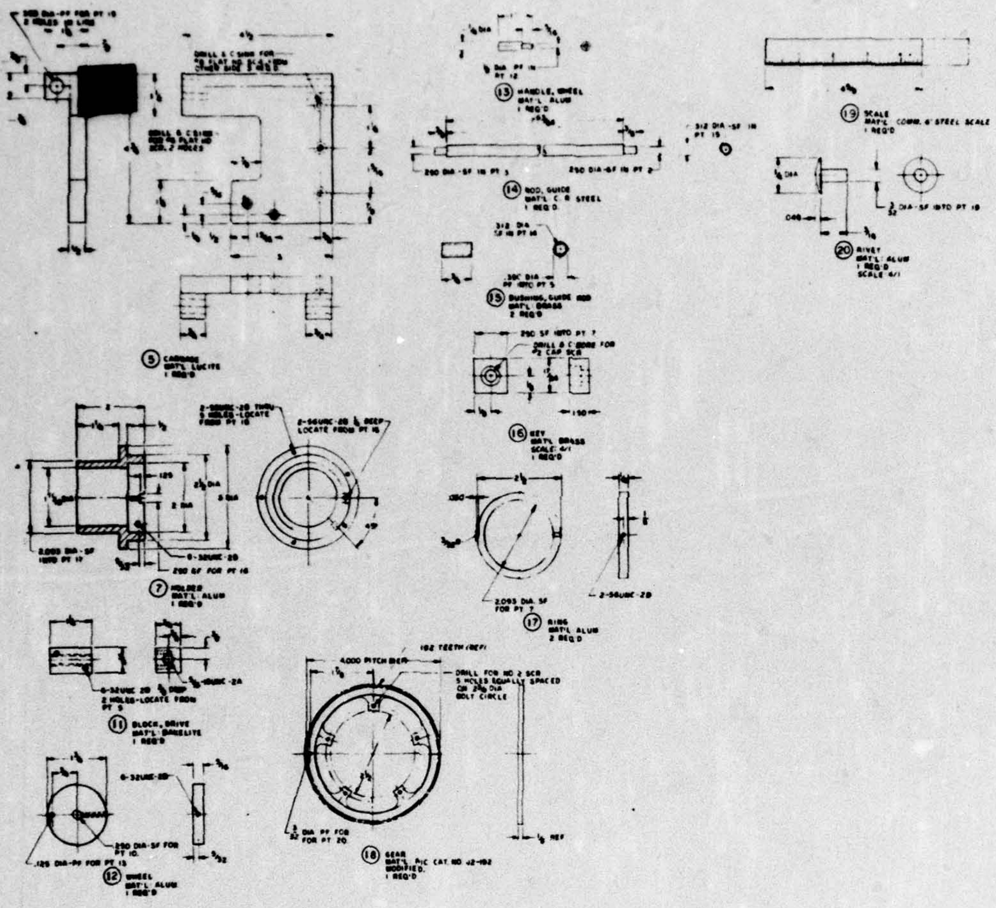

Figure A-2. Rotational scanning fixture (cont'd).

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