

ARTILLERY PROJECTILE INSPECTION WITH EMAT'S

C. M. Fortunko
Science Center, Rockwell International
Thousand Oaks, California 91360

ABSTRACT

A technique for ultrasonically inspecting 135 mm artillery projectiles has been demonstrated. Non-contact EMAT's placed on the outside of the projectile excited 2.25 MHz surface waves and 1.8 MHz angle shear waves which were used to detect EDM slots on both the inner and outer surfaces. The defect locations and sizes, 0.051 cm (0.020 in.) deep and 0.508 cm (0.200 in.) long were chosen on the basis of fracture mechanics analysis. Each was detected with signal-to-noise ratios in excess of 30 dB. These results indicate that it is feasible to construct a system for full inspection of projectiles at normal production line rates. Among the desirable features of such a system are the absence of an ultrasonic couplant, the resulting potential for high speed operation, and the convenience with which multiple transducers can be incorporated to achieve high coverage and to gain additional information for defect characterization.

This poster presents the results of a recently completed study which demonstrated the feasibility of inspecting artillery projectiles for critical defects with electromagnetic transducers. The purpose was to show that the non-contact feature of EMAT's could be used to advantage in the design of a high-speed system for 100%, on-line inspection.

Figure 1 shows a longitudinal cross-section of a M107 projectile on which the locations of defects that were studied are indicated. These were placed in regions where high stresses are produced during firing.

Figure 2 shows in addition a circumferential cross-section showing one possible location of transmitting and receiving transducers.

A photograph of the laboratory test-bed is shown in Fig. 3. The large electromagnet provides the necessary bias field. The transducer coils are seen on top.

Figure 4 shows that the same transducers can be used to inspect the exterior with 2.25 MHz surface waves or the entire wall, including interior surfaces, with angle shear waves at 1.8 MHz, traveling circumferentially around the shell.

Figure 5 shows the ultrasonic surface wave signals reflected from a 0.020 inch deep, 0.200 inch long EDM notch on the exterior. Note that the signals propagating completely around the shell are observed and that the flaw is easily detected at any point in the circumferential belt interrogated by the transducers.

Figure 6 shows similar results for the angle shear mode. In this case, the full circumferential signals are not seen as clearly because the

inner surface is not parallel to the exterior surface of the projectile wall. However, the defect signals again have high signal-to-noise ratios.

Figure 7 shows an artist's concept of an on-line inspection system, which would include a raster of transducers of the type shown in Fig. 3 positioned along the length of the projectile. Included are the conclusions of this successful feasibility demonstration, which indicate that high-speed on-line inspection should be possible with this technique.

Acknowledgement

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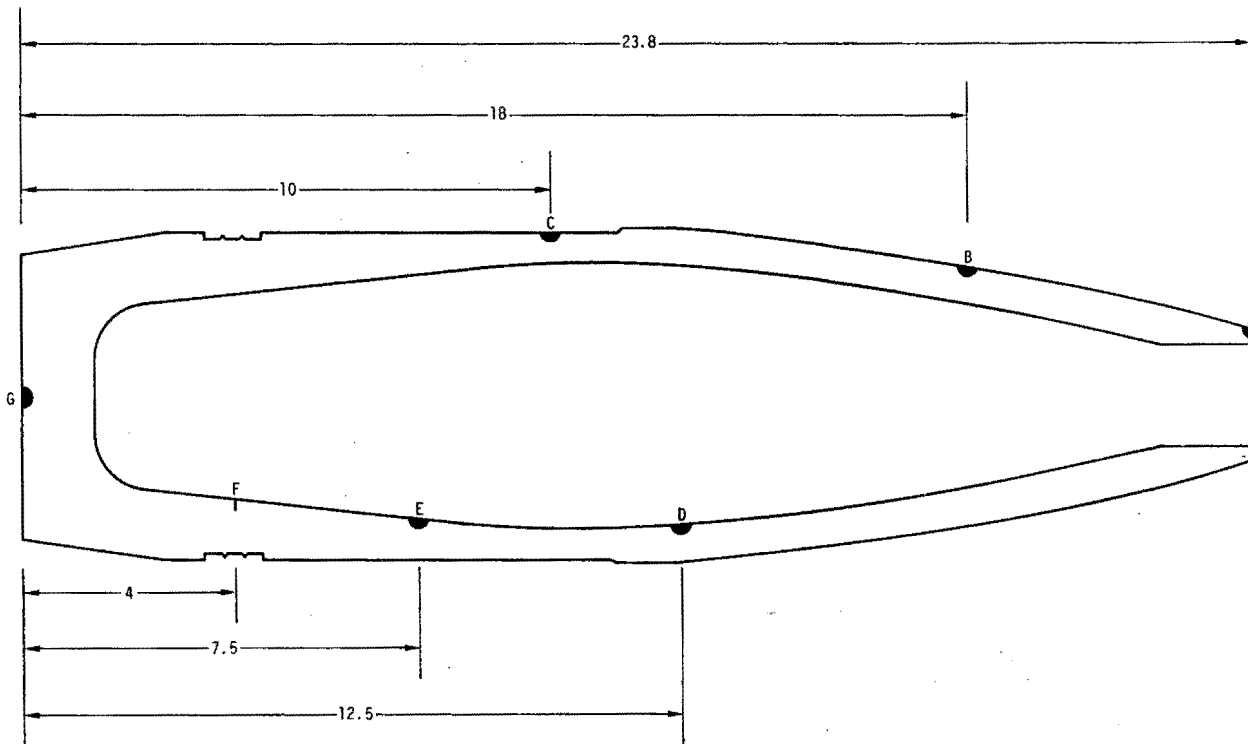
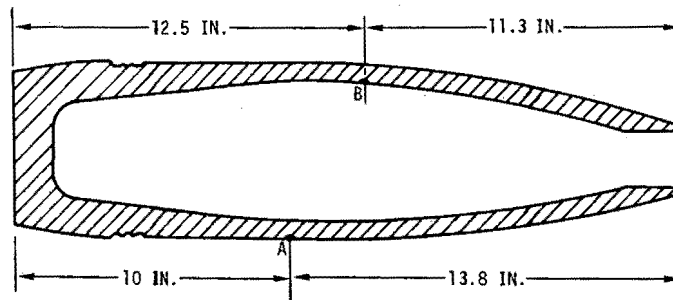


Figure 1. Cross sectional view of a 155 mm artillery projectile with EDM slots machined in exterior and interior surfaces.

LOCATION OF SLOTS IN 155, M107 PROJECTILE

(EDM SLOTS 0.020 INCH DEEP, 0.200 INCH LONG)



EXPERIMENTAL SETUP

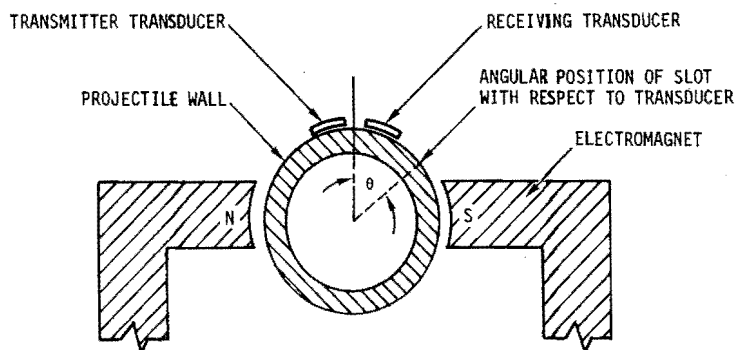
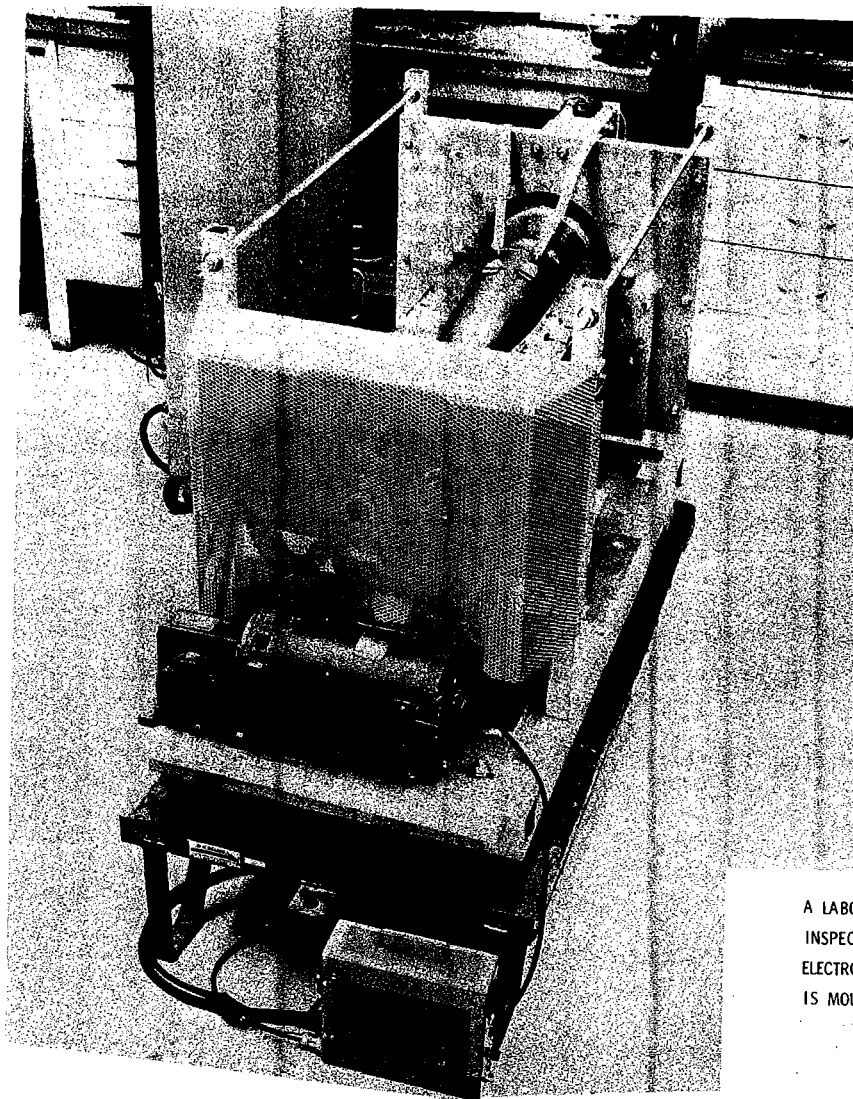


Figure 2. Circumferential cross section of a M107 projectile (155 mm) showing one possible location of transmitting and receiving transducers.



A LABORATORY TEST-BED FOR ARTILLERY PROJECTILE INSPECTION, INCLUDING TWO MEANDER COIL ELECTROMAGNETIC TRANSDUCERS. THE PROJECTILE IS MOUNTED IN THE GAP OF AN ELECTROMAGNET

Figure 3. Laboratory test bed.

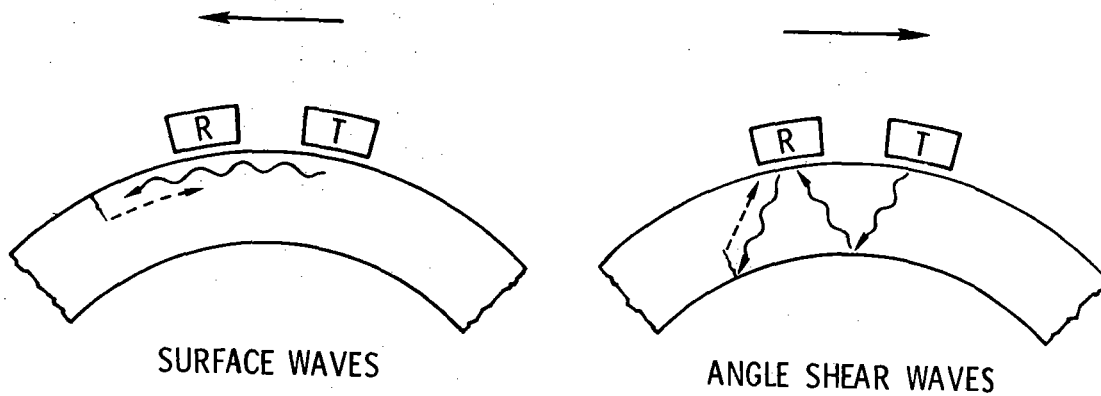


Figure 4. Inspection of projectile wall.

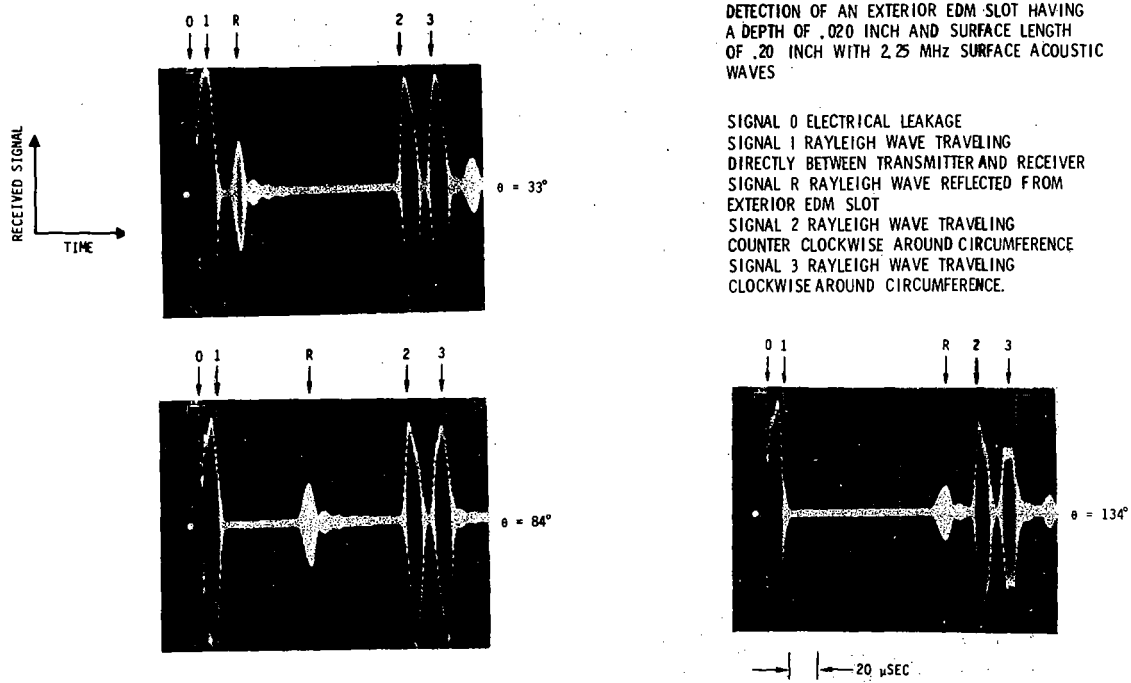


Figure 5. Detection of an exterior EDM slot with 2.25 MHz surface acoustic waves.

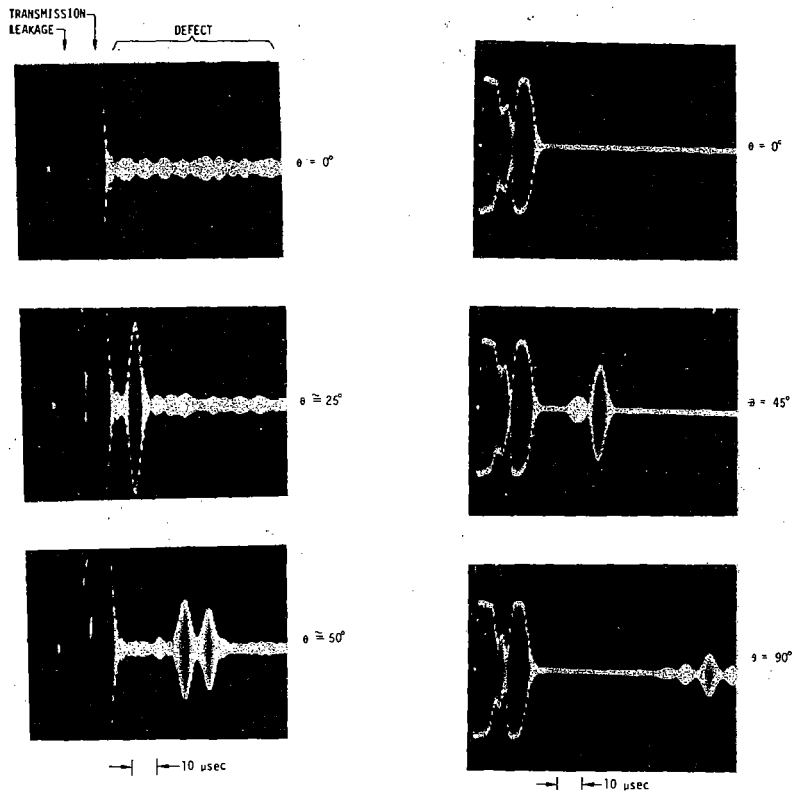
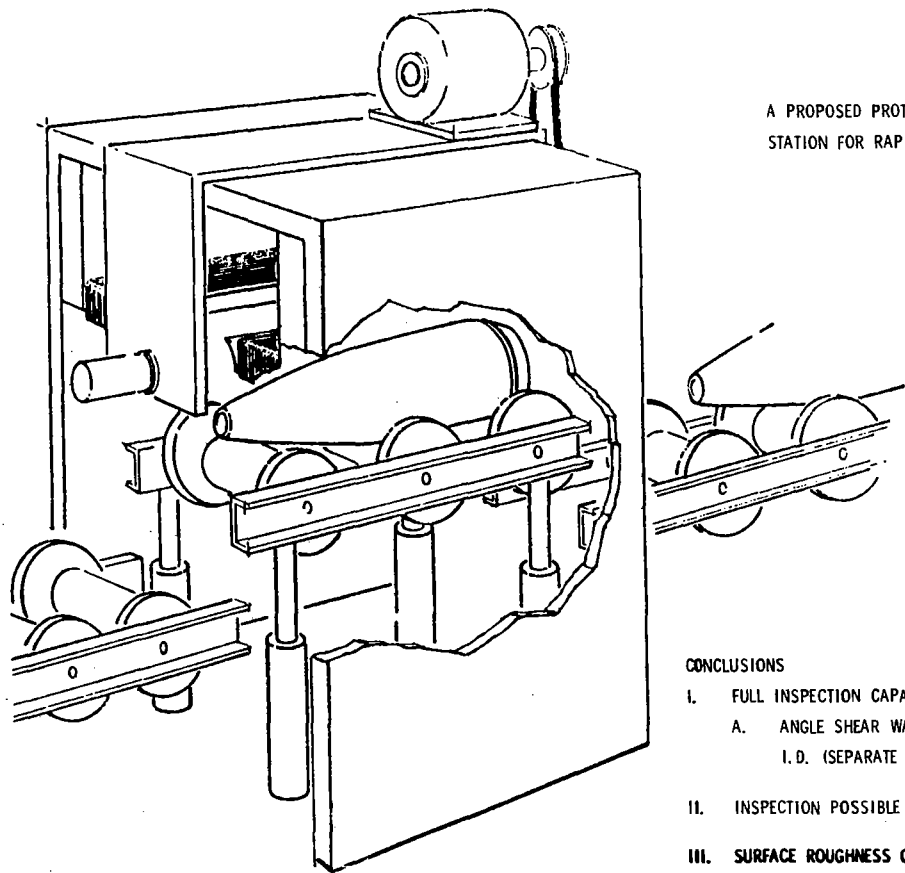


Figure 6. Detection of exterior and interior defects with 1.8 MHz angle shear waves.



A PROPOSED PROTOTYPE OF A FULLY AUTOMATED INSPECTION
STATION FOR RAPID INSPECTION ON A PRODUCTION LINE

CONCLUSIONS

- I. FULL INSPECTION CAPABILITY CAN BE ACHIEVED USING
 - A. ANGLE SHEAR WAVES FOR INSPECTION OF O.D.,
I.D. (SEPARATE PROBES)
- II. INSPECTION POSSIBLE AT PRODUCTION LINE RATES, NO COUPLANT
- III. SURFACE ROUGHNESS OR PAINT CAN BE TOLERATED

Figure 7. Artist's concept of an on-line inspection system.