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CHAMBER PROFILE MEASUREMENT SYSTEM

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OCTOBER 1980



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

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MATERIALS TESTING TECHNOLOGY PROGRAM (AMS 4931)

Report No. WVT-QA-8002

Title: Chamber Profile  
Measurement 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  
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PROTOTYPE EQUIPMENT (IN MECHANICAL,  
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| 19. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>The chamber of a gun tube consists of a series of intersecting conical and cylindrical surfaces, which require stringent locational and diametrical tolerances. A gaging system was required to accurately and precisely record the actual profile of the chamber without interpretation and recording by an operator.<br>The system developed under this project utilizes electronic and optical measuring techniques in a mechanical assembly to drive a digital display and printer for recording total part configurations. |                                     |                                                                                                    |

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# ABSTRACT

The chamber of a gun tube consists of a series of intersecting conical and cylindrical surfaces, which require stringent locational and diametrical tolerances. A gaging system was required to accurately and precisely record the actual profile of the chamber without interpretation and recording by an operator.

The system developed under this project utilizes electronic and optical measuring techniques in a mechanical assembly to drive a digital display and printer for recording total part configurations.

#### ACKNOWLEDGEMENT

The authors gratefully acknowledge Mr. A. Gallo from Quality Engineering Division for his advice and direction in this project and the technical assistance contributed by Mr. Dave Sofranko and Mr. Tom Breen from Metrology Laboratory Division, Product Assurance Directorate, Watervliet Arsenal.

## 1. INTRODUCTION

The 105MM M68 gun fires fixed ammunition utilizing either brass, steel or aluminum cartridge cases. The case is thin enough to be expanded by the pressure released from the burning propellants to form a tight fit against the tube chamber wall, thus preventing rearward escape of gas (obturation). Subsequent to firing the cases relax sufficiently to facilitate case extraction. Among the problems caused by out of tolerance conditions in the tube chamber are: lack of obturation, difficulties with chambering the ammunition and/or difficulties with case extraction.

In 1960 Watervliet Arsenal designed gages to inspect the then new 105MM M68 chamber. Four plug gages were designed which utilize a fixed diameter disk and verify chamber taper by measuring how far this disk can be fitted into the tapered zones. Also designed was an air tracer gage. This tracer utilizes air cartridges which tract along the chamber wall and measure distance from the chamber wall to a master template positioned in the chamber by the gage body. This tracer gage is able to effectively measure the entire chamber while the operator views the level of floats in two air column readouts. This gage which has been used for many years has several shortcomings. The gage must rely on the shop air supply which has proven to be unreliable with regard to moisture content and purity. Also, determination of the distance that the tracer tips have traveled into the chamber (from the rear face of the tube) is a cumbersome procedure, which is not up to current standards of accuracy and repeatability.

Lastly the readout system provides only a visual float level as an indicator of component size and the only inspection records are notes the inspectors might make.

An updated system has been developed to take advantage of the state of the art electro-optical measuring systems. Air is not required for operation, air cartridges are replaced with electronic cartridges, downbore distance is measured by an optical scale and a printer records both chamber size and downbore distance to provide a complete inspection record.

## 2. SYSTEM REQUIREMENTS

The electronic tracer system for cannon chambers was required to be able to completely measure the chamber of a 105MM, M68 gun tube. The system was required to duplicate the inspection of the existing tracer air gage yet add capability to overcome the air gage's shortcomings. It was required that the basic gage fixture be similar in design to the proven air gage concept. Modifications were permitted as necessary to incorporate electronic (LVDT) cartridges in place of the air cartridges and to incorporate a high accuracy down-bore measurement system. A remote-controlled printer was required to print out both deviations from basic drawing dimensions and the downbore location of the deviations.

The following section describes the new chamber profile measuring system as developed under this project.

### 3. SYSTEM DESCRIPTION

The system consists of two units, an electronic control/data processing unit (console) (see figure 1), and the cannon chamber gage (gage assembly) (see figure 2).

The gage assembly contains a master tool steel template scaled 1:1 to the longitudinal cross section profile of the M68 chamber. Two radially opposed position sensors (LVDT's) measure the difference in a cross sectional diametrical plane between the master template and the chamber under inspection. A linear scale senses the down chamber location of the position sensors with respect to the rear face of the tube (RFT).

The linear scale consists of a glass incremental grating scale and a traveling reading head. The reading head transmits light from a miniature filament lamp through the optical grating scale to two pairs of photo detectors on the opposite side. As the head moves it generates two signals each of which is a close approximation of a sine wave. One signal train is displaced  $90^{\circ}$  in phase with respect to the other. This permits detection of direction of travel with the proper electronics.

Other features of the gage assembly are:

1. Micrometer controlled down chamber positioning of the master template to allow registration with the chamber under inspection.
2. An electromechanical drive system for positioning the LVDT carriage in the chamber with a pressure sensitive "stiff stick" for infinitely varying the rate of travel from zero to maximum. A manual vernier control is incorporated to permit fine position setting (see figure 3).

3. Magnetic holding for securing the gage assembly against the RFT eliminating the need for operator hand steadying of the gage assembly.

4. A built in mechanical gaging station containing two reference surfaces with a known diametrical separation. This serves as a built in set check. The console contains the necessary amplifiers, counters and BCD converter for driving the seven segment display and the printer. The console contains the following:

1. Continuous display of the output of each LVDT with .0001 inch resolution. Each readout has an adjustable electronic zero.

2. All displays are independantly switchable from customary (inch) units to metric (MM).

3. Continuous display of the downbore distance with .0001 inch resolution. This display may be reset to "0" at any location or to preset valve set by thumbwheel switches at the touch of a button.

4. A cable connected manual push button control commanding the printer to start. The front panel also has a switch to perform this function. Upon command the displayed LVDT valves and the downbore distance reading will be printed.

#### 4. TESTING RESULTS

Testing of the system to assure proper performance (and conformance to the specification) was accomplished in the setting check used for the air gage and in an actual 105MM M68 tube chamber. The setting check was used to verify centering of the measurement transducers with respect to the support points of the gage body (see figure 4). The master cam template was disassembled from the gage body and inspected by the Metrology Laboratory Division, PAD, Watervliet Arsenal, using standard measuring techniques. The electronic LVDT cartridges and the optical scale were inspected and also found to be acceptable. The gage was reassembled and put into a tube chamber for complete system check out (see figure 5). The carriage carrying the measurement transducers was moved through the chamber to various points as outlined in an inspection procedure specified by the Arsenal. Measurements were taken of chamber diameters, tapers and location of tapers, datum diameter locations, concentricity of tapered zones and intersection of conical frustums. This same chamber was also inspected utilizing the present air gage system and results were compatible. The gaging system was found to be functionally acceptable and all components met drawing requirements and accuracy specifications. Based on the above tests the system was accepted.

The major advantages realized from use of the new gaging system come from the capability of recording data and the elimination of problems associated with the air gaging cartridges and column readouts. The new system has increased capability over the air gaging system in that the accurate downbore measurement scale allows additional data that can be evaluated

at any selected point to determine the actual taper of any point as compared to the nominal taper expressed on the cam template.

## 5. CONCLUSIONS

The chamber profile system as received did advance the inspection capabilities with reference to the 105MM M68 chamber. The utilization of a master cam has increased the expense of the system because of the extremely close tolerances that must be maintained. Much effort was directed into elimination of the master cam template but no substitute systems were found that could accomplish the measurements with the required accuracy over the entire range of chamber diameters. All available systems investigated had insufficient range or accuracy or would not physically fit into the tube bore. Efforts will continue at every opportunity to find a system to make these required measurements in all our gun chambers. One possible solution under consideration utilizes a simpler stepped cam template that reduces the required measurement range of the electronic cartridges as they are moved from the breech face to the bore. This system would require an interfaced calculator system to compare template size and electronic cartridges reading at each point to ascertain actual chamber configuration. Upcoming required designs for inspection of the 120MM XM256 cannon chamber will hopefully be able to make use of a system with no master cam or at least a cam with a much simplified configuration. As part of the 120MM system a plotter may also be incorporated which can, with calculator control, plot actual chamber configuration versus nominal.

6. IMPLEMENTATION

This measurement system is being implemented on the 105MM M68 production line. Quality Control personnel will utilize the gage as per the written inspection procedures for final inspection of the M68 chamber and will include the printed inspection reports with the other tube inspection data.

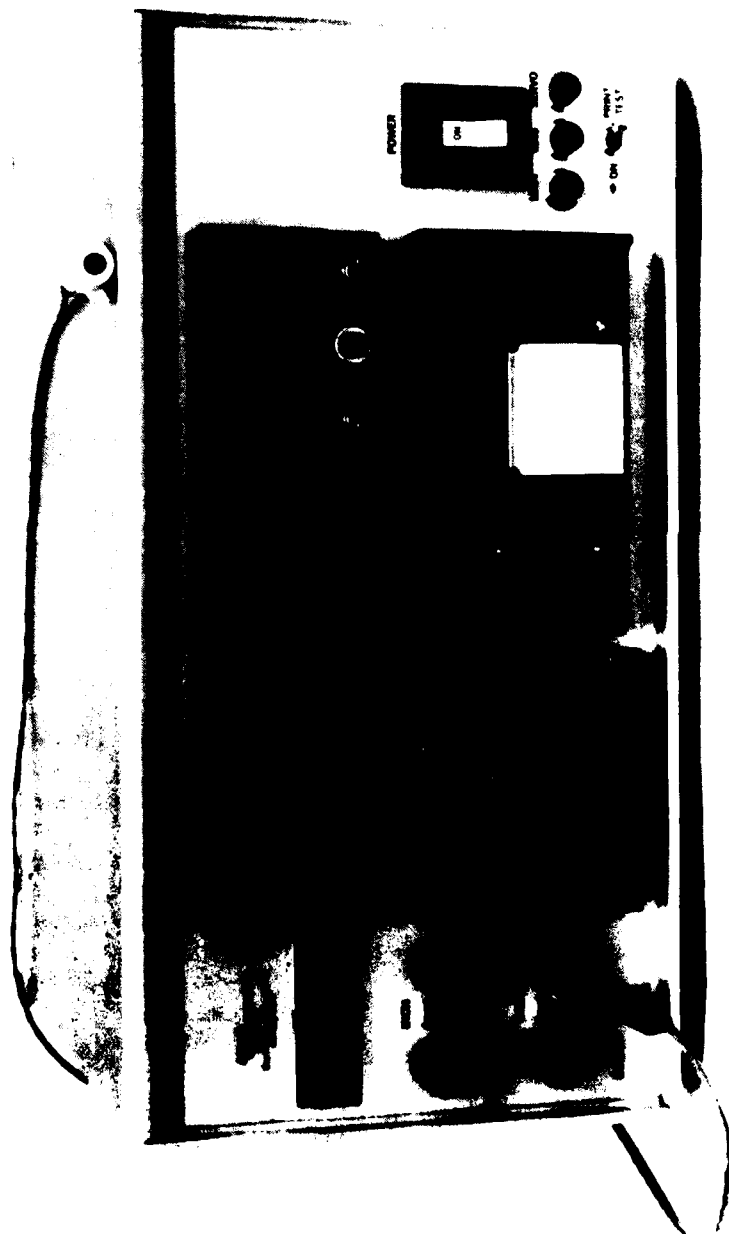


FIGURE 1. CONSOLE WITH READOUTS

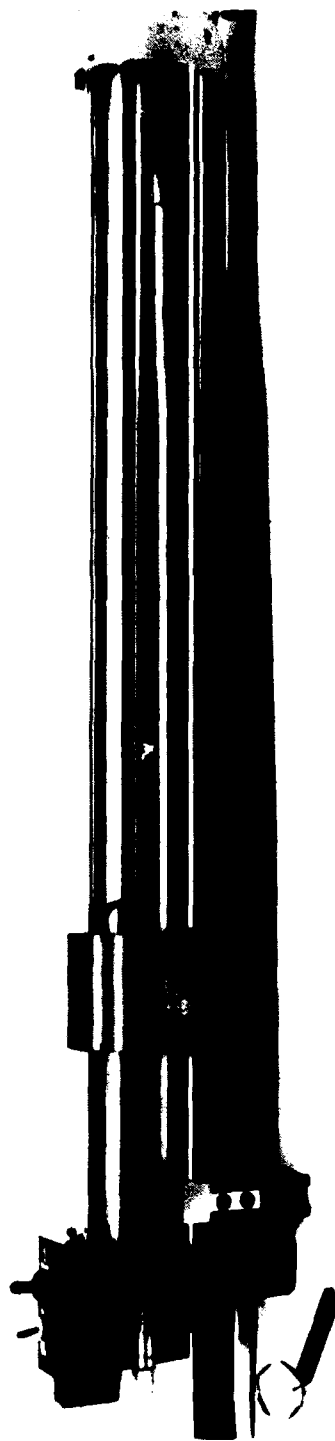


FIGURE 2. CHAMBER GAGE BODY

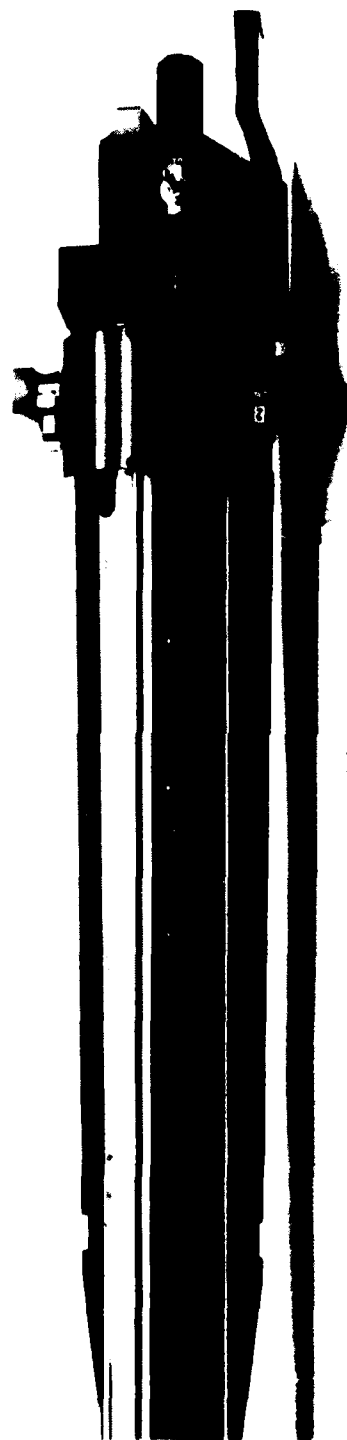


FIGURE 3. MASTER CAM, LVDI CARRIAGE  
AND SERVO CONTROL

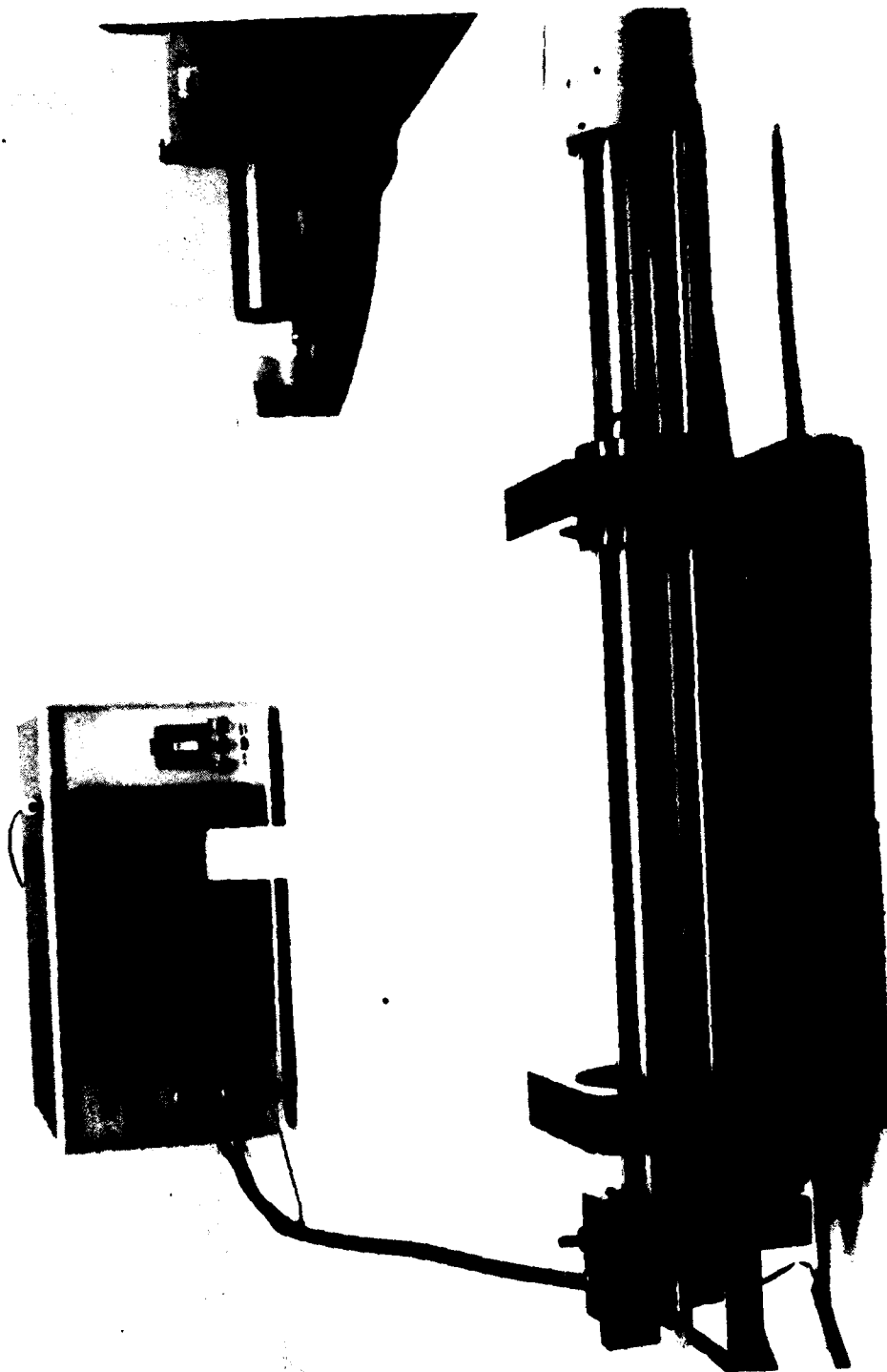


FIGURE 4. GAGE IN POSITION IN SET CHECK



FIGURE 5. GAGE IN POSITION IN  
TUBE CHAMBER

**DATA  
FILM**