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DEVELOPMENT OF A HIGH-PRESSURE MEDIUM VELOCITY HELIUM GUN FOR FIRING 17-GRAIN FRAGMENT SIMULATORS

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13. ABSTRACT

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Technical Report by

JOSEPH M. ROGERS

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FOREWORD

The Army is continuously involved in evaluating the ballistic resistance of new, lightweight materials as they become commercially available. An inherent disadvantage of these tests conducted with gun-powder as a propellant is the lack of reproducibility in missile velocity, especially at low velocities. Guns using pressurized helium as the propellant have been known and used for some time, but have been limited to velocities below 1000 fps for 17-grain fragment simulators. Pressurized helium, however, offers the possibility of providing smaller dispersion (greater reproducibility) in missile velocity while still retaining the convenience and safety of a pneumatically operated device. Current material development and testing programs require that ballistic testing be performed at increasingly higher velocities while maintaining minimum velocity dispersion.

The work described in this report was undertaken to develop a helium gun which would deliver the desired velocities and reproduce them consistently.

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I. INTRODUCTION

There is a continuing need to improve the methods of studying ballistic impact and penetration phenomena of polymers, plastics, and textile fabrics. Included is the need to develop a helium gun firing a cal. .22 fragment simulator at velocities ranging from 100 fps to at least 1700 fps with small dispersion in velocity. Small dispersion in velocity is very important for evaluating experimental materials available in limited quantities (e.g., 6"x6" samples) because the ballistic performance must be determined from only a few shots which are closely controlled in velocity.

Up to the present time, the helium guns used in the ballistic range at the U.S. Army Natick Laboratories (NLABS), and now at the Army Materials and Mechanics Research Center (AMMRC), have provided a maximum velocity of 950 fps. The first helium gun at NLABS consisted of a pressure chamber,* a smooth-bore barrel 28 inches long, and a 1500 psi Airmatic solenoid valve with a 5/32-inch orifice. The barrel was bored out to 0.2175 inch by the manufacturer. The gun was fired at pressures ranging from 50 psi to 1500 psi from a fixed mount position, providing a maximum velocity of 700 fps at 1500 psi. With this gun the missile was loaded from the muzzle end.

The second helium gun at NLABS, designed and built by Robert E. Carpenter, Edgewood Arsenal, consisted of a pressure chamber, a smooth-bore barrel 36 inches long, and a Sporlan solenoid valve (operating at 115 volts, 60 cycles) Type 73P (maximum pressure 800 psi). The barrel was bored out to 0.219 inch by the manufacturer. The gun was operated at pressures varying from 50 psi to 800 psi from a fixed mount position, producing a maximum velocity of 1000 fps.

II. DEVELOPMENT OF IMPROVED HELIUM GUN AT AMMRC

A. Selection and Modification of Components

To increase the ballistic impact velocities, three solenoid valves were tested for firing the helium gun. Two of these valves were rejected because of the long rise time involved; this caused expulsion of the missile from the barrel before full release of the pressure had occurred, and hence the missile velocity realized was far less than that obtainable at that pressure. The valve which seemed to meet the requirements was the Asco (Red Hat) valve. This is an angle valve, 1/2-inch pipe size (tapered) with a 3/8-inch orifice; the valve has a maximum pressure of 1500 psi and has a rise time of 8 milliseconds with a 120-volt, 10.7-watt, class B coil. However, this valve at first did not function as expected; it leaked at pressure between 0 and 20 psi, pushing the fragment simulator part way down the barrel before firing, thus giving a wide dispersion in missile velocities. This problem was overcome by fabricating new needle valves at AMMRC (to the same size and specifications given by the manufacturer) and by installation of a more powerful coil (120 volts, 60 cycles, 16.7 watts a.c.) to replace the one supplied with the valve. This coil produced a shorter rise time of 3.5 milliseconds.

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*STEWART, GEORGE M. *A Helium Gun for Propelling Various Shaped and Weighted Missiles (U).* Edgewood Arsenal, Maryland, CWLR 2076, 16 November 1956.

B. Construction

1. The present helium gun system was designed, developed, and built by the author at AMMRC. The gun itself consists of the Asco (Red Hat) solenoid angle valve, a 31-cubic inch helium gas reservoir, and a smooth-bore rifle barrel 0.218 inch inside diameter, 1.250 inches outside diameter, 48 inches long (Figure 1). The gun barrel was modified at AMMRC so that loading could be accomplished by inserting the fragment simulator into the barrel forward of the solenoid valve. Figure 2 is a photograph of the breech opening with the breech plug set on top of the barrel and the locking clamp open. Figure 3 shows a closeup view of the gun barrel showing the opening, the breech plug, the fragment simulator in the barrel, and the locking clamp in the open position.

2. The helium gun is mounted on a 500-pound-capacity hydraulic table for ease of raising and lowering the system. There are two drilled and tapped holes (3/8 inch NPT) in the gas reservoir to which are connected two flexible high pressure hoses (3000 psi rating). One of these hoses is connected to a Hoke (3000 psi rating) regulator valve on the helium cylinder, the other connects to a 3000 psi pressure gauge. The gun is fired by opening the solenoid valve by means of a micro switch (see parts list below) connected to the solenoid coil.

3. A list of components is as follows:

Pressure Regulator
Hoke Phoenix. Maximum pressure 3000 psi
Manufactured by Hoke, Inc., Creskill, New Jersey

Solenoid Valve
Asco (Red Hat) valve (normally closed). Maximum pressure 1500 psi
Manufactured by Automatic Switch Co., Florham Park, New Jersey

Pressure Gauge
Heise solid-front C-56281. Maximum pressure 3000 psi
Manufactured by Heise, Newtown, Connecticut

High-Pressure Hose
Flexible, high-pressure hose. Maximum pressure 3000 psi, 0.750-inch O.D. E8. Weatherhead 0.250-inch, I.D. H.25
Sold by Black and Webster Sales, Inc., Waltham, Mass. 02154

Gas reservoir
A high-pressure steel cylinder 12.750 inches long, 3 inches O.D., 2 inches I.D., 2-inch removable end, 0.750-inch-thick solid end
Fabricated at AMMRC

Firing Switch
Micro Switch, Freeport, Illinois
Catalog Listing 1Ah2 10A, 125 V, 3/4 hp, 115 V ac

Gun Tubes
Cal. .22 (0.2175 inch) smooth-bore barrel 36 inches long
Cal. .22 (0.2175 inch) smooth-bore barrel 48 inches long