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TECHNICAL REPORT AFATL-TR-74-26

BALLISTIC/AERODYNAMICS RESEARCH SYSTEM

(BARS)

FACILITY

Paul C. Mayer, 1Lt, USAF
BALLISTICS BRANCH
GUNS AND ROCKETS DIVISION

JANUARY 1974

FINAL REPORT: May 1967 to December 1973

Distribution limited to U. S. Government agencies only; this report documents test and evaluation; distribution limitation applied January 1974 . Other requests for this document must be referred to the Air Force Armament Laboratory (DLDL), Eglin Air Force Base, Florida 32542.

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Vertical Air Jet
Pylon/Rack Ejection Test Stand

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

This report describes the equipment, test capabilities and support facilities of the Ballistic/Aerodynamics Research System (BARS) Facility. The Facility consists of a 28 by 40 inch subsonic wind tunnel, a series of six compressed air guns used to launch aerodynamic models for investigation, a 6.7 inch smooth bore powder gun for launching high velocity/high weight test items, a 30mm smooth bore powder gun, an instrumented 250 ft yaw card range, a vertical air jet, and a pylon/rack ejection test stand. Electronic instrumentation is available for signal conditioning, monitoring, and recording purposes. An automatic digital data acquisition (see reverse)

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) system processes data from the wind tunnel and can also be utilized on any of the other test systems. A small machine shop and electronics workshop are available for model and instrumentation fabrication and equipment repair and modification.

PREFACE

This report describes the equipment and test capabilities of the Ballistic/Aerodynamics Research System (BARS) Facility. The BARS Facility is located at Test Area A-22 and is a part of the Ballistics Branch, Guns and Rockets Division, Air Force Armament Laboratory, Eglin Air Force Base, Florida.

This technical report has been reviewed and is approved.

DALE M. DAVIS
Director, Guns and Rockets Division

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SECTION I

INTRODUCTION

The Ballistic/Aerodynamics Research System (BARS) Facility is one of the test facilities within the Ballistics Branch (DLDL), Guns and Rockets Division, Air Force Armament Laboratory (AFATL), Eglin Air Force Base, Florida. The Facility (Figure 1) occupies Building 419 at Test Area A22. The function of the BARS Facility is to provide quick response test support for AFATL and other Air Force System Command agencies and to originate state-of-the-art technology in the areas of subsonic aerodynamics, munition ballistics, and impact and flight phenomena. The BARS Facility also maintains a continuing program of ballistic and aerodynamic equipment development.

The BARS Facility was established as the response to a proposal that AFATL develop the in-house capability to obtain accurate free-flight data. In May 1967, the basic facility plan was established, and Test Area A22 was chosen for the site of the free-flight test facility. Originally, only compressed air guns were used to launch test items. However, with the addition of the subsonic wind tunnel in 1968 and, subsequently, the digital data acquisition system, the test capabilities were increased to cover a wide range of aerodynamic investigations of conventional munitions.

The BARS Facility has five primary test systems:

(1) 28 x 40 inch subsonic wind tunnel.
(2) Air and powder guns.
(3) Instrumentated yaw card range.
(4) Vertical air jet.
(5) Pylon/rack ejection test stand.

This report contains a description of the air guns, powder guns, yaw card range, and additional test capabilities. In each case, an explanation of the procedures, equipment, and theories behind these types of ballistic testing are provided. Additional support capabilities are also described. The instrumentation available for data signal conditioning, monitoring, measurement, and recording is described as it applies to the air gun, powder gun, and yaw card systems. A small machine shop and electronics workshop are available for model and equipment fabrication. The wind tunnel and data acquisition system will be described in detail in a subsequent publication.

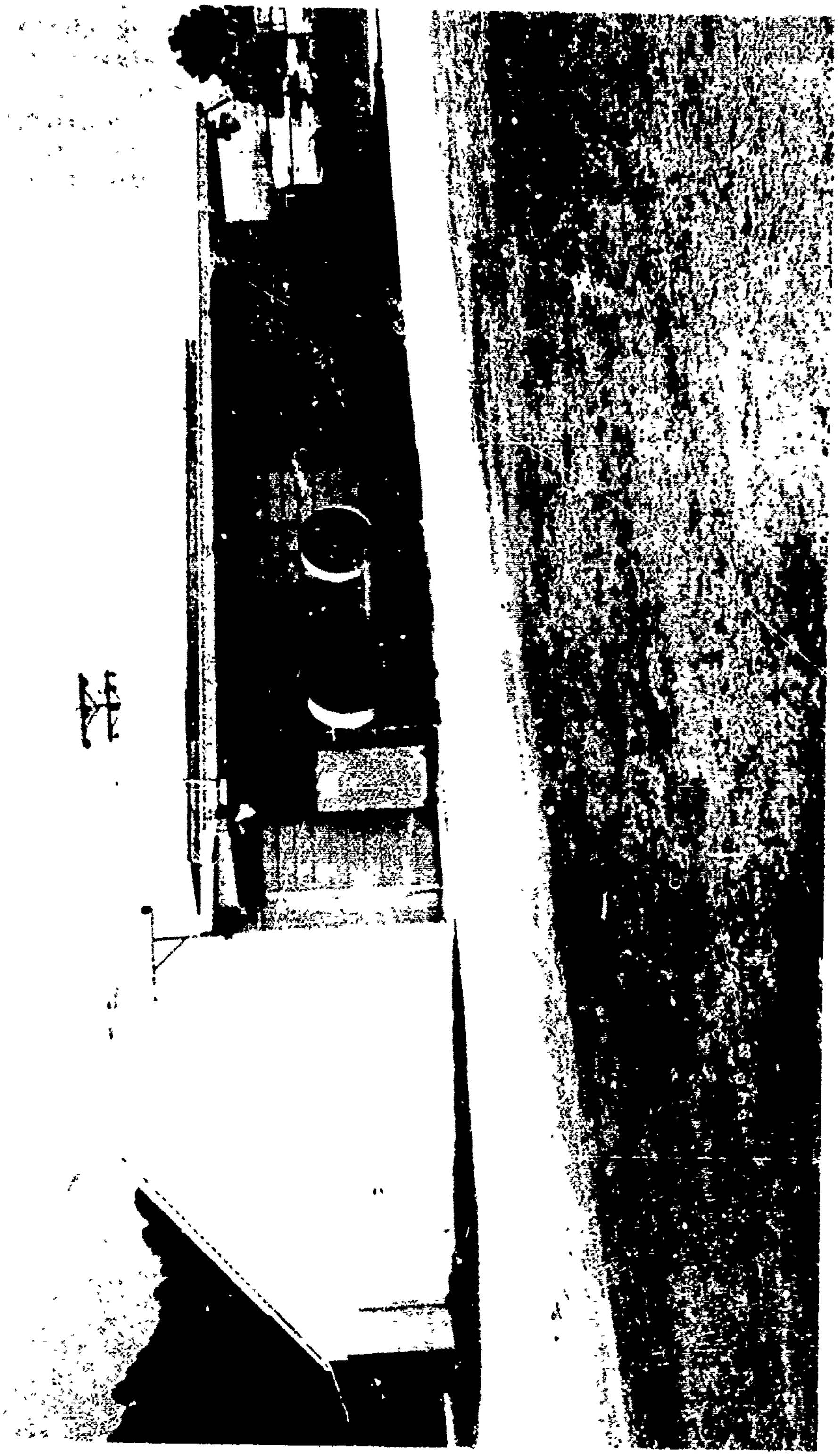


Figure 1. BARS Facility

SECTION II

COMPRESSED AIR GUNS

Compressed air guns consist of a pressure chamber, air dumping system, and item launching barrel. The air guns used at the BARS Facility utilize a sliding internal piston to dump the compressed air and launch the test item (Figure 2). This type of gun has been applied to ballistic testing because of the simplicity of operation, flexibility in the types of items that can be launched, safety surrounding the test area, and rapidity of the firing sequence.

1. TEST EQUIPMENT

A series of three groups of sliding internal piston valved air guns have been designed and are maintained at the BARS Facility to provide launch capabilities for weights up to 100 pounds and velocities up to 1500 ft/sec. Each group consists of one mobile and one stationary gun of the same size. The mobile guns are mounted on artillery gun carriages, which allow easy transportation to remote ranges. The stationary guns are permanently mounted on the gun pad located at Test Area A22.

Air guns are categorized by their chamber volumes and maximum chamber pressures, since these quantities are the most critical in determining the weight and velocity limitations. The smallest gun in the BARS inventory has a chamber volume of 0.693 cubic foot and a maximum chamber pressure of 500 pounds per square inch (psi). The mobile gun of this size is shown in Figure 3. The medium size gun has a chamber volume of 2.0 cubic feet and a maximum chamber pressure of 800 psi; the permanent gun of this size is shown in Figure 4. The largest gun in the inventory has a chamber volume of 3.2 cubic feet and a maximum chamber pressure of 2000 psi; the mobile gun of this class is shown in Figure 5.

The velocity of a projectile launched from these guns can be controlled by varying either the chamber volume, the operating pressure, or the barrel diameter and length. All of the guns have interchangeable barrels; a list of available sizes is given in Table 1. Besides velocity control, the barrels can be changed to accommodate different sized projectiles.

Each of the guns is equipped with a completely remote firing system which includes a solenoid operated dump valve that fires the gun in less than 0.001 sec. The remainder of the system includes a digital pressure read-out, a remote bleed valve in case of a misfire or test item malfunction, a pressure transducer to monitor the chamber pressure during charging and firing, and mechanical bypass valves in case of an electric power failure. This firing system is portable for the mobile guns and is hard-wired into a firing console for the guns on the pad. The facility gun console also includes camera control, range warning light and bell control, range gate control, weather monitoring equipment, and radio control with the Range Safety Tower.

TABLE 1. BARREL INVENTORY

NUMBER	DIMENSIONS	SHAPE	LENGTH	MATERIAL	REMARKS
00	4-1/2" x 4-1/2"	SQUARE	12 FT	STEEL	BREECH LOADED
1	6" DIA	ROUND	16 FT	ALUM	MUZZLE LOADED
2	6" DIA	ROUND	14 FT	ALUM	SABOT STRIPPER
3	9-3/4" DIA	ROUND	12 FT	ALUM	MUZZLE LOADED
4	5-1/2" DIA	ROUND	10 FT	STEEL	MUZZLE LOADED
5	5-1/2" DIA	ROUND	8 1/2 FT	STEEL	SABOT STRIPPER
6	10" DIA	ROUND	16 FT	STEEL	PORT IN END, MUZZLE LOADED
7	4" DIA	ROUND	8 FT	STEEL	MUZZLE LOADED
8	4" DIA	ROUND	5 1/2 FT	STEEL	SABOT ALIGNMENT, TAPERED
9	5-1/2" DIA	ROUND	6 FT	STEEL	SABOT ALIGNMENT, PRE-SPIN TAPERED
10	4-1/2" x 4-1/2"	SQUARE	6 FT	STEEL	BREECH LOADED
11	4" DIA	ROUND	8 FT	STEEL	MUZZLE LOADED
12	3-3/8" x 3-3/8"	SQUARE	6 FT	STEEL	BREECH LOADED
13	2-1/2" DIA	ROUND	5 FT	STEEL	MUZZLE LOADED
14	12.5" DIA	ROUND	18 FT	ALUM	SABOT STRIPPER

The guns are charged with compressed gas from either of two sources. For tests conducted at a site that includes electric power, a Joy air compressor is used (Figure 6). For remote sites where no electric power is available, a compressed air bottle cart is used (Figure 7). This cart includes a manifold system which allows continuous charging even while changing from one cylinder to another.

Shielding of the guns from the operator is necessary at all times. This is accomplished at the BARS Facility by launching all projectiles from the gun pad, which is shielded from the building by a 12 ft dirt revetment. Shielding at other locations is done by portable steel plates mounted on wheels.

2. TEST CAPABILITIES

The weight versus velocity capabilities for the air guns are summarized in Table 2. Some of the velocities at the upper limits are computer predicted and as yet no test item has been launched at these speeds. The diameter of any proposed projectile is limited only by the barrels available. For special test requirements, new barrels can be fabricated on 90 day notice The maximum projectile length that is practical to launch by this method is 4 feet.

Two types of air gun tests are most frequently conducted; impact test and trajectory study tests. The impact tests cover a wide range of both targets and purposes (References 1 and 2). Items can be launched into steel, concrete, wood, barrels, boxes, trucks and other motor vehicles, tires, and pattern paper. These tests can be conducted at varying impact angles to study ricochet effects or penetration distances. Structural integrity can be examined by varying the hardness of the targets monitoring eventual structural failure. Different materials can be examined against the same target in order to select the appropriate one from which to fabricate the final product.

Trajectory studies include flight characteristics, deployment of drag chutes and ballutes, flight times to special events, function of munition items, and dispersion patterns. Test items can be launched up to 85^{o} above the horizontal and 20^{o} below.

References:
1. Schlegel, M.O.: Impact Tests of BLU-26/B, BLU-61/B, BLU-62/B, BLU-63/B, and Modified BLU-63/B Fragmentation Bombs. AFATL-TR-73-228. Air Force Armament Laboratory, Eglin Air Force Base, Florida. November 1973 (Unclassified)

2. Mayer, P.C.: Structural Impact Test Comparing Misch Metal, Magnesium Alloy A231B, and Magnesium/Aluminum Cylindrical Cases at Low Velocities Using Air Gun Techniques, AFATL-TR-74-24, Air Force Armament Laboratory, Eglin Air Force Base, Florida. January 1974 (Unclassified)

TABLE 2. BARS AIR GUN CAPABILITIES

CHAMBER VOL (CU FT)	BARREL DIA (INCHES)	BARREL LENGTH (FEET)	LAUNCH VELOCITIES (FT/SEC) 5 (LB)	10 (LB)	25 (LB)	50 (LB)	100 (LB)
.693	3.0	6.0	425	300	---	---	---
2.0	5.5	10.0	1200	825	525	---	---
2.0	10.0	10.0	---	1250	775	550	---
3.2	6.0	16.0	2500	1775	1125	800	---
3.2	9.75	12.0	---	2250	1400	1000	700
3.2	12.6	16.0	---	---	1750	1250	900

Sabots are utilized to take up the excess space around the test item inside the barrel; an example is shown in Figure 8. Sabot design depends on the test item, the launch velocity, and desired initial conditions. The most common sabot material is a plastic foam that can be molded to fit both the test item and the barrel; this plastic is light and provides a good air seal in the barrel. Other materials that can be used include epoxy and walnut shell mixture, lexan, wood, and aluminum. The larger weighted items and higher velocities demand stronger sabots to prevent break-up inside the barrel. In most cases, solid pusher plugs are used to provide an even force distribution and a solid air seal. These are placed between the test item (including sabot) and the chamber, inside the barrel. Velocities are calculated based on the total weight of the test item, sabot, and pusher plug, since all are launched simultaneously.

A special barrel design allows items to be pre-spun before launch, if desired. This has been used in the past to test spin activated fuzes in some types of munitions. Items can be orientated prior to launch by utilizing adapter rods and grooving the sabot, and angles of attack can be imparted to the item by designing a special sabot. Several barrels are equipped with sabot strippers to prevent the sabot from traveling down range behind the test item.

One drawback to air gun testing, as compared to air drop testing, is the large accelerations the test item must withstand during launch. For example, a test item that is launched at 900 ft/sec from a 16 foot barrel will experience more than 700 g. For higher velocities, accelerations could reach as high as 1000 g. Some test items cannot survive this environment, and for them, the air gun is not a feasible testing system. Some of this effect can be minimized by utilizing longer barrels, decreasing velocities, or strengthening the model. However, in some cases, the mobility and launch angle capability suffer accordingly.

3. DATA COLLECTION

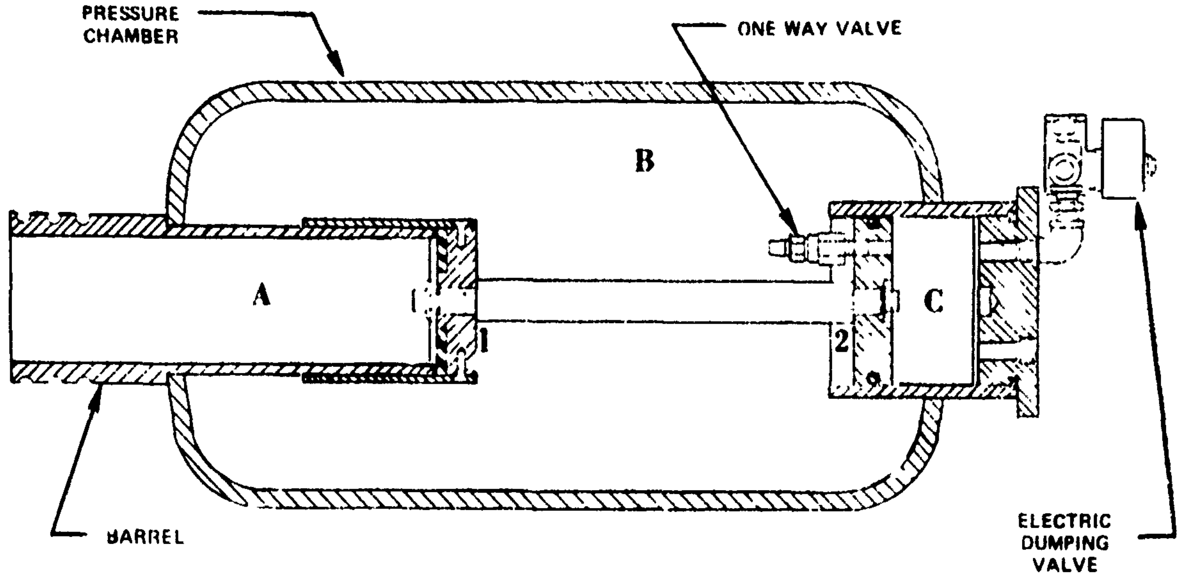
The data collected from air gun tests fall into two main categories: flight aerodynamics and visual examination. Flight data can include pitch angle (accuracy ± 1 degree), yaw angle (± 1 degree), roll rate (± 1 rps), drag force (from the velocity, ± 1 ft/sec), and all of the related rates of change. The primary data required to generate the aerodynamic data is a velocity history for some portion of the flight. The BARS has several systems which can collect these and other data.

The main data collection technique is high speed photography. By utilizing different camera positions, combined with varying shutter speeds and frame rates, accurate velocity and angle data can be collected over 300 feet of trajectory. Figure 9 shows two frames of a 16mm velocity data film. Note the clarity of the sabot and pusher plug in these frames. This film can also be used to examine events during flight, munition functioning, and flight stability. Along with high speed film coverage, the BARS personnel are designing and fabricating a Doppler radar system that will give instant velocity history on site. This will enable inputs to vary before each shot to obtain desired conditions in the shortest possible time. This system is scheduled for completion in 1974.

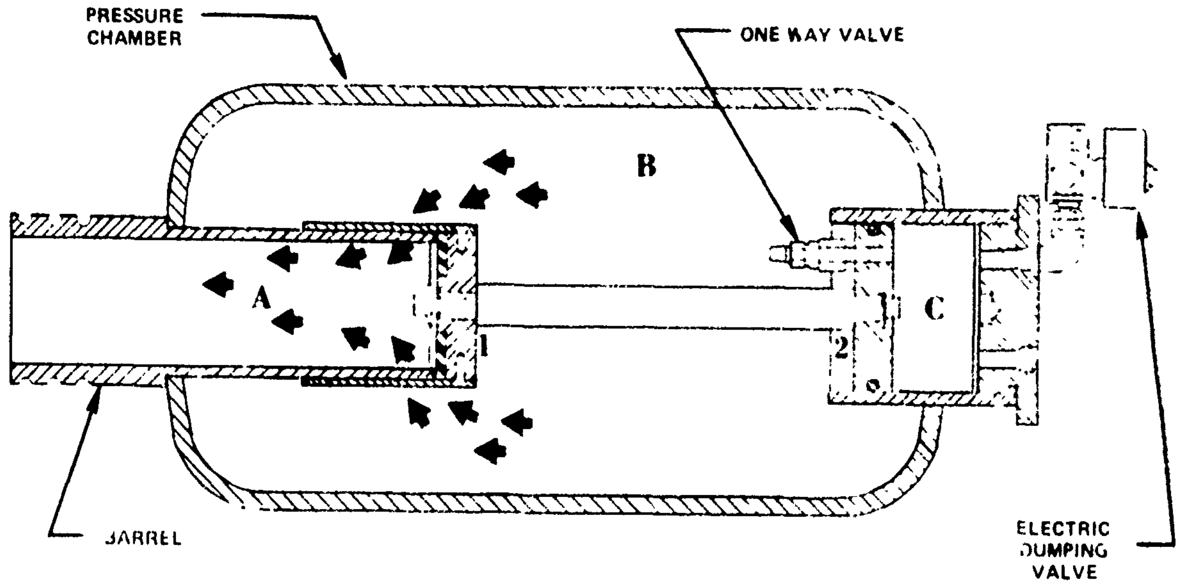
For some types of tests, knowledge of only the launch velocity is necessary. For this purpose, a laser velocity system is available to provide instant velocity readings just beyond the barrel opening. For some tests, the sabot must be stripped from the test item before leaving the barrel, and in these cases, velocities must be measured inside the barrel. For those cases when sabot stripping is necessary, the velocity is measured with either a break-wire system or a microswitch system. Both are operational and reliable.

For dispersion studies, Test Area B82 has a surveyed grid 1000 feet wide and 2500 feet long, where dispersion items can be launched singly or in clusters and be scored accurately to 1 inch (Reference 3). This range is equipped with a gun mounting area and can be scheduled for use by the BARS for project support when accurate scoring is necessary.

Reference:
3. Mayer, P.C.: Free Flight Tests of S-Curve Bomblets. AFATL-TR-73-67, Air Force Armament Laboratory, Eglin Air Force Base, Florida. March 1973 (Unclassified) (AD909473L)



(a) With the piston forward, the chamber is pumped to the desired operating pressure; volumes B and C are at this pressure while volume A is at atmospheric pressure; piston head 1 is small than 2



(b) By venting volume C to atmospheric, the piston slides backward due to the differential force on the piston heads; this allows the volume of air in the chamber to be vented down the barrel, thereby launching the test item.

Figure 2. Operation of BARS Compressed Air Guns

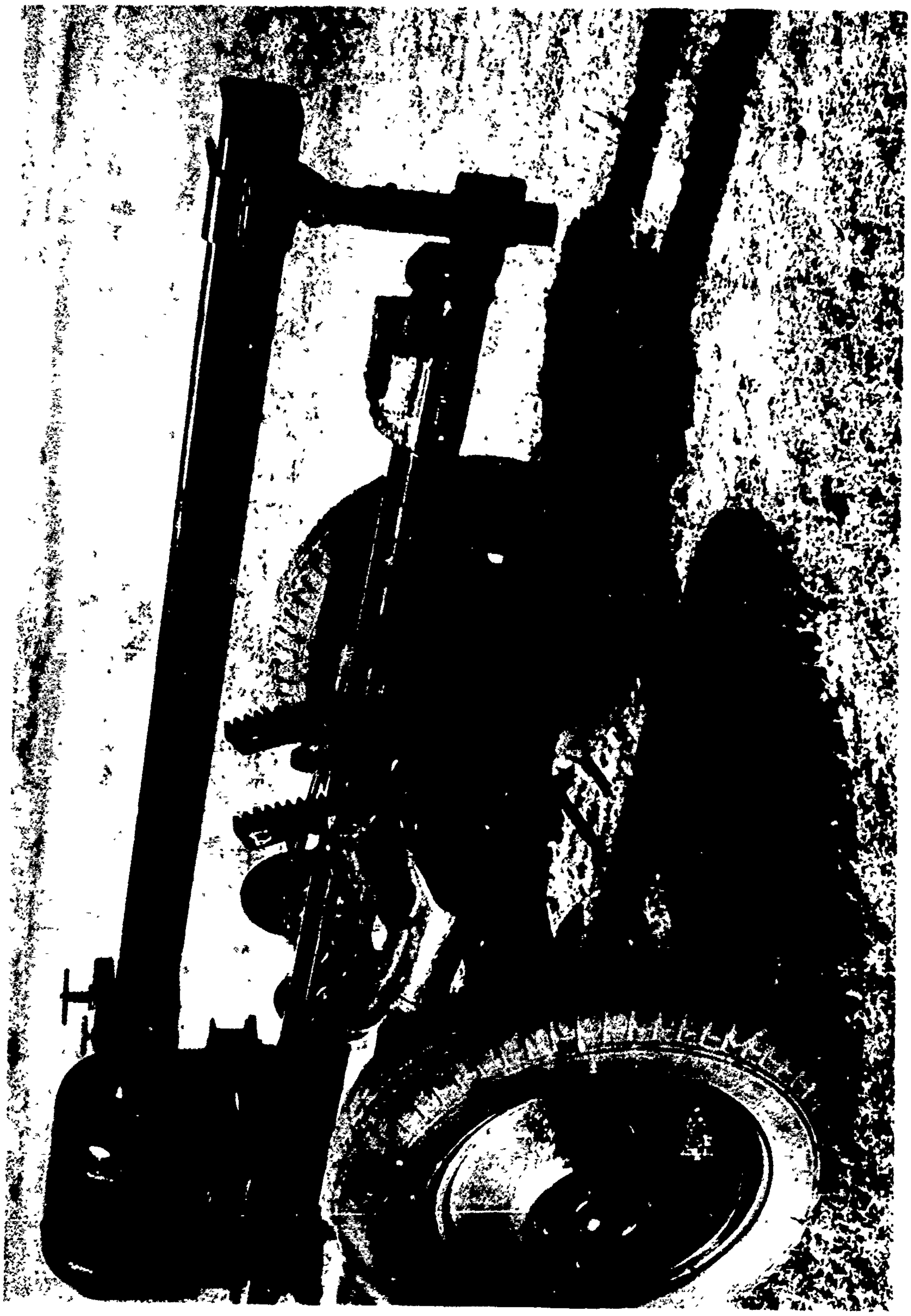


Figure 3. BARS 500 psi Air Gun

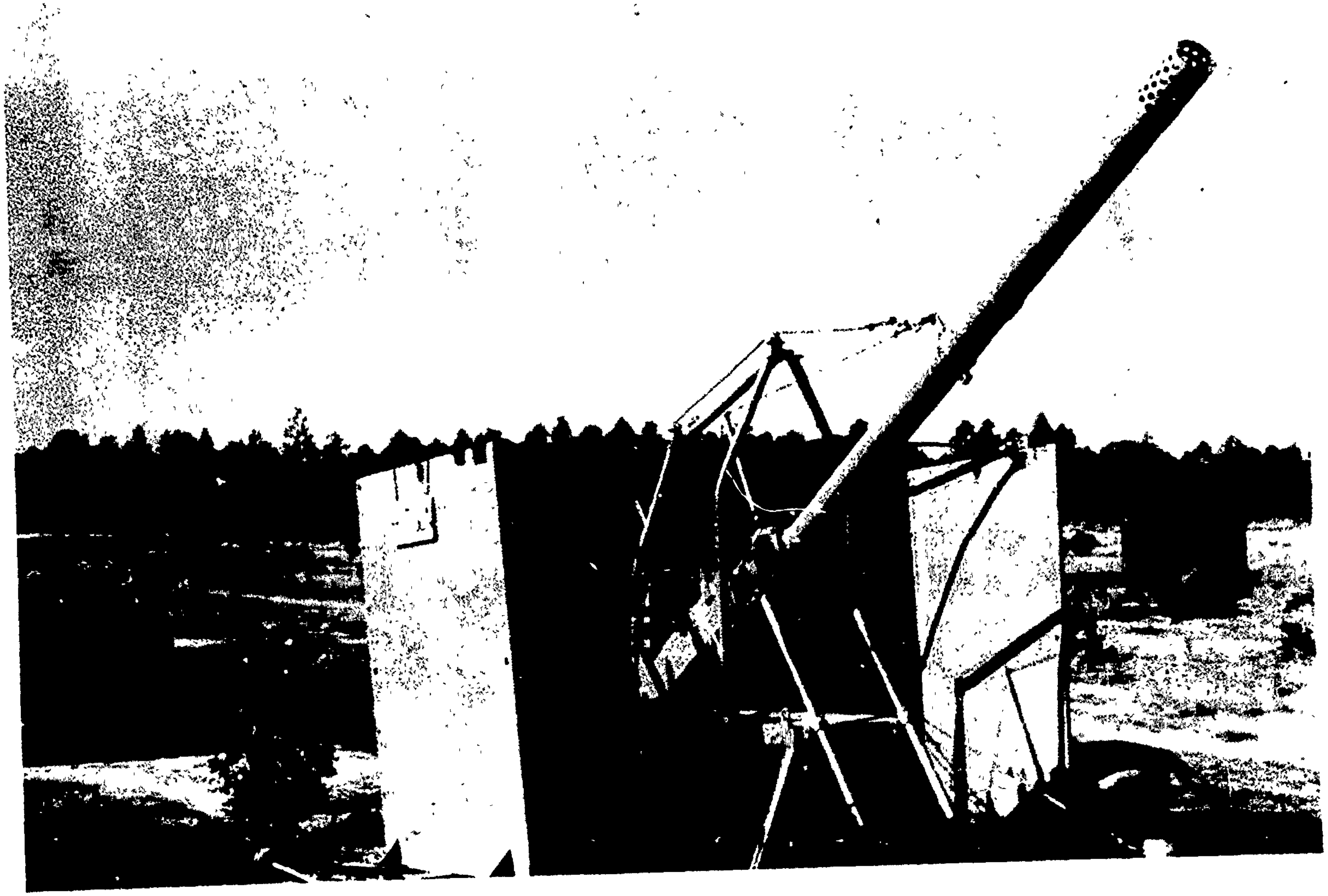


Figure 4. BARS 800 psi Air Gun

Figure 5. BARS 2000 psi Air Gun

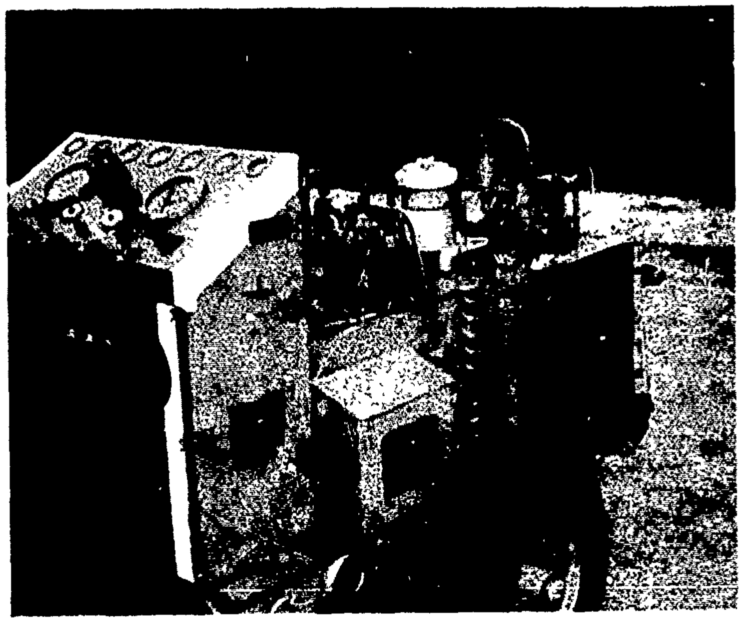


Figure 6. Joy Air Compressor

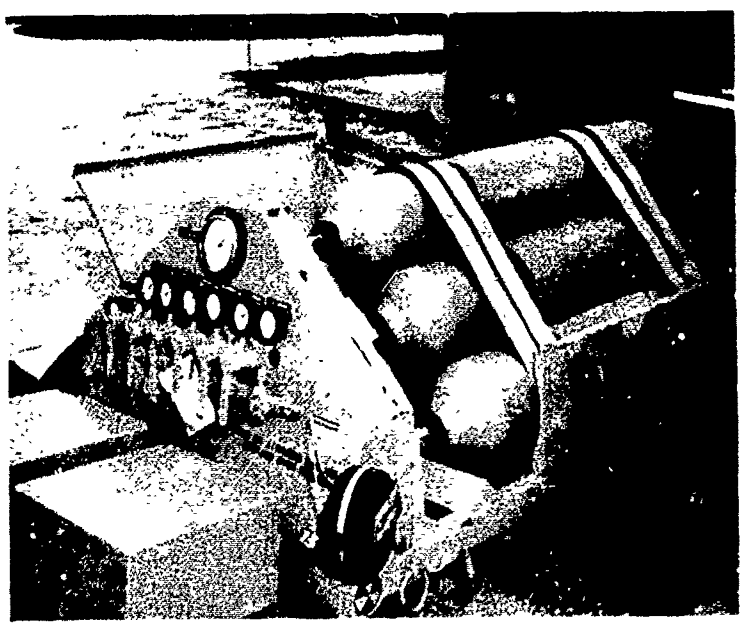


Figure 7. Air Bottle Cart

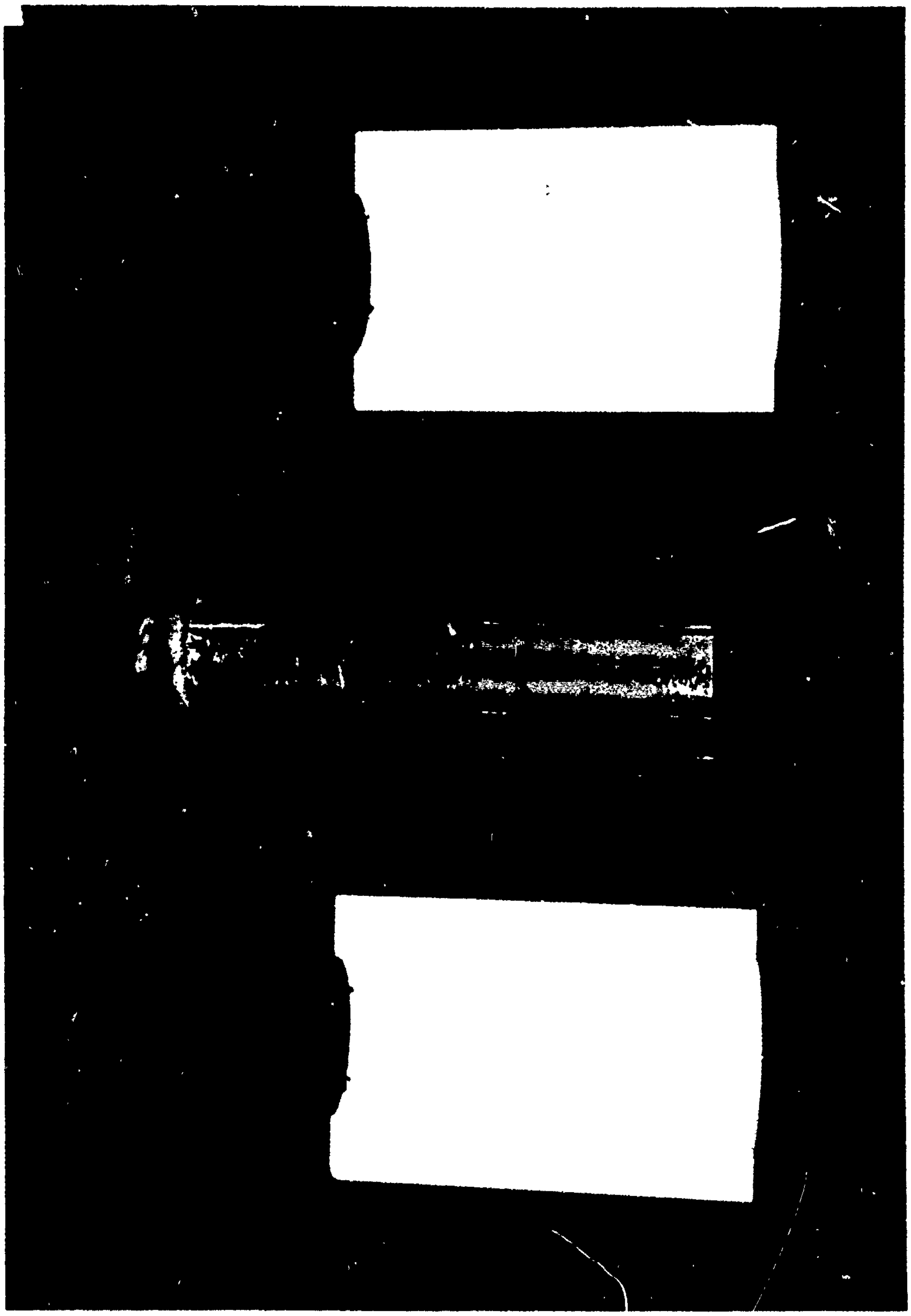


Figure 8. Sabot and Test Item

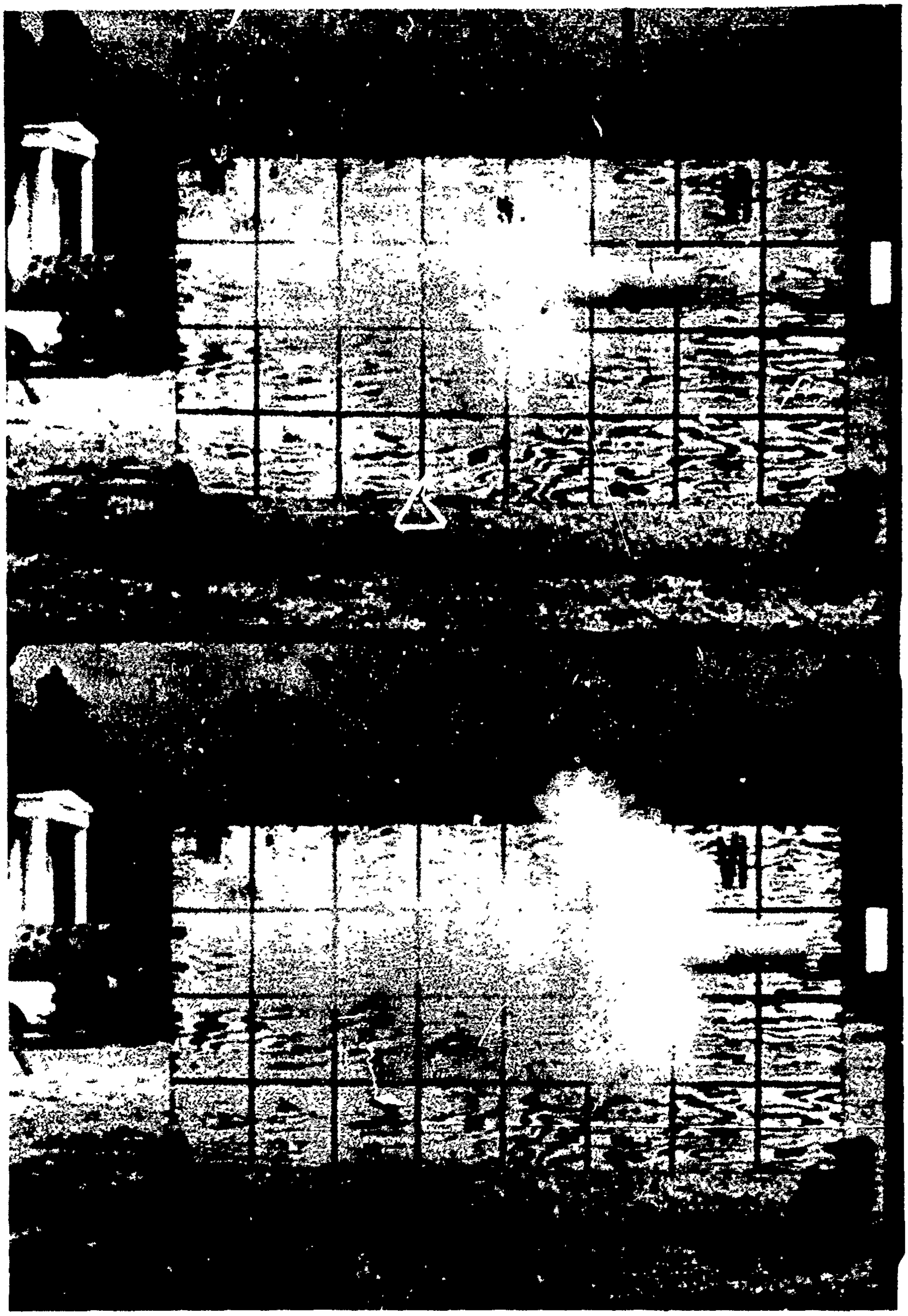


Figure 9. Two Consecutive Frames of Velocity Data Film

SECTION III

SMOOTH BORE POWDER GUNS

1. TEST EQUIPMENT AND CAPABILITIES

The BARS Facility has two operational smooth bore powder guns that are used to reach very high velocities and to launch heavy items. The largest of these guns is a two-stage, 6.7 inch bore, powder gun, while the smaller is a 30mm smooth bore gun. Other guns are available within AFATL.

The two-stage powder gun (Figure 10) was manufactured from a modified 155mm howitzer artillery gun and uses a smokeless gun propellant powder that is burned in a stainless steel chamber. This chamber (Figure 11) is capped with a hemispherical lid containing seven ports, which are sealed with a brass diaphragm designed to rupture at 10,000 psi internal pressure during the burning of the propellant. The propellant is ignited with a standard primer. The powder is pre-weighed and placed in the chamber and a new brass diaphragm is placed in the cap; the chamber is then loaded in the rear of the gun (Figure 12). The primer is loaded, and the gun is fired with a remote solenoid firing circuit. This gun can launch up to 150 pounds at velocities up to 1500 ft/sec. The velocity can be varied by changing powder weight, port size in the cap, and diaphragm thickness. The same restrictions concerning acceleration apply here as it did with the air guns.

The 30mm smooth bore gun (Figure 13) is used with, but not limited to, the BARS Facility Yaw Card Range. This gun uses a standard 30mm casing loaded with varying amounts of powder to control the velocity, which can range from 1000 ft/sec up to about 3500 ft/sec. Items launched with this system are small in weight and size. This gun can be used independently of the range.

Figure 10. Two-Stage Powder Gun

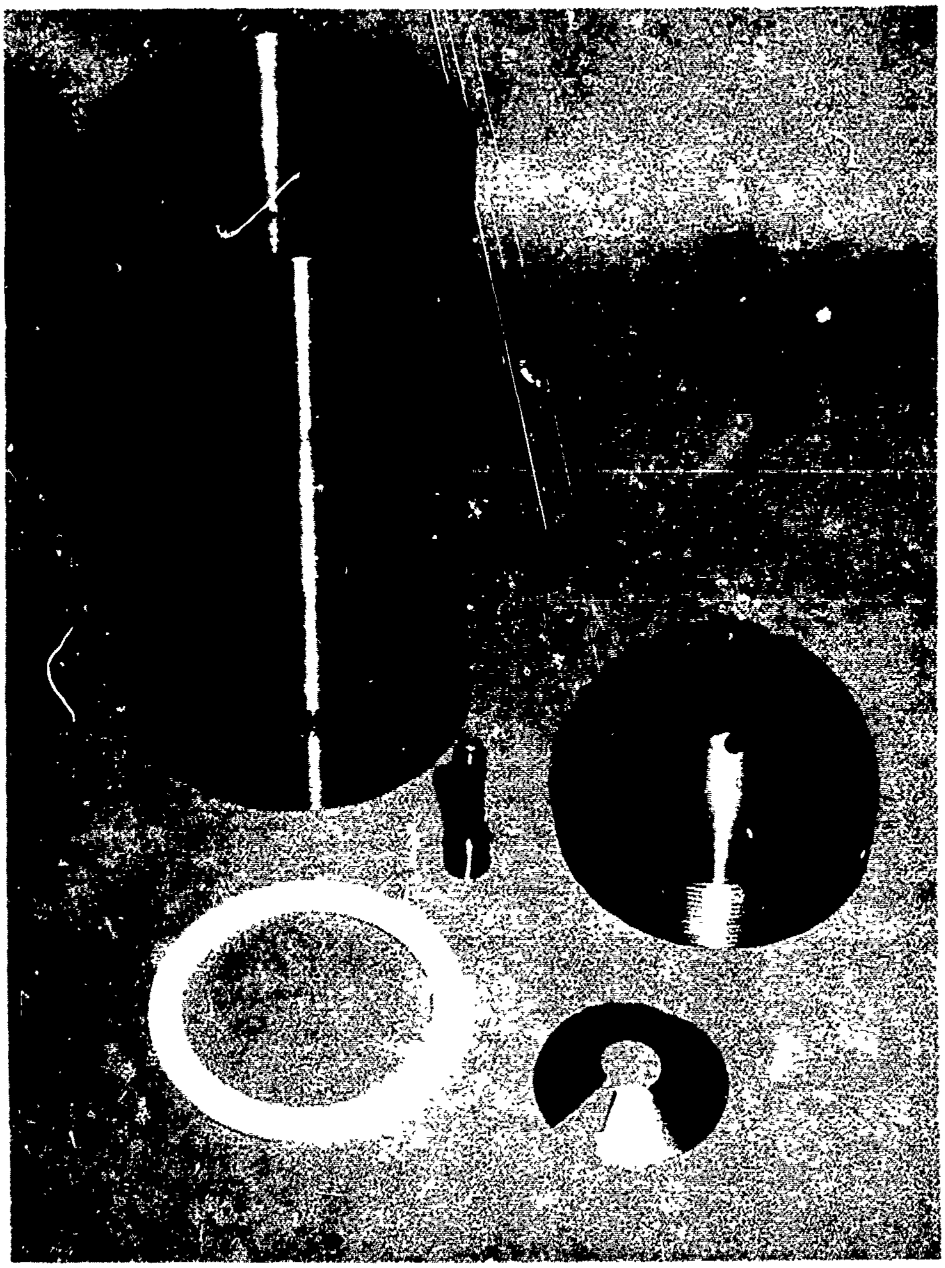


Figure 11. Two-Stage Powder Chamber with Primer, Diaphragm, Seal, and Cap

Figure 12. Powder Chamber Being Inserted into Powder Gun

Figure 13. 30mm Smooth Bore Powder Gun

SECTION IV

YAW CARD RANGE

Ballistic range testing originally began with a yaw card system. Later, it developed into a sophisticated science with large indoor ranges and complex optical data collecting systems. The yaw card procedure is still used for many preliminary aerodynamic investigations. It provides an inexpensive means by which limited test objectives can be accomplished in the flight dynamics field. Yaw cards are used to analyze preliminary model designs and to do preliminary flight tests prior to testing in more complex indoor ranges where an unstable or high dispersion model could damage expensive equipment.

1. TEST EQUIPMENT

The BARS Facility Yaw Card Range consists of a concrete gun pad for mounting the launcher, 250 feet of concrete stripping for yaw card frames and sabot deflector, and a dirt impact mound to capture the rounds. The gun pad has parallel mounting rails that allow mounting of the smooth bore guns or air guns for testing. The gun mount itself is shown in Figure 13 with the 30mm barrel in place. The mount has azimuth and elevation control, and the guns are equipped with complete remotely fired electronic systems.

The concrete strip has I-beam rails along the entire length to allow easy placement of the yaw card stands. There are presently 25 stands equipped with replaceable wooden frames to allow attachment of the yaw cards by stapling. These stands can be placed at any interval along the range. The range is equipped with a moveable sabot deflector which prevents the sabots from traveling down the instrumented portion of the range.

Wiring has been placed along the entire length of the range to allow placement of the screens used to collect velocity data for each shot. These screens can be changed to give greater intervals or more data points as desired. By utilizing all possible combinations, over 30 data points can be generated per shot.

Presently, the dirt impact target is 10 feet deep, 5 feet high, and 5 feet wide. It is lined with steel plate to prevent the projectile from passing through the dirt and down range. A dirt yaw card range is presently being designed and is scheduled for completion in 1974. This range will allow projectiles to be launched through dirt, penetrating the yaw cards, and generating data similar to those obtained in free flight. These data will be used for studies of munitions designed to penetrate submerged bunkers and dirt mounds.

2. TEST CAPABILITIES

The present hardware allows the launching of 20mm, 30mm, and 40mm sized test items. (An example of a type of test item previously launched is shown in Figure 14. Also shown is the aluminum sabot, the 30mm powder casing, and the associated plugs and rubber cushion.) This particular item was launched at velocities ranging from 1000 to 3000 ft/sec. Larger items can be launched by using an air gun instead of the powder gun. A wide variance of aerodynamic data, such as the following, can be collected from this type of testing:

(1) Yaw versus distance history

(2) Gyroscopic stability factor

(3) Spin rate versus distance history

(4) Pitching moment coefficient derivative

(5) Dynamic stability derivative (At least whether the round is dynamically stable or unstable)

(6) Magnus moment coefficient

(7) Drag coefficient

(8) Center of pressure location

In obtaining some of these data, initial perturbations are introduced to force the test item to generate the behavior necessary to obtain the desired information.

3. DATA COLLECTION AND REDUCTION

The purpose of using yaw cards is to generate a position, attitude, and time history of the projectile. This is done by analyzing the footprint, or hole, left by the item in successive cards. In sophisticated ballistic ranges, complex optical systems take pictures of the test item during flight. With yaw card ranges, the paper cards replace these optics.

In some cases, the item must be enclosed in a sabot to obtain good flight characteristics. This sabot must be deflected in order to prevent it from entering the instrumented portion of the range with the round. The first step in this procedure is to determine the location of the sabot deflector. As the test item travels down range, the sabot is aerodynamically separated from the item. The sabot is then deflected by placing a truncated cone at a position where the apex will allow the item to pass but will deflect the sabot. Initially, witness cards are mounted at intervals along the range and a prototype model is flown to determine sabot separation behavior; an example of the witness card after a shot is shown in Figure 15. Analysis of these data allow for optimum placement of the deflector. An additional reason for deflecting the sabot is to prevent it from bumping the test item and causing uncontrolled perturbations in the flight.

The velocity is measured using paper that has a printed circuit over its entire area. The projectile punches a hole in the circuit, providing the discontinuity that triggers an electronic counter. One screen is used to trigger and one to stop the counter, thereby providing a time interval over a pre-determined distance. By using combinations of stop/start sheets, over 30 velocity data points can be obtained per shot.

The yaw cards are made of single weight photography paper. By examining the holes in the cards after the shot, the projectile position and angular orientation can be determined; an illustration of this is shown in Figure 16. The length of the hole (ℓ_c) is a direct function of the total angle of attack of the projectile as it passes through the cards. For example, the total angle of attack (α_T) of the projectile shown in Figure 17 can be determined by the following two relations:

$$\alpha_T = \text{Sin}^{-1}\left(\frac{\ell_c - \frac{d}{2}}{\ell}\right) \text{ when } \alpha_T \text{ >nose angle}$$

$$\alpha_T = \text{Sin}^{-1}\left(\frac{\ell_c - d}{\ell - \ell_N}\right) \text{ when } \alpha_T \text{ <nose angle}$$

Each card is marked with the shot number and the card location. A vertical line is drawn on each card to use as reference in determining angular orientation (ϕ). The stands themselves are square to the trajectory. Once α_T is known, data reduction is accomplished by basic range techniques (Reference 4).

Data reduction is performed by several computer programs after the initial data are read from the yaw cards by a trained technician. An equation is fitted to the measured data which have determined unknowns that are a function of aerodynamic coefficients. The drag is determined from the change in velocity over the length of the range. All data reduction can be accomplished by computer, and the necessary programs are

Reference:
4. Murphy, C.H.: Free Flight Motion of Symmetric Missiles, Ballistics Research Laboratory, BRL-R-1216, July 1963 (Unclassified)

available through BARS, so that only aerodynamic and stability data in their final form are transferred to the Project Engineer.

High Speed photography is used to determine item and sabot behavior prior to sabot deflection. This coverage can also be placed down range to examine actual flight behavior.

A detailed description of the first test program run at this range can be found in Reference 5.

Reference:

5. Mayer, P.C., Wichenbach, G.L.: Free Flight Tests of a High Density Armor Piercing Flechette Utilizing Yaw Cards. AFATL-TR-74-73, Air Force Armament Laboratory, Eglin Air Force Base, Florida, April 1974 (Unclassified).

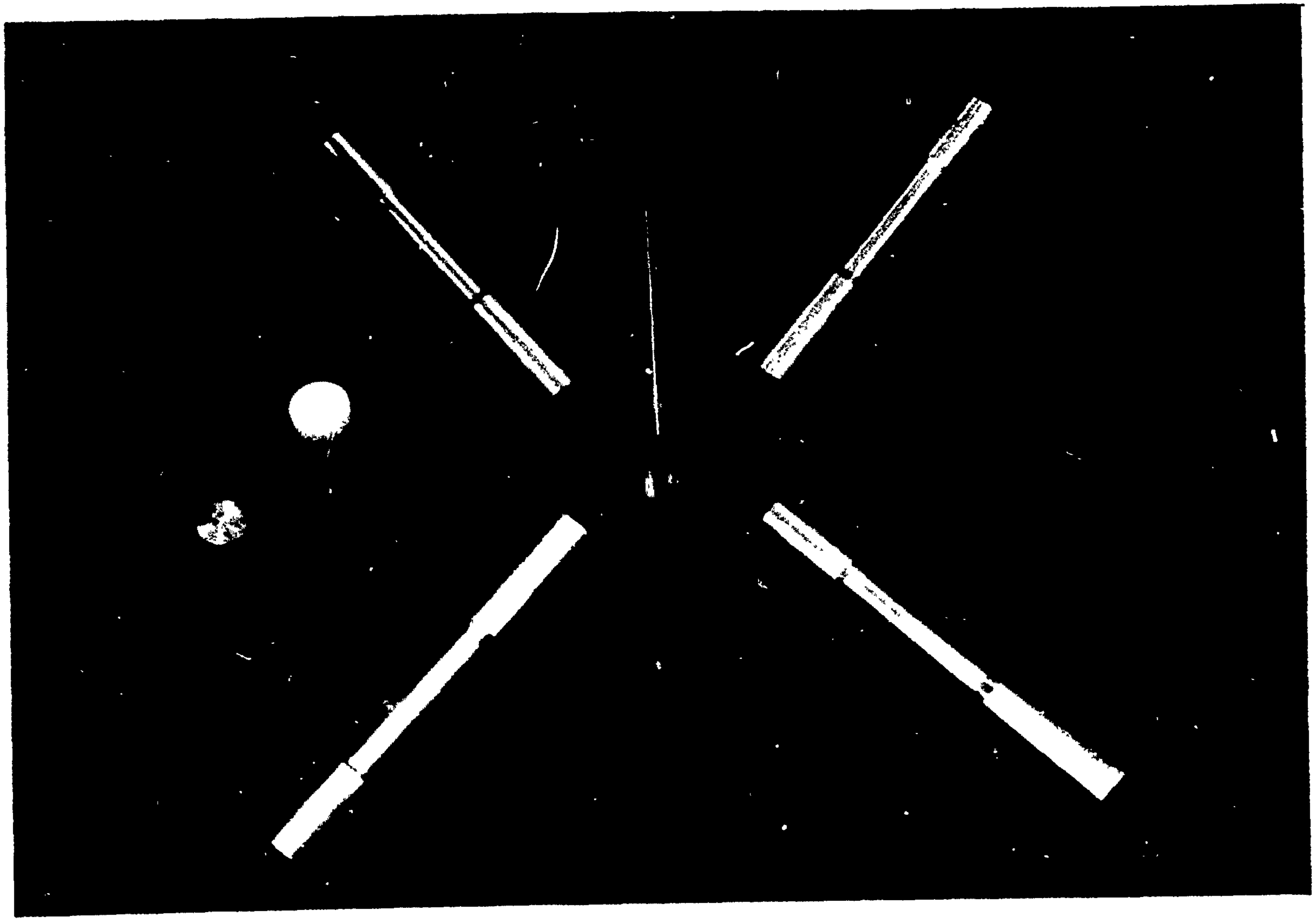


Figure 14. High Density Armor Piercing Flechette Tested on the BARS Yaw Card Range

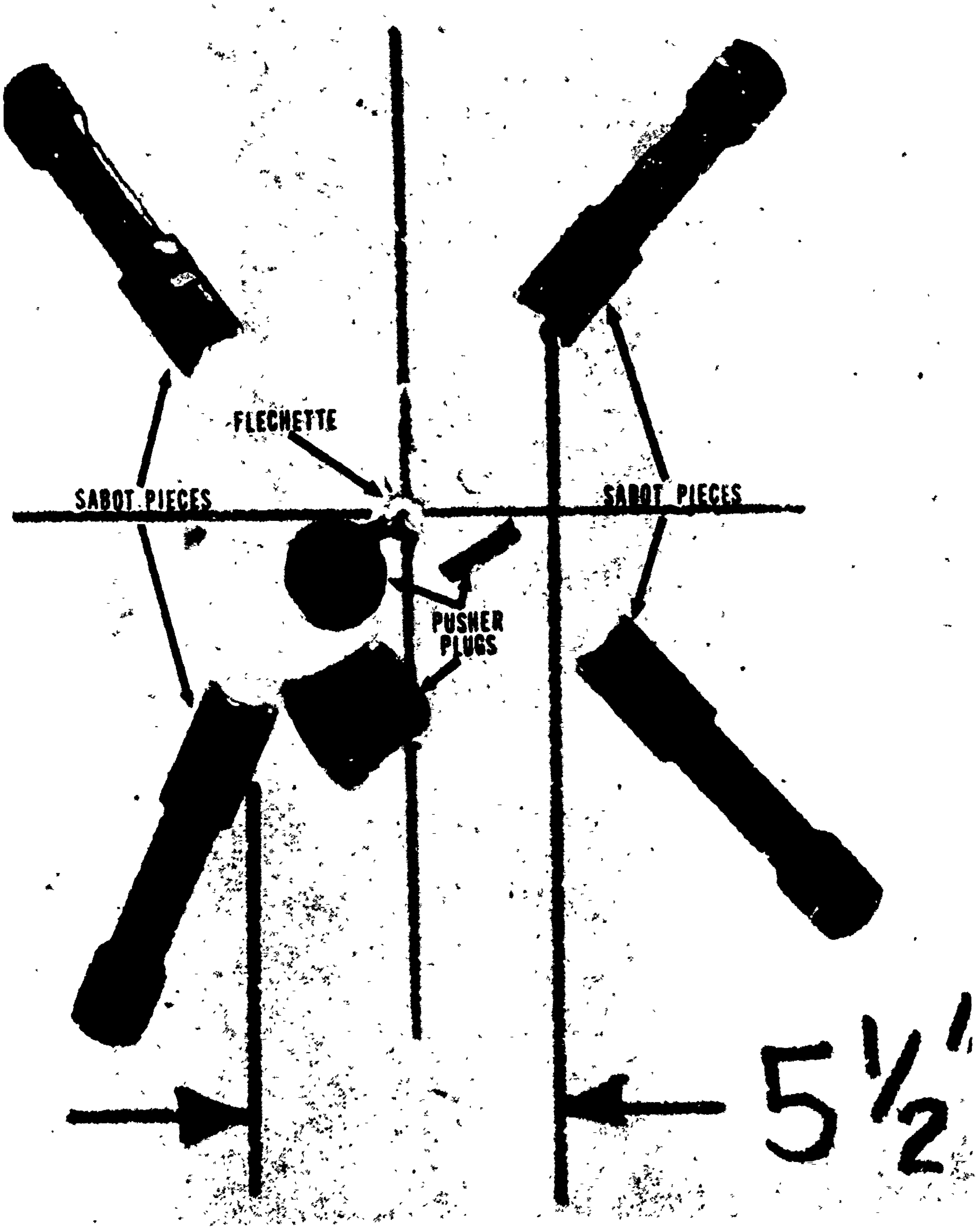
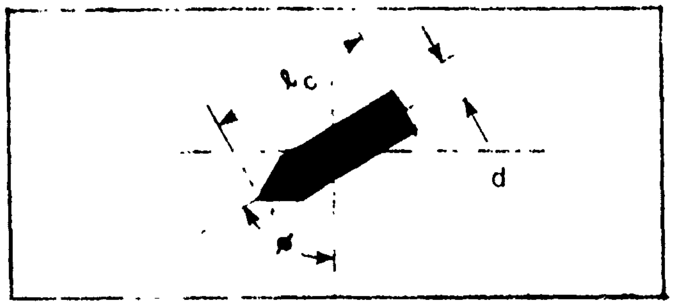
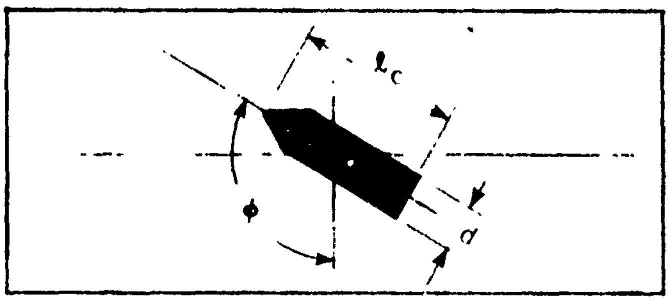


Figure 15. Sabot Separation Witness Card



(a) Card 1



(b) Card 2

Figure 16. Two Successive Yaw Cards

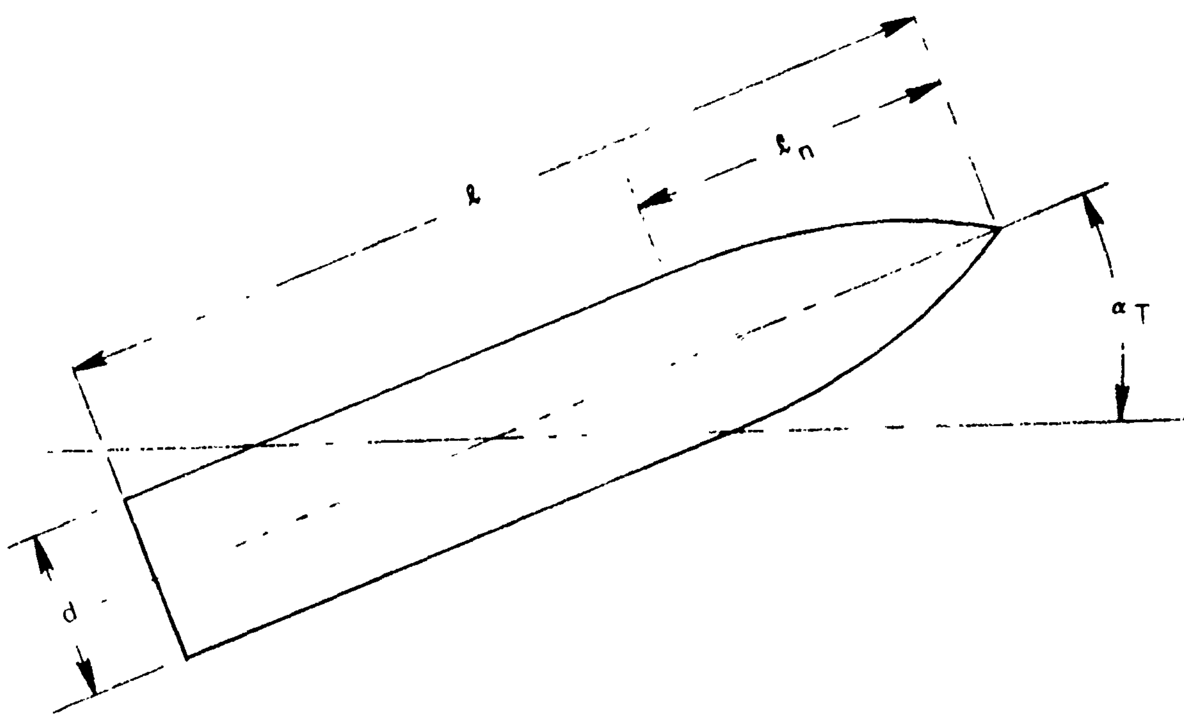


Figure 17. Projectile

SECTION V

ADDITIONAL TEST CAPABILITIES

Besides the test systems already described, the BARS can provide several additional test capabilities.

1. AIR JET

The BARS Facility developed and fabricated a vertical air jet to test spherical bomblet design. This test system utilizes a 150 psi compressed air system to generate a vertical column of air. Spherical bomblets are dropped into this column and are held aloft by the force of the air. If ribbed, they will spin with their designed rotational speed; Figure 18 shows the air jet in operation. Note the sphere being held up in the plexiglass cylinder. This system is available for any similar test requirements.

2. EJECTION TEST STAND

The BARS Facility has a static ejection test stand that is presently being used by the Suspension and Release Team at AFATL. This stand enables the user to test bomb release mechanisms without having to utilize aircraft. This stand is shown in Figure 19 with a release mechanism in place and a dummy bomb on the rack next to the stand. This test facility is also available for any similar testing requirement.

Figure 18. Air Jet in Operation

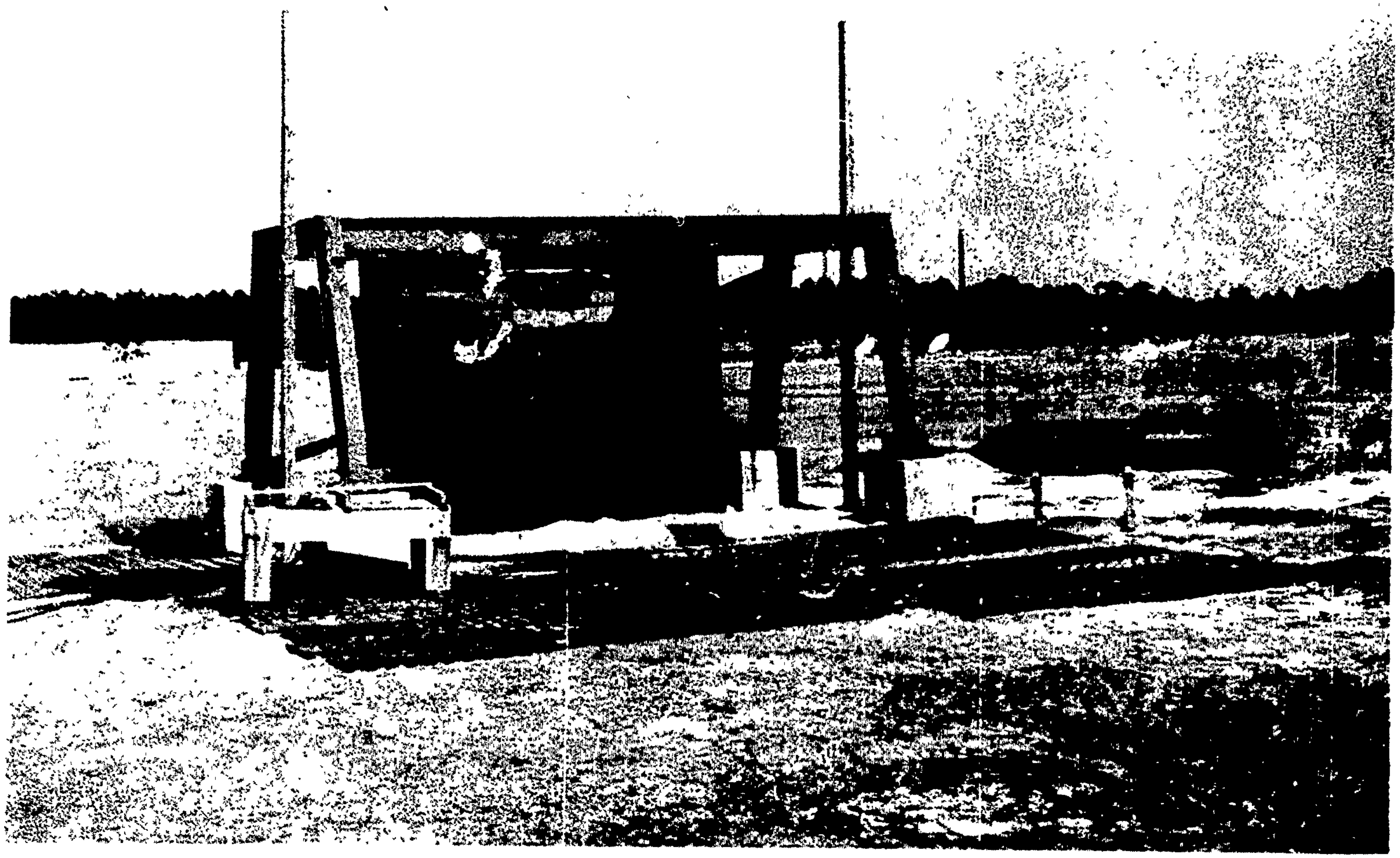


Figure 19. Pylon/Rack Ejection Test Stand

SECTION VI

SUPPORT

The BARS Facility has several additional support cababilities that are essential to providing a quick response to a test request. These capabilities allow tests to be completed with a minimal amount of outside support. Being almost entirely self-supporting ensures a quick initial response, flexibility in providing test modifications, and timely data production and reduction.

1. MACHINE SHOP

The BARS Facility has a completely equipped machine shop that can provide quick test item fabrication, equipment modification, repairs to test facilities, and engineering inputs to item design; Figure 20 shows a portion of this shop. A full time machinist is available to perform these functions and a complete bench stock is maintained. Wind tunnel models can be built to meet special design requirements and to almost any scale necessary. Air gun models and test equipment can be fabricated quickly and can be changed to attain different test objectives.

2. ELECTRONICS WORKSHOP

A small electronics repair and fabrication workshop is maintained to provide flexibility in test monitoring instrumentation. This workshop includes an extensive bench stock of electronic components, a small group of monitoring equipment, and fabrication capabilities. Engineers and instrumentation technicians are available to perform data collection and reduction, as well as fabrication of test set-ups.

3. PHOTOGRAPHY

With photography being the primary data collection system now being used, the BARS Facility has the capability to take both still and motion pictures of tests. These are used primarily for still photo documentation and velocity coverage. The motion pictures are obtained with a 16mm, 400-frame-per-second camera (Milliken) that can be used to record velocity data and also flight characteristics and event occurrences. As yet, no high speed camera coverage is available in-house; however, arrangements can be made to obtain high speed camera coverage (1,000 to 10,000 frames per second).

4. EQUIPMENT

Additional support equipment is available if needed. Several portable cranes are available for moving heavy test items or to quickly modify any test set-up. One of the ranges is entirely backed with a photographic background to provide good contrast for movie coverage. Lumber and wood working equipment are available for target fabrication and repair. A clean chamber, equipped with a microscope, is available for damage inspection, wind tunnel model assembly, and electronic fabrication and cleaning.

5. PROJECTILE MEASUREMENTS LABORATORY

Physical measurements of test items can be performed by personnel from the Projectile Measurements Laboratory. These measurements include moments of inertia, center of gravity position, linear measurements, angular measurements, and preflight and postflight damage assessment.

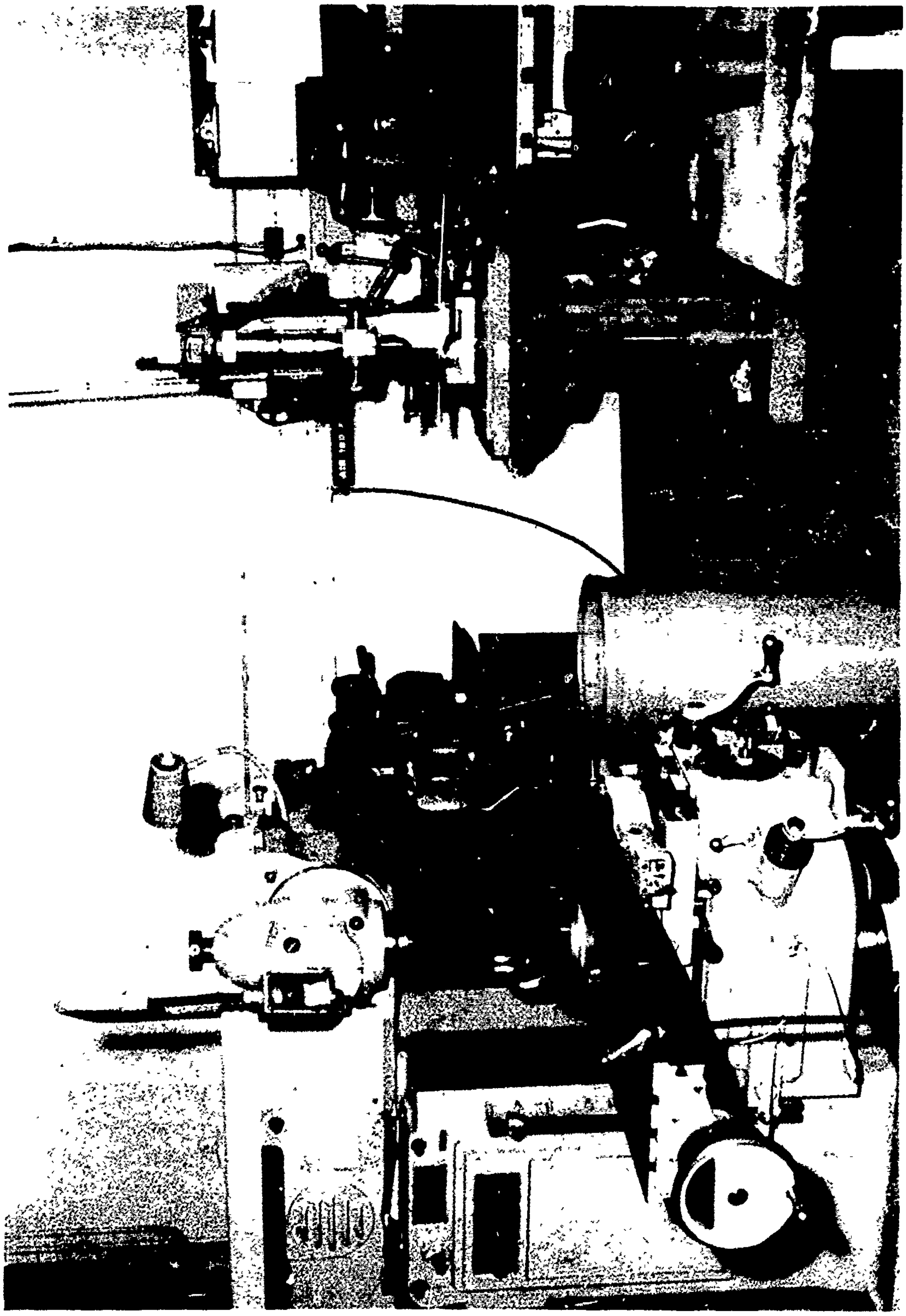


Figure 20. Machine Shop

SECTION VII

SUMMARY

The BARS Facility has two basic missions: first, to provide project support in the shortest possible time with the greatest flexibility and second, to originate research and development projects that will contribute to the conventional munitions field.

The available facilities include a subsonic wind tunnel and a complete series of air and powder guns, as well as a fully instrumented yaw card range. These systems can provide basic aerodynamic data on almost any size or shape of object, whether stable or unstable. The BARS Facility can provide these data at a minimal cost and in the quickest possible time.

The following partial list gives some examples of the past projects that have been investigated. It is provided as a guide to the capabilities of the BARS Facility. Wind tunnel tests have been omitted since they are discussed in other publications.

TITLE	TESTING SYSTEM	DESCRIPTION
IMPACT TESTS OF BLU-26/B, BLU-61/B, BLU-62/B, BLU-63/B FRAGMENTATION BOMBS	AIR GUN	A NUMBER OF TEST ITEMS OF EACH KIND OF BOMB WERE LAUNCHED INTO A STEEL IMPACT TARGET COVERED WITH WOOD. STRUCTURAL DAMAGE WAS ASSESSED.
S-CURVE BOMBLETS	AIR GUN	DISPERSION PATTERNS WERE GENERATED FOR TEST ITEMS LAUNCHED SINGLY AND IN CLUSTERS. PATTERN WAS 2000 FEET FROM AIR GUN.
MISCH METAL, MAGNESIUM, MAGNESIUM/ALUMINUM CYLINDERS	AIR GUN	CYLINDERS WERE LAUNCHED AGAINST STEEL TO STUDY FAILURE ON IMPACT WITH RANDOM IMPACT ANGLES AND CONSTANT VELOCITY.

FLAME FUELS	AIR GUN	MULTIPLE SHOTS TO DETERMINE BREAK-UP IN FLIGHT OF FLAME FUEL MATERIAL AND BEHAVIOR AFTER RICOCHET. TEST DONE AT AMBIENT AND BELOW ZERO TEMPERATURES.
HEAVY DUTY ARMOR PENETRATOR	POWDER GUN	FLIGHT DATA GENERATED USING YAW CARD RANGE AND VARYING LAUNCH VELOCITIES.
FUEL AIR EXPLOSIVE CANISTER	AIR GUN	SCALE MODELS OF FAE CANISTERS WERE LAUNCHED TO TEST FUZE FUNCTIONING.
MODULARIZED INCENDIARY BOMB	AIR GUN	A 50 LB TEST ITEM WAS LAUNCHED AGAINST CONCRETE TO TEST TOTAL FUZE AND INCENDIARY PACKAGE.
TETHERED AEROSOL DETONATOR	AIR GUN	TEST CONFIGURATION STUDIED SPIN CHARACTERISTICS OF A DETONATOR THAT WAS TO TRAIL A FAE BOMB TO IMPACT.
BLU-62 IMPACT TEST	AIR GUN	SPIN TEST TO CHECK FUZE FUNCTION OF A PRODUCTION BOMB. ITEM SPUN IN BARREL AND IMPACTED IN DIRT.
BLADDER BOMB	AIR GUN	FLEXIBLE FLAME FUEL BOMB LAUNCHED AGAINST DIRT TO STUDY FLAME PATTERN. BOMB WAS MADE OF RUBBER.
ORIENTATION/STABILIZATION DEVICE	AIR GUN	TEST ITEM WAS EQUIPPED WITH A PARACHUTE AND WAS LAUNCHED AT A 30 DEGREE ANGLE TO TEST FUNCTIONING.
BALLUTE MODEL	AIR GUN	TEST ITEM HAD INFLATIBLE BALLUTE TO INCREASE DRAG. LAUNCHED TO DETERMINE BALLUTE INFLATION TIME AND FUNCTION.

The preceding and similar projects are discussed in the following technical reports, which provide additional information on the capability of the BARS Facility.

Brunk, J.E.: Monte Carlo Analysis of S-Curve and Roll-Through-Zero Bomblet Dispersion Characteristics. AFATL-TR-73-15, Air Force Armament Laboratory, Eglin Air Force Base, Florida. January 1973 (AD 908907L)

Graham, J.J.: Ballute Stabilization for Various Munition Configurations. AFATL-TR-72-75, Books 1 and 2, Air Force Armament Laboratory, Eglin Air Force Base, Florida. April 1972 (AD 9089[illegible]3L and AD 908927L)(Unclassified)

Mayer, P.C.: Free Flight Tests of S-Curve Bomblets. AFATL-TR-73-67, Air Force Armament Laboratory, Eglin Air Force Base, Florida. March 1973 (AD 909473L)

Mayer, P.C.: Structural Impact Test Comparing Misch Metal Magnesium Alloy A231B, and Magnesium/Aluminum Cylindrical Cases at Low Velocities Using Air Gun Techniques, AFATL-TR-74-24, Air Force Armament Laboratory, Eglin Air Force Base, Florida. January 1974 (Unclassified)

Mayer, P.C., Wichenback, G.L.: Free Flight Range Tests of a High Density Armor Piercing Flechette Utilizing Yaw Cards, AFATL-TR-74-73, Air Force Armament Laboratory, Eglin Air Force Base, Florida (Unclassified)

McGirr, P.G., Schlegel, M.O.: A Dispersion Technique For The MK-82 Bomb, AFATL-TR-73-146, Air Force Armament Laboratory, Eglin Air Force Base, Florida. July 1973 (Unclassified)

Murphy, C.H.: Free Flight Motion of Symmetric Missiles, Ballistics Research Laboratory, BRL-R-1216. July 1963 (Unclassified)

Parrish, G.E.: USAF Armament Laboratory Wind Tunnel Test Facility Instrumentation Modernization, AFATL-TR-73-51, Air Force Armament Laboratory, Eglin Air Force Base, Florida. March 1973. (Unclassified) (AD 909029)

Schlegel, M.O.: Impact Tests of BLU-26/B, BLU-61/B, BLU-62/B, BLU-63/B and Modified BLU-63/B Fragmentation Bombs, AFATL-TR-73-228, Air Force Armament Laboratory, Eglin Air Force Base, Florida. November 1973 (Unclassified)

Schlegel, M.O.: Static Ejection Test of the Compass Quiver Subunit From the SUU-42/A Dispenser, AFATL-TN-71-4, Air Force Armament Laboratory, Eglin Air Force Base, Florida. November 1971

Schlegel, M.O.: Wind Tunnel Tests of Modified BLU-87/B Fragmentation Bombs, AFATL-TR-72-132, Air Force Armament Laboratory, Eglin Air Force Base, Florida, July 1972 (Unclassified) (AD 750872)

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