Report No. 139

BRL-139

BALLISTIC RESEARCH LABORATOR[redacted]

REPORT

FIRING SIDEWISE FROM AN AIRPLANE

II. EFFECTS OF A 400 MILE PER HOUR AIR SPEED

Project RX 114

by

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ABERDEEN PROVING GROUND

ABERDEEN, MD.

March 28, 1939

Report No. 139

F. A. Form No. 156.

Frankford Arsenal—4-21-41—2,000

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HPH/emh
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Abstract

The variations in the magnitude and orientation of the yaw in the bore of a machine gun, firing sidewise from an airplane with a speed of 400 miles per hour, might cause large dispersions at a range of 500 yards; but not at 100 yards.

1. OBJECT: In Part I, "Theoretical considerations",* the motion of bullets fired from a machine gun, mounted on an airplane with a speed of 200 mi/hr, in a direction perpendicular to the line of flight of the airplane, was studied; it was found that the maximum dispersion caused by variations in the magnitude and orientation of the yaw in the bore appears to be too small to ruin the accuracy of fire. Since airplane speeds may be increased to 400 mi/hr in the near future, the Chief of Air Corps has asked for a determination of the effect of a cross wind of this magnitude on the dispersion of machine gun fire.

* Ballistic Research Laboratory Report No. 116.

2. DATA: Except for the air speed (600 ft/sec), we shall assume the same conditions as before:

a. Bullet, Cal. 0.30 ball M1.
b. Direction of fire, horizontally to starboard.
c. Muzzle velocity, 2600 ft/sec.
d. Yaw in the bore, 0.15° (this is probably the largest yaw that would be obtained in a good gun).
e. Orientation of the yaw in the bore, at the muzzle, 90° and 270° (these values give extreme conditions, as the variation is usually much less than this).

3. YAW:

a. Under these conditions, the windage yaw is 12.995°. This would be the initial yaw relative to the air if there were no yaw in the bore.

b. With the assumed yaw in the bore, at an orientation of 90°, the motion is somewhat different with a 600 ft/sec cross wind than with a 300 ft/sec cross wind. In the latter case, the initial yaw is a maximum, as stated in the previous report. But, in the former case, the initial yaw is a minimum; furthermore, the successive minima decrease numerically, instead of increasing as before. With the higher air speed, the value of the initial yaw is 13.145°; the theoretical initial maximum yaw is 14.79°.

c. If the orientation of the yaw in the bore is 270°, the motion is similar to what it is at 300 ft/sec. The initial yaw, resulting from the higher speed, is 12.845°; the theoretical initial maximum yaw is 23.47°.

4. DEVIATIONS: Figures 1 and 2 show the calculated* deflection and fall, in mils, for the conditions assumed in paragraph 2. The values for a speed of 300 ft/sec may be obtained from figures 15 and 16 of the previous report. The following table shows the results at ranges of 100 yd (91 m) and 500 yd (457 m).

* M. E. Harrington assisted in the calculations.

Range	Air Speed	Orientation	Deflection	Fall
yards	ft/sec	deg.	mils	mils
100	600	270	19.9	6.9
		90	14.2	5.7
			5.7	1.2
100	300	270	5.4	3.8
		90	4.4	2.9
			1.0	0.9
500	600	270	85.9	11.8
		90	67.7	10.1
			18.2	1.7
500	300	270	28.7	8.3
		90	24.1	6.8
			4.6	1.5

5. DISCUSSION: For comparative purposes, the deviations computed in the classic manner, without yaw, are also shown by the upper curves in figures 1 and 2. It is notable that the effects of windage yaw on the horizontal deflection are greater than on the vertical deviation, whether we consider the maximum dispersion due to initial conditions or the variations from the classic values. Evidently, the increased resistance due to yaw, with the consequent increase in time of flight, is the preponderating cause of the increase in deviation, except at very short ranges. Near the beginning of the trajectory, the so-called cross wind force causes most of the variation: this is apparent from the windage jump, which is almost vertically downward (this is explained in the previous report). For most ranges, therefore, it is more important to determine the drag-yaw coefficient and the damping factors than the cross wind force.

6. CONCLUSION: The maximum dispersion of 18 mils at 500 yards is quite large. Actually, however, the dispersion will probably be less than this amount, since the yaw in the bore of a caliber 0.30 gun is usually less than 0.15°, and since uniformity in loading conditions tends to group the muzzle orientations within a range of less than 180°. Furthermore, unless fire control mechanism

is considerably improved, firing will not be accurate beyond 100 yards, when the air speed is 400 mi/hr. At this range, the total dispersion due to variations of the yaw at the muzzle is less than 6 mils. This should cause no difficulty in hitting.

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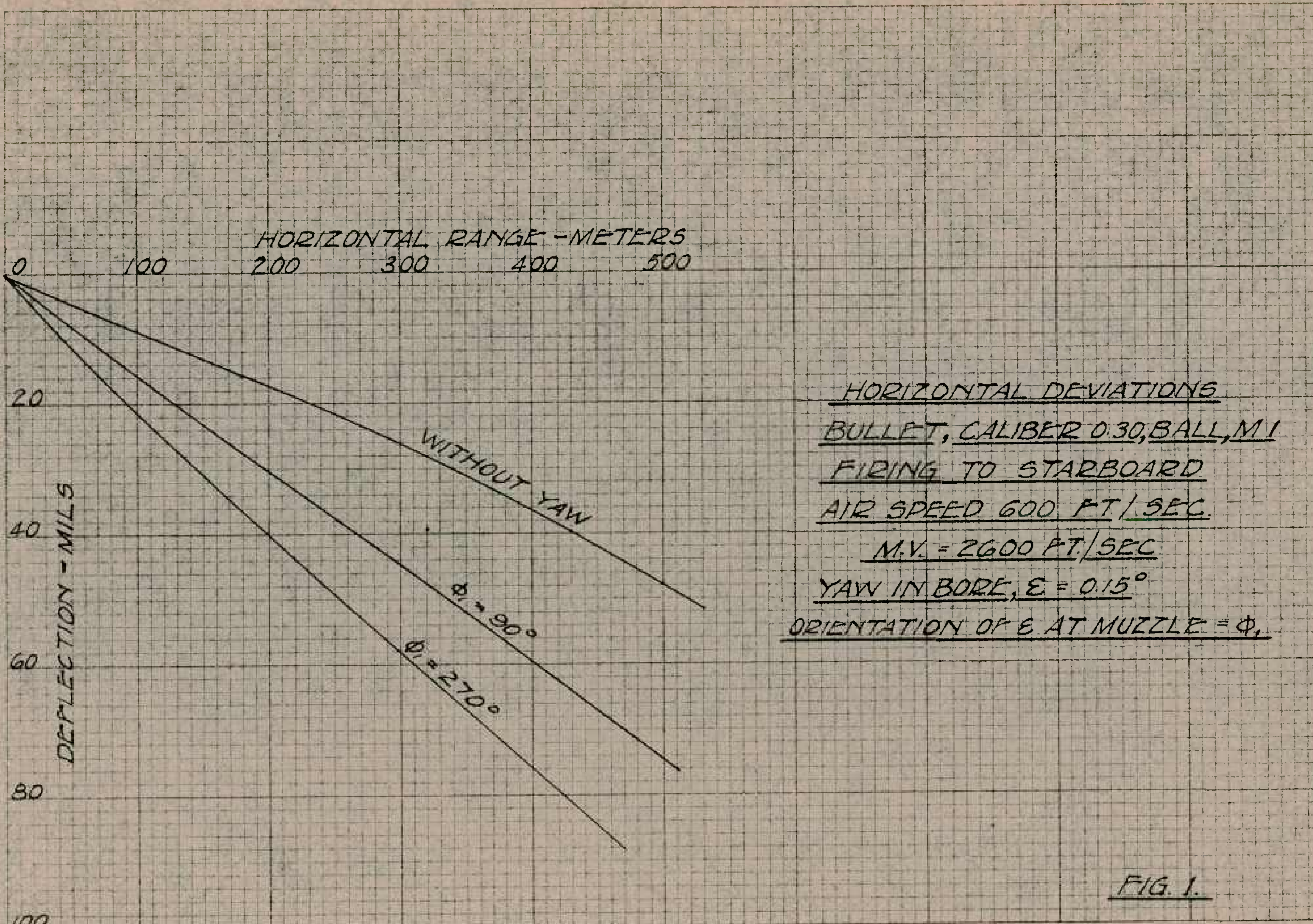
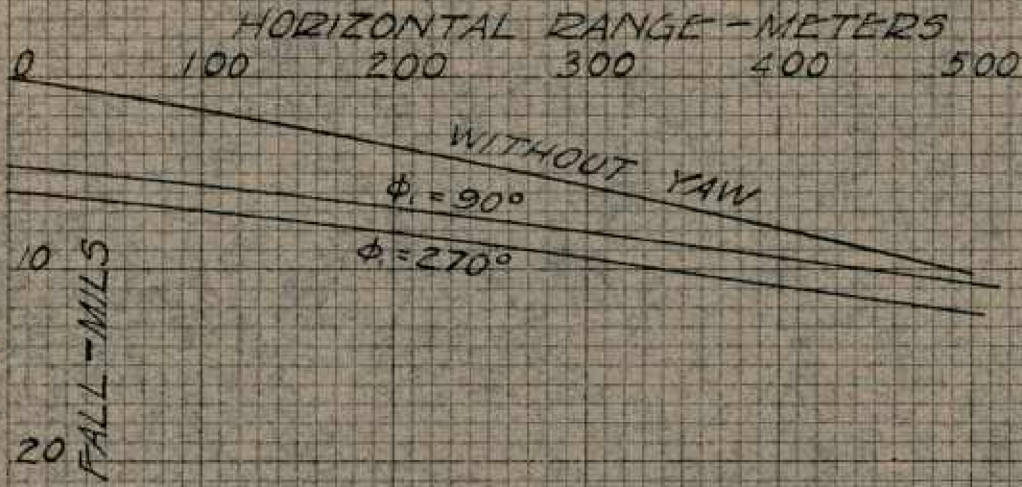

HORIZONTAL RANGE - METERS
0
100
200
300
400
500
DEFLECTION - MILS
20
40
60
80
100
WITHOUT YAW
Φ1 = 90°
Φ1 = 270°
HORIZONTAL DEVIATIONS
BULLET, CALIBER 0.30, BALL, M1
FIRING TO STARBOARD
AIR SPEED 600 FT/SEC.
M.V. = 2600 FT/SEC
YAW IN BORE, ε = 0.15°
ORIENTATION OF ε AT MUZZLE = Φ1

FIG. 1.



VERTICAL DEVIATIONS

BULLET, CALIBER 0.30, BALL, M1

FIRING TO STARBOARD

AIR SPEED = 600 FT./SEC.

M.V. = 2600 FT./SEC.

YAW IN BORE, ε = 0.15°

ORIENTATION OF ε AT MUZZLE = ϕ_1

FIG. 2

TITLE: Effects of a 400 Mile Per Hour Air Speed Proj. RX 114 - Firing Sidewise from and Airplane

AUTHOR(S): Hitchcock, H.P.

ORIGINATING AGENCY: Aberdeen Proving Ground, Ballistic Research Lab., Aberdeen, (Md.

PUBLISHED BY: (Same)

ATI- 41294

REVISION: (None)

ORIG. AGENCY NO.: R-139

PUBLISHING AGENCY NO.: (Same)

DATE	DOC. CLASS.	COUNTRY	LANGUAGE	PAGES	ILLUSTRATIONS
March '39	Unclass.	U.S.	Eng.	6	graphs

ABSTRACT:

The motion of bullets fired from a machine gun mounted on an airplane in a direction perpendicular to the line of flight of the airplane was studied. Maximum dispersions caused by variations in the magnitude and orientation of the yaw in the bore were determined. At a speed of 400 miles per hour large dispersions occurred at a range of 500 yards but not at 100 yards. For comparative purposes the computed deviations without yaw were shown graphically. It was notable that the effects of windage yaw on the horizontal deflection are greater than on the vertical deviation.

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DIVISION: Ordnance and Armament (22)

SECTION: Ballistics (12)

SUBJECT HEADINGS: Gunnery, Aerial - Speed deflection - Computation (47482.5); Gunnery, Aerial - Firing accuracy (47428.2)

ATI SHEET NO.: R-22-12-44