Balloon targets for centimetre equipment

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C O N T E N T S

I. BALLOON TARGETS FOR CENTIMETRE EQUIPMENT

A.D.R.D.E.* suggested the use of a cluster of trihedrons on a free balloon as a standard of range performance for ten-centimetre radar, particularly GL Mark III. Several targets were built at N.R.C. to conform to their standard, and tested in conjunction with a GL Mark IIIC equipment. These tests showed that the range at which the signal-to-noise ratio was 2:1 was considerably beyond the maximum range of the GL IIIC range system, and so a smaller target was required. At the same time it was noticed that this type of target gave an echo which faded and "flared up" rather badly.

Since the matter of signal strength precluded the use of the existing standard and forced a change, it was felt that other liberties might well be taken in an endeavour to reduce the amount of fading.

A copper sphere was tried and the results were immediately satisfactory. The size required was settled at two feet diameter, and a method of quantity fabrication sought, which would also permit compact shipment. The device finally decided upon consists of two papier maché hemispheres made by Hawley Products Ltd., Brantford, Ont. (pith helmet manufacturers), sprayed with aluminum, shipped stacked inside one another, and laced together on the site with string, like a football. The assembled sphere weighs about 4-1/4 pounds, 1/2 pound of which is aluminum. Four-foot paper parachutes are tied between the spheres and the balloons. The parachutes are radio-sonde 'chutes supplied by the Dennison Manufacturing Co., Cambridge, Mass., and the balloons are Darex meteorological balloons #350 supplied by the Dewey and Almy Chemical Co., Cambridge, Mass. Plate I shows the target assembly ready to be released.

The final form of this assembly provides an echo which fades less than 2:1 and which can be tracked to one-half the range of a Harvard type training aircraft. With normal wind velocity the time of flight is thus in the region of twenty to forty minutes on fire control radars, and a reasonable elevation angle is easily obtained.

Included after the plates of this report is a copy of an instruction pamphlet issued to cover a typical use of these targets for checking range sensitivity.

Experience on about twenty test flights shows that even with mediocre operators it is easy to get within 3 db. of the correct answer with a single test, and within 1 db. with three tests. Actually the results used as an example in the attached instruction were obtained on the first try by inexperienced operators.

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* A.D.R.D.E. Report R107-I/ESS "Balloon Marker for Centimetre Equipment"

Because each type of radar equipment may have different detector characteristics, the departure of the graph from a straight line will be different for each. However, the correct type of curve may be chosen by averaging the results for a number of flights. Plate No. 2 shows an average of the seven best sets of readings for a GL Mark IIIC. (Note that the upward trend suggested in the GL IIIC Instruction is almost non-existent).

Trials have been made on GL IIIC's with 6 db. of loss added in the R.F. system, and on others with "hot" crystals, as a check on the sensitivity and reliability of the measurements. In each case the variation is correctly and emphatically shown by the graphs drawn.

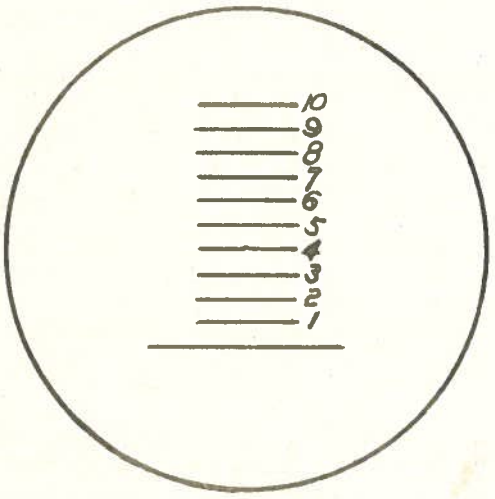
As a result of this development, the Canadian Army RDF Section is in the process of fitting out a van with the necessary balloon target equipment, to travel from site to site for routine sensitivity check on operational GL IIIC's. This group also plans to use the targets in lieu of aircraft for routine check of azimuth and elevation alignment of the radio and optical axes.

II. INSTRUCTIONS FOR USE OF BALLOON AND TWO-FOOT SPHERICAL TARGET FOR TEST OF GL MARK IIIC RANGE SENSITIVITY.

The GL should be prepared for the test in the following manner:

(1) Switch on and allow sufficient lapse of time for "drifting" to be complete,--say 15 or 20 minutes.

(2) Tune in a saturation signal and adjust the Range C.R.T. Vertical Shift so that the space between the baseline and top of the signal is reasonably centred on the C.R.T. Mark the location of the baseline with a china-marking pencil. Now, make a series of lines spaced 1/4" vertically up the centre of the tube from the baseline mark,--number these. The result is intended to be a scale from which to read the signal amplitude.



(half-scale)

(3) Check strobe and integrator systems to be sure they are operating correctly in all respects, as set forth in the instructions.

(4) Adjust the set carefully for maximum signal-to-noise ratio on a weak echo.

(5) In addition to the three RB operators, a man should be stationed on the roof with telephone communication to an extra man in the trailer. The extra man in the trailer might well be the Recorder, equipped with paper and pencils.

Having completed the foregoing preparations, the balloon and target should be released. For best results it should be inflated so that it drifts away at an elevation angle of from 20° to 40°. Angles much lower than this lead to difficulties from ground echoes, and much above this may cause premature breaking of the balloon.

As the target drifts away, the man on the roof calls suitable instructions into the telephone, to be repeated by the Recorder, so that the operators may train on the target within, say five degrees. Ordinarily this should continue in a leisurely manner until the target is out to 2000 yards' range, at which time the echo will be detected by the Range Operator, and radar tracking may begin. In cases of hazy or poor visibility when the roof man is in danger of losing sight of the target, it may be advisable to have the Range Operator shift the strobe to the right to permit tracking before 2000 yards. The man on the roof should endeavour to keep track of the target as long as possible after radar tracking begins, in case some mistake is made by the operators, and the target lost.

When tracking has settled down, and before the target has reached 4,000 yards, the Range Operator should make the following adjustments:

(1) Adjust gain until noise is approximately 1/4-inch high.

(2) Adjust vertical shift until base line is exactly on the zero mark of the amplitude scale.

(3) Readjust gain so the noise is exactly 1/4-inch (one division) high. This adjustment is properly made when the top of the general illumination is at 1/4 inch, at which time one or two flicks per second will reach two divisions, and practically none will exceed 2-1/2 divisions.

Adjustment of the baseline position and the noise height should be carefully watched by the Range Operator and Recorder throughout the test, and readjusted if necessary.

As soon as the the target has drifted far enough to cause the echo to drop below saturation, recording begins. At each 300-yard and 800 yard mark (such as 3800, 4300, 4800, 5300, etc.) the Recorder calls "begin observation" and the Range Operator then watches the top of the echo carefully until the 500-yard or 1000-yard mark is reached, at which time the Recorder calls "end observation" and the Range Operator states the maximum height of the echo achieved in the interval. (This maximum height figure should ignore spasmodic large increases in signal height). During the period of observation the Azimuth and Elevation Operators make every effort to track precisely, and unless they report that trouble was encountered, the Recorder then records the signal amplitude opposite the appropriate range. The Range Operator should take his readings at a point on the "grass" on top of the blip, corresponding to the point considered as the top of the noise set at one division.

This procedure is repeated as the balloon drifts out, part of the non-recording intervals being used by the Range Operator to check the narrow strobe centering, noise height, tuning, etc., and by the Azimuth and Elevation Operators to make 1/2° excursions or

brackets to check that direction-finding is correct,--particularly as the signal becomes weak.

When the target has reached such a range as to yield signals below two, recording stops, and every effort is concentrated on tracking until the target is irrevocably lost. Cautious angle tracking and bracket excursions help to avoid erroneous tracking. The range at which the target is lost is recorded.

A table such as the sample given below should now result:

RANGE	HEIGHT
3,000 yards	--
3,500 "	--
4,000 "	10
4,500 "	8
5,000 "	8
5,500 "	5
6,000 "	4
6,500 "	3-1/2
7,000 "	3
7,500 "	2-3/4
8,000 "	2-1/4
8,500 "	1-3/4
9,000 "	
9,500 "	
10,000 "	
lost at 11,000 yards	

Now the reciprocal of the signal heights should be plotted against range squared, as shown on Plate 3, and a smooth curve drawn through the points. Remember zero-zero is one point, and that the curve is a straight line up to about .35, and perhaps a slight upward curve after this.

If the range sensitivity of the set is up to normal (see PRB-86), the range at which the curve crosses 0.5 (signal = 2) should be at least 8500 yards, and further, if the direction-finding sensitivity and action is normal, the target should not be lost before 12,000 yards. The set shown on the graph, Plate 3, was down approximately 1/2 db.

REMEMBER, the accuracy of this test depends on the care with which the noise level is adjusted to one division.

OTTAWA
November 10th, 1943

J. W. Bell

III. APPENDIX

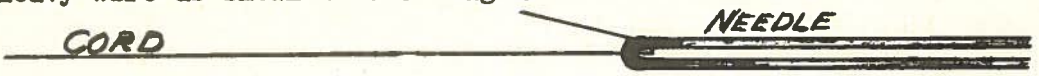
PREPARATION OF THE TARGET FOR FLIGHT, AND INFLATION OF THE BALLOON

The spherical targets are broken down into hemispheres for shipping, and the hemispheres may be stitched together into spheres on the site of the test, as follows:

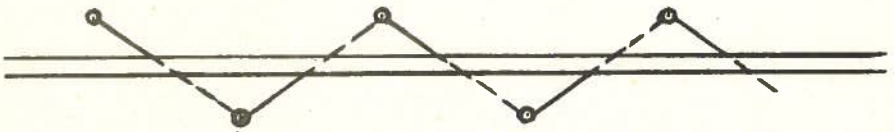
(1) Mark points on each hemisphere about two inches apart, and about 3/4-inch from the rim. Care must be exercised to keep the holes in one hemisphere in close alignment with those in its mate.

(2) Drill 1/8-inch holes as marked in (1).

(3) If a large needle is not available, one may be readily made from heavy wire as shown in the diagram.



(4) Thread with heavy cord as in the diagram below, passing the cord over and under from hole to hole.

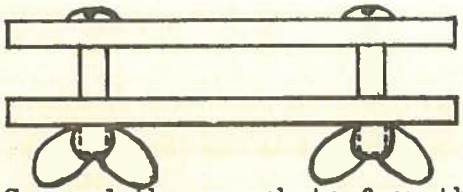


(5) Thread the cord through loosely to start with, then draw it up tight and tie it securely.

(6) The time required is approximately one hour.

The target and parachute may be secured to the balloon, and the balloon may be inflated and released as follows:

(1) Prepare a suitable wooden clamp as shown, and fit it loosely to the neck of the balloon.



(2) Suspend the parachute from the clamp with about one foot of heavy cord.

(3) Suspend the target below the parachute.

(4) Attach the balloon to the hydrogen cylinder with about two feet of rubber hose with suitable fittings.

(5) Release the hydrogen, allowing the balloon to inflate slowly.

(6) When the balloon reaches a diameter of about 5-1/2 feet, tighten the wooden clamp, release the balloon from the hydrogen cylinder, and check the buoyancy of the balloon and target. The buoyancy should be such as to allow the target to drift away on the wind at an angle of elevation between 20° and 40°.

CAUTION - No Smoking - If a balloon should burst in the face of a smoker, the hydrogen suddenly released would almost certainly ignite.

CAUTION - Nearby Air Ports should be notified before balloons are released, to avoid confusion over false reports telephoned in by observers.

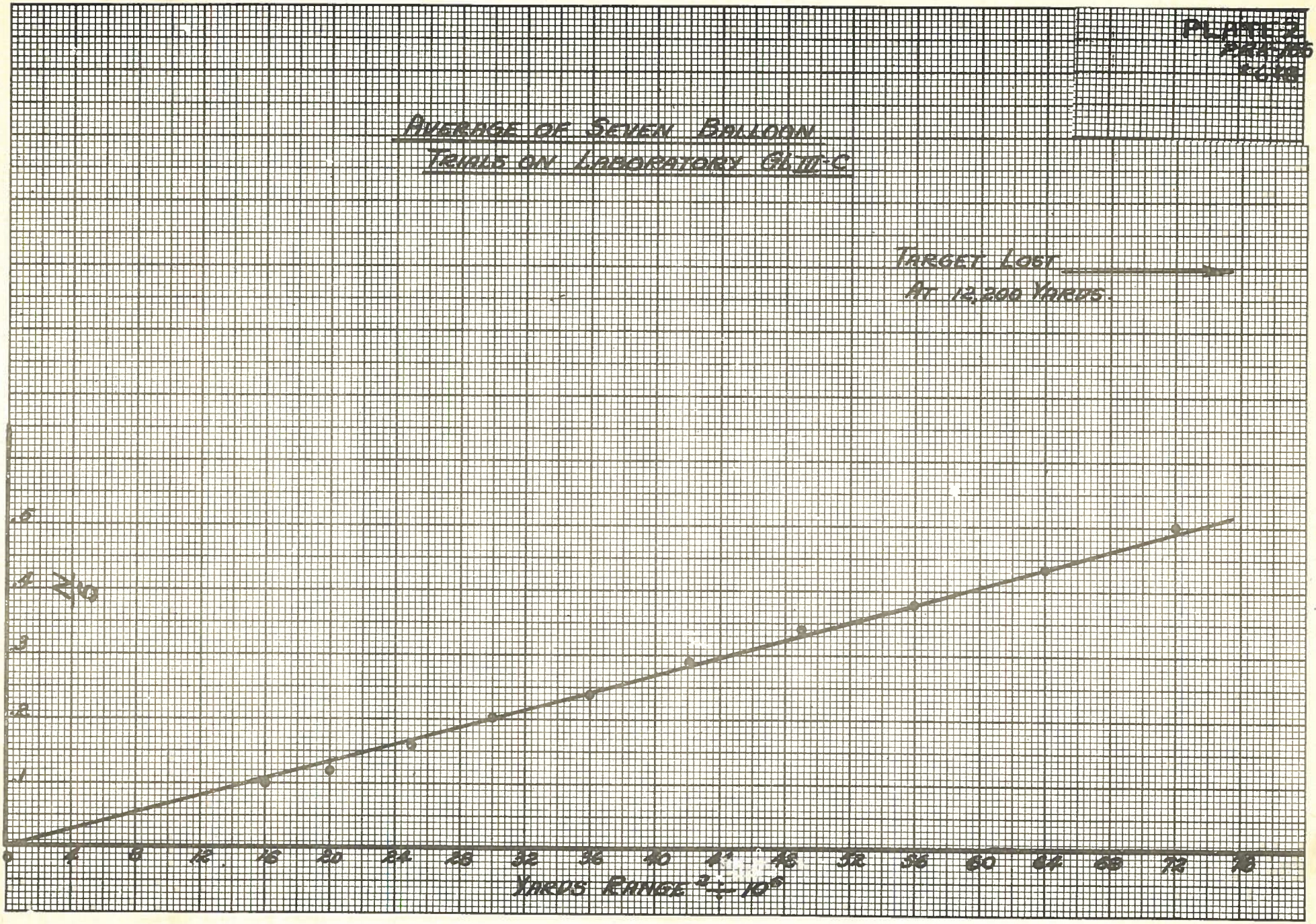
OTTAWA
November 11, 1943

G. A. Miller

N.R.C. PHOTO
FIG. 1

PLATE 2

Average of Seven Balloon Trials on Laboratory Gun-C



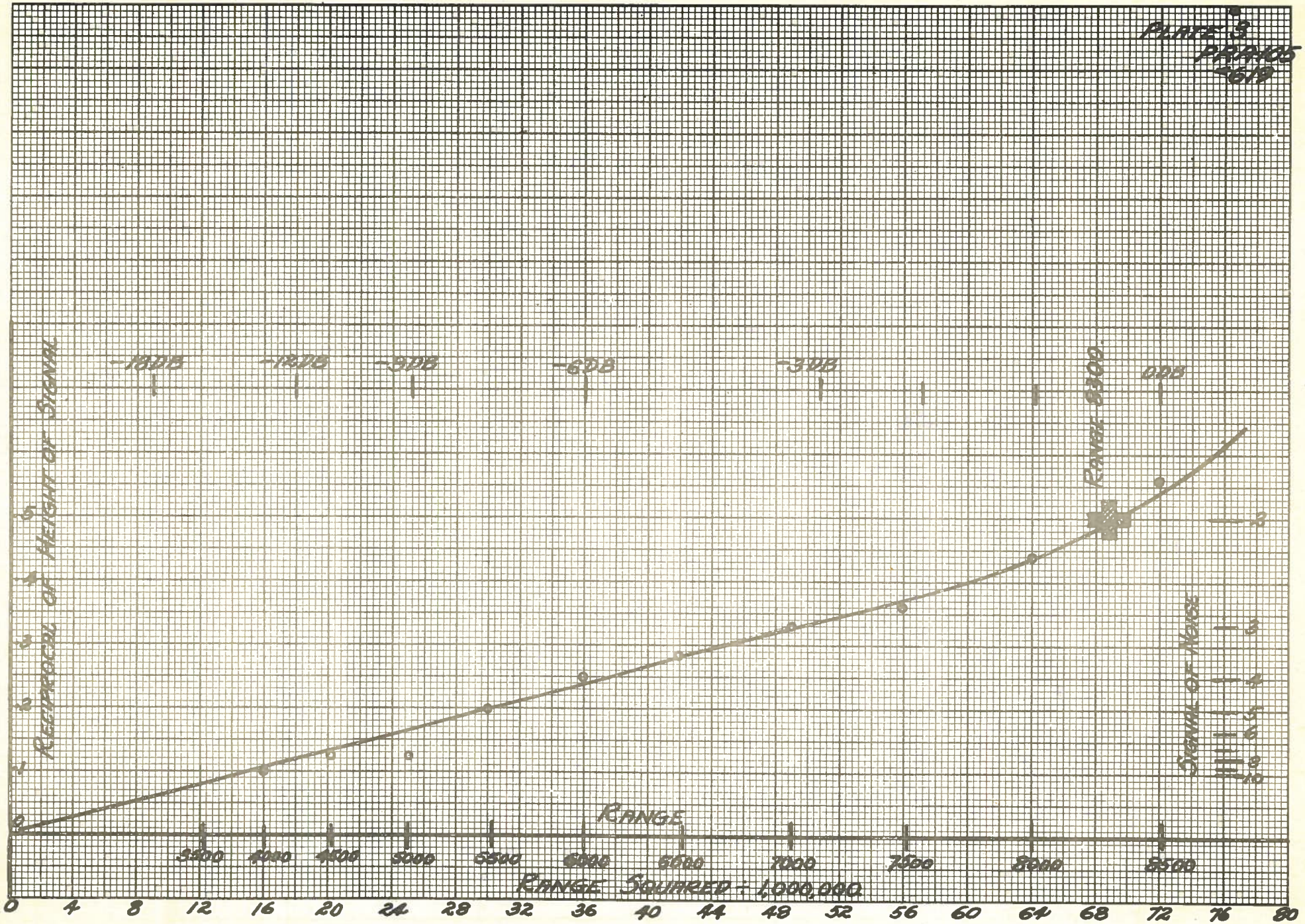


PLATE 3
-18DB
-12DB
-6DB
-3DB
0DB
Power Ratio
Decibels of Noise
Reciprocal of Height of Signal
Range
Range Squared ÷ 1,000,000
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 76 80
1 2 3 4 5
2 3 4 5 6 7 8 9 10