RESTRICTED

ORDNANCE PAMPHLET NO. **1081**

COMPUTER MARK 12, MOD. 1
OPERATOR'S MANUAL

A BUREAU OF ORDNANCE PUBLICATION

30 SEPTEMBER 1943

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NAVY DEPARTMENT

BUREAU OF ORDNANCE

WASHINGTON 25, D. C.

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COMPUTER MARK 12, MOD. 1, OPERATOR'S MANUAL

1. Ordnance Pamphlet No. 1081 contains a description of the Computer Mark 12, Mod. 1 as well as instructions for its use. This computer is to be mounted directly on the sight yoke of all 3″/50 caliber guns, and is designed to furnish the sight setter of the gun with the proper values of sight angle to maintain a line of sight barrage on a horizontal or glide bomber that is attacking the ship on which the gun is mounted. This computer is considered stand-by equipment for those guns having directors.

2. This pamphlet should be used by all gun crews and others interested in the use of the 3″/50 caliber gun as a defense against bombing.

3. This pamphlet does not supersede any existing publication.

4. This publication is *RESTRICTED* and should be handled in accordance with the provisions of Article 76, U. S. Navy Regulations, 1920.

W. H. P. Blandy

W. H. P. BLANDY,
Rear Admiral, U. S. Navy,
Chief of the Bureau of Ordnance

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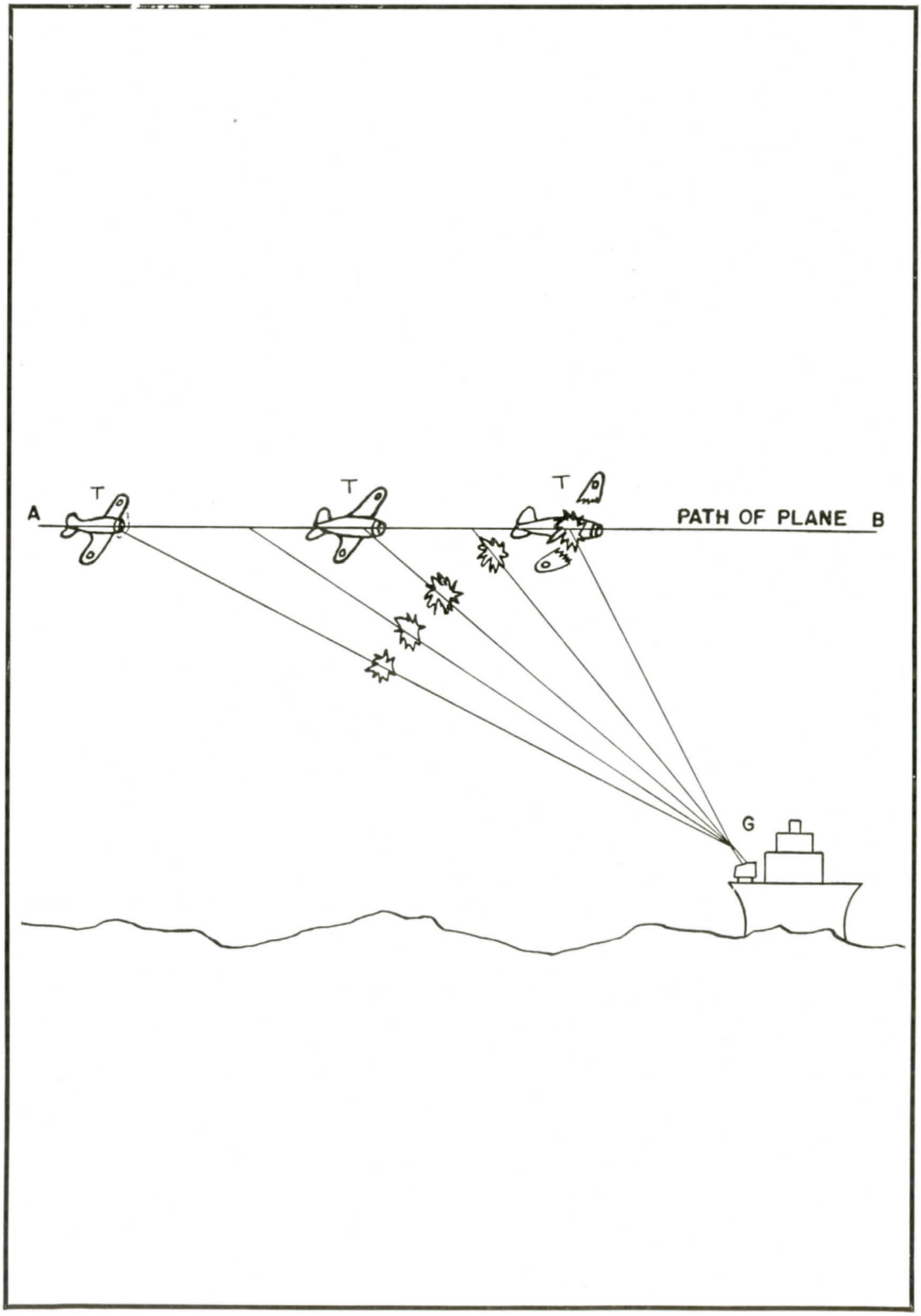


Figure 1

INTRODUCTION

The computer, Mark 12, Mod. 1, is a device which is mounted directly on the sight yoke of a 3 inch/50 caliber gun, and which furnishes the sight-setter of the gun with the proper values of sight angle to maintain a line of sight barrage on a horizontal or glide bomber that is attacking the ship on which the gun is mounted.

The computer is designed to furnish sight angle only, for either a glide or horizontal bomber which is attacking your own ship. It will *not* furnish data for a glide or horizontal bomber which is attacking any other ship. It will *not* furnish data (except in a very approximate form) for a dive bomber or a torpedo plane which is attacking any ship. The computer does not furnish any data for deflection. Deflection must be computed or estimated separately, and then the bursts spotted on in deflection.

The use of this computer requires no communication between the gun and any other point. Therefore it is suitable as a standby means of control on ships having directors and as a primary means of control on ships having no directors.

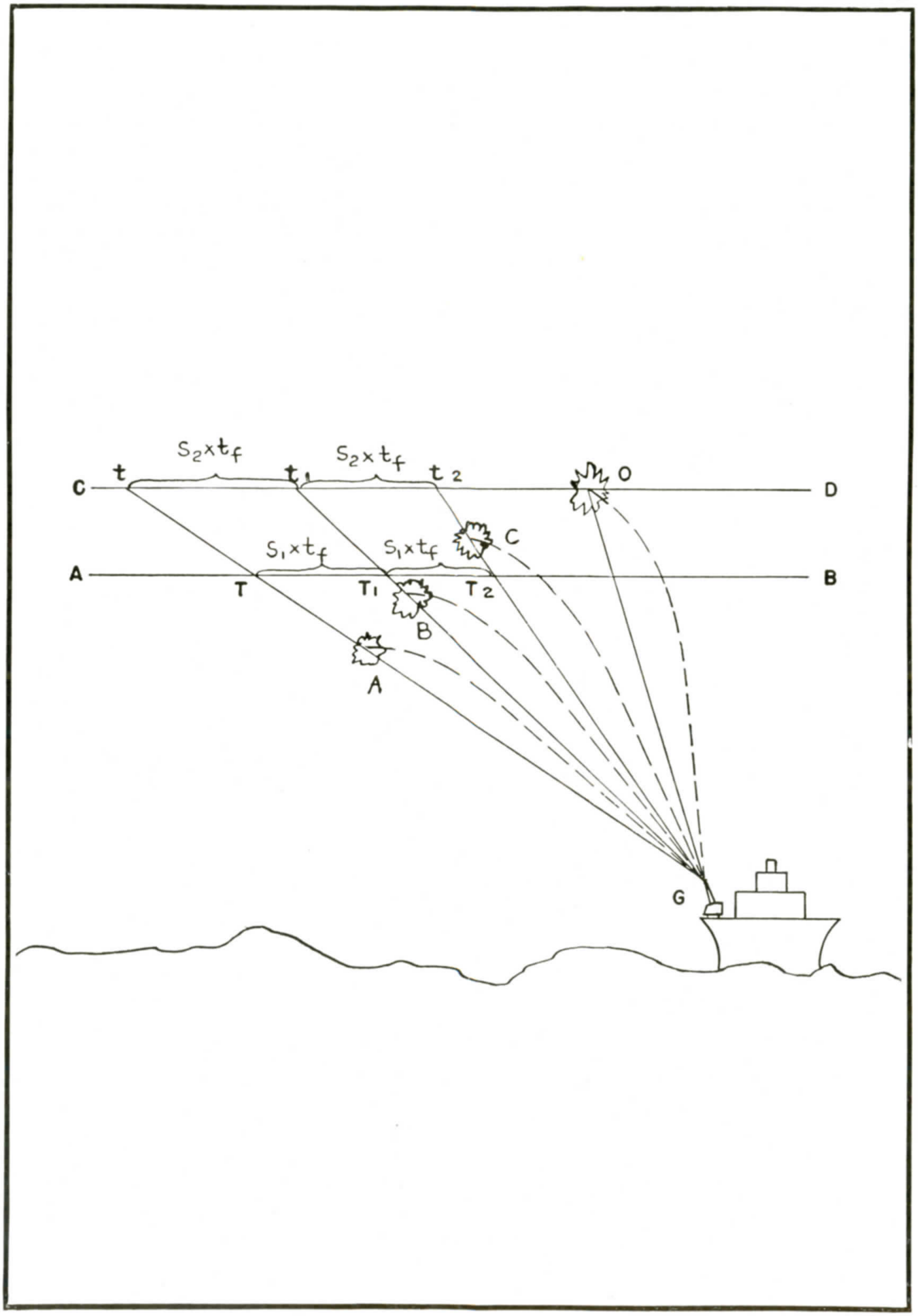
LINE OF SIGHT BARRAGE

Before finding out just how the computer works, it is necessary to have clearly in mind just what is meant by a line of sight barrage, and how such a barrage is fired.

A line of sight barrage is a series of rounds fired as quickly as possible from a gun, all of them with the same fuze setting, and all of them properly aimed so that they burst directly along the line of sight from gun to target. Since the computer will only solve the problem for a horizontal or glide bomber attacking your own ship, we shall consider that type of target only.

Consider Figure 1. The target, T, is making a horizontal bombing run on the ship, moving along the line AB. As it moves along line AB the line of sight from the gun, G, to the target, changes as shown by the series of lines from the gun to the line AB. If a large number of shells are fired, each with the same fuze setting, and each with the correct sight angle to burst in the line of sight, the bursts will move upward as shown, forming a curve which is almost a circle. At some point in the plane's flight, the range to the plane will equal the range of the burst; that is, the curve described by the bursts will intersect the plane's path, and the plane will be hit. Now it is relatively simple for the pointer to keep following the target as it follows the line AB, so that the line of sight to the target is established. The problem then is to know the correct sight angle at each instant so that the sights may be set correctly to make the bursts lie in the line of sight. It is the duty of the computer to inform the sight setter of this correct sight angle so that he may set it into the sights.

In order to understand how the computer does this, let's look at another drawing, (Fig. 2), similar to the first. The target is again attacking along the line AB. Now whenever we fire at a target the projectile takes a certain time to get to the point at which it bursts. During this time the target is moving. Thus if we fire while the target is at T the burst (A) will not occur until the target has moved to T1 and if we fire when the target is at T1 the burst (B) will not occur until the target is at T2. So in order to cause the burst to occur in the line of sight we must not fire the gun at the plane but at some point ahead of the plane. The angle ahead of the plane at which we must fire is called "lead" angle. Of course to cause the burst to occur at a definite point we must elevate the gun an additional amount to compensate for



C
t
$S_2 \times t_f$
t_1
$S_2 \times t_f$
t_2
O
D
C
$S_1 \times t_f$
$S_1 \times t_f$
A
B
T
T_1
T_2
B
A
G

Figure 2

the pull of gravity on the projectile. This additional elevation is called "superelevation." Then the total amount which the gun must be elevated above the line of sight to the target is the sum of the lead angle and the superelevation, and is known as sight angle.

Now consider that another plane (Fig. 2) is making a bombing run along the line CD, and moving faster than the first target, so that the line of sight will elevate at the same rate as before. If we fire while it is at t the burst will occur when it has reached t1, which is directly in line with the point at which the first plane was when the burst occurred. Obviously then, we want to fire the burst (B), when either of the two targets is at T or t, and the sight angle necessary to fire the round is the same for both targets. Thus it is the speed with which the line of sight is changing that determines the proper sight angle. Therefore to fire a correct barrage, we do not need to know the plane's altitude or its speed, but merely how fast it is causing the line of sight to elevate.

The design of the computer assumes several different conditions of target motion, that is, several different speeds at which the line of sight is elevating. To each of these speeds is assigned a class letter, as A, B, etc. Then the proper sight angles are computed for each of these classes for different position angles, and for different fuze times. It is these sight angles which the sight setter obtains from the computer and cranks into the sight.

It is now possible to study the computer itself and see how it furnishes the proper sight angle.

DESCRIPTION OF THE COMPUTER

The computer consists essentially of a plate, in the shape of a quadrant, mounted on the sight yoke of the gun. Figure 3 shows a front view of the computer, as the sightsetter sees it. Pivoted at the point of the quadrant is an arm with three small windows along its edge. The arm can move along the quadrant, and the data printed on the plate may be viewed through the windows of the arm. A thumb screw is provided at the left of the plate to lock the arm when not in use.

The plate itself is mounted on a backing plate, and can be moved relative to the backing plate. This relative movement is used to set into the computer the value of glide angle of the target. A slot and scale along the bottom of the plate are used for this setting, and a thumb screw at the right holds the plate in any desired position.

DESCRIPTION OF THE DATA PLATE

The data plate itself varies according to the gun and fuze for which the computer was designed. The only difference however is in the actual values of sight angle and fuze time, the principle remains the same.

The chief portion of the data plate is the sight angle scale for the various types of bombing run and fuze time. These are arranged in parallel rows along the quadrant. Each row is designated by a number and a letter, the number representing the fuze time in seconds, and the letter being the class letter previously mentioned. Along the bottom of the sight angle scales is a scale of position angles.

Above the sight angle scales, are approximate data for dive bomber and torpedo bomber targets. For each of these types of target the data consists merely of one arbitrary value of sight angle which is set into the sights and used during the entire barrage.

At the bottom of the quadrant is a scale for setting in glide angle of the target.

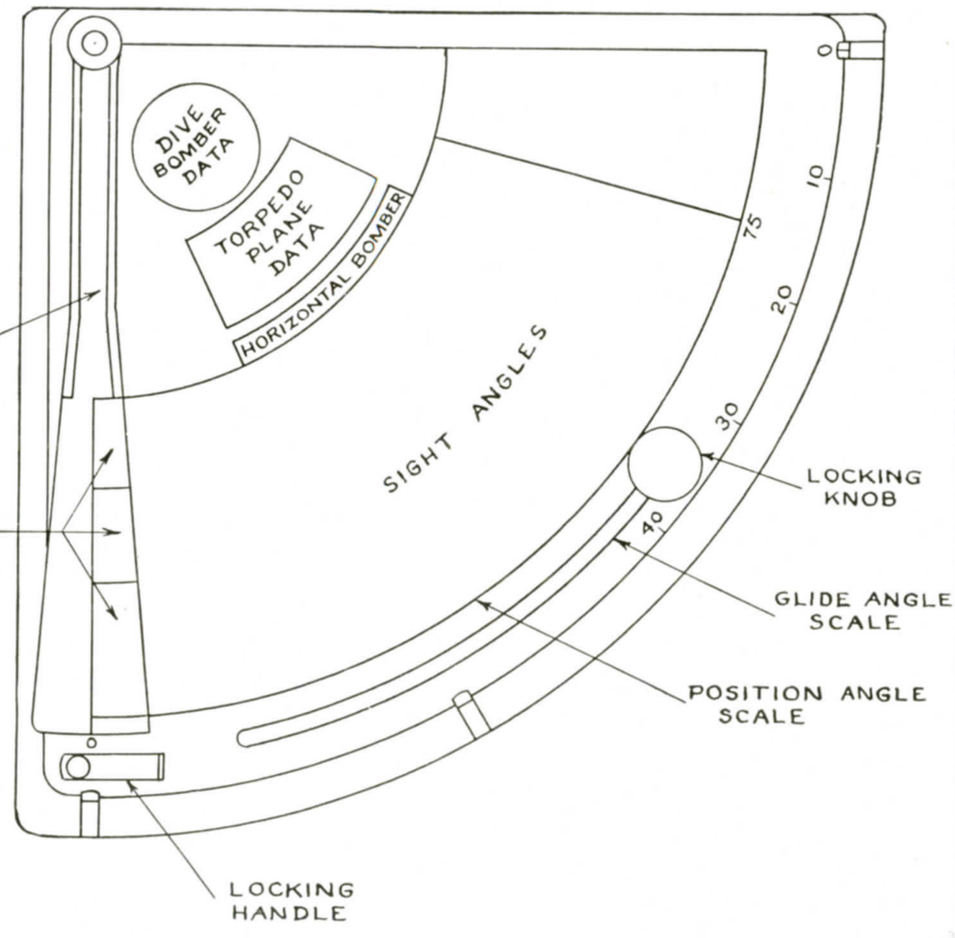

DIVE BOMBER DATA
TORPEDO PLANE DATA
HORIZONTAL BOMBER
SIGHT ANGLES
0
10
75
20
30
40
ARM
WINDOW
LOCKING KNOB
GLIDE ANGLE SCALE
POSITION ANGLE SCALE
LOCKING HANDLE

Figure 3

OPERATION

The operation of the computer is extremely simple. The control officer, or gun captain, observes the target and determines what fuze and class letter to use. Methods of determining these will be given in a later section of this pamphlet. He calls out a number and letter representing these two quantities. The pointer gets on the target and elevates the gun so as to keep his horizontal cross-wire on the target as it approaches. The sight setter observes the position of the arm on the computer and reads through the window of the arm the sight angle on the data plate which is opposite the proper letter and number on the arm. Thereafter, as the pointer keeps on the target and the gun elevates, he keeps changing the sight angle to agree with that shown on the plate opposite the proper point of the arm. The arm of course stands still, and the data plate moves under it as the sights elevate. Therefore the arm is always opposite the proper value of sight angle corresponding to the target elevation. The sight setter must constantly change the sight angle, cranking slowly so as to agree with the value on the plate as soon as he gets to the value. This is the only difficult part for the sight setter.

As long as the pointer tracks the target properly and the sight setter keeps the sights set to the proper value as shown on the quadrant the problem is theoretically solved and every burst should obscure the target; that is, should burst in the line of sight.

If the arm swings violently due to shock of gun fire or lurching the ship it must be steadied by hand.

If the bursts do not lie in the line of sight, the original determination of the class letter was wrong and the control officer should order a new letter. If the burst was low, order a new letter earlier in the alphabet. If the burst was high, order a new letter further along in the alphabet. As soon as one burst obscures the target the problem is theoretically solved and all bursts should thereafter lie in the line of sight.

The computer does not furnish any data for deflection. The deflection must be figured separately and put into the sights before firing. Then the bursts should be spotted directly onto the target in deflection.

DETERMINATION OF THE PROPER CLASS LETTER

Two methods are possible for determining the proper class letter. They are the tracking method and the spotting method. The tracking method is the most accurate and should solve the problem with the least number of rounds fired, but it can be used only when there is sufficient time to track the target for some time before opening fire. The spotting method must be used when there is not sufficient time to track the target before opening fire. The methods of performing the two methods are as follows:

Tracking Method. Have the pointer and trainer track the target. While tracking, measure the position angle of the target at any moment and then measure how long it takes for the position angle to increase ten degrees. Position angle may be read off the position angle scale below the sight angle scales of the computer.

Each gun captain or control officer is furnished with a table, a copy of which appears as Table 1 in this pamphlet. Enter the table with the position angle at the beginning of the measurement and with the number of seconds required for position angle to increase 10 degrees, and take out the class letter from the top of the table. Commence firing with this class letter.

Spotting Method. Commence firing immediately when the target is sighted, using class letter H, which is the central class. Then spot the bursts onto the target by a change in class letter as explained above.

DETERMINATION OF THE PROPER FUZE SETTING

The computer supplies data for firing barrages with either of three different fuze settings. For the three inch gun these are 4, 6, and 8 seconds. It is necessary to determine just which barrage to use before opening fire.

The proper fuze setting depends on the range of the target. The range corresponding to each fuze setting is given in Table 2.

If some means of obtaining range is available the fuze setting can be easily obtained from the range. Each control officer should know the range corresponding to each of the three fuze settings. As soon as he finds out the range he knows to begin firing at that fuze setting which gives a range lower than the target range. Thus if on a 3 inch/50 caliber gun, he finds out that the range is 4000 yards he commences firing with a fuze 6 seconds because the range is between the two ranges of 6 and 8 second fuzes.

In the majority of cases, however, no means of determining range will be available. Then the first barrage should be fired with the longest fuze setting, which it is estimated will produce bursts short of the target. If, while firing, it becomes apparent that the target has penetrated the barrage, the fuze setting should be changed to the next lower setting and firing continued. When changing to the next lower setting it is not necessary to change the class letter, merely change the fuze setting. Thus if you are firing a barrage of 8H and it is evident that the target has penetrated the barrage, the correct order is "6H. Resume firing," or "4H. Resume firing." Do not hold up fire while the fuze setting is being changed but continue to fire as fast as possible.

GLIDE BOMBERS

All of the above data is given for horizontal bombing targets. The engraved plate should be set at zero angle of dive under such conditions. However, the data shown on the plate is approximately correct for glide bombers. If the angle of glide is estimated at approximately 20°, set the engraved plate at 20° angle of dive and use as before. The important thing is to make all bursts cover the target. If using Tracking Method, to find the class letter, enter Table 1 with first position angle minus the angle of glide which is set into the computer.

DIVE BOMBERS AND TORPEDO PLANES

In firing a line of sight barrage at either a dive bomber or a torpedo plane, the problem is somewhat different from firing at a level or glide bomber. In the case of either the dive or torpedo plane, the target is attacking along the line of sight, so the line of sight remains fixed instead of moving as in the level bomber. Therefore the sight angle need not be changed as the target approaches, but may remain fixed. An approximate sight angle for each of these two types of planes has been computed and engraved on the face of the computer.

If the target is diving at you, use the data shown in the small engraved circle in the upper left corner of the predictor. If the target is making a torpedo run, set data as indicated in the engraved square. This data is not exact and should be corrected by spotting when bursts appear. Never check fire to spot.

MOUNTING

The computer is mounted on the sight yoke of the gun by means of a mounting bracket which is behind the backing plate of the computer. This bracket cannot be seen in Figure 3. Two adjusting holes are provided so that the plate may be adjusted with respect to the bracket and hence with respect to the sight yoke. Minor adjustments should be made with shims.

The computer may be easily mounted by the ship's force. The mounting, particuarly the two final steps, should be done while the ship is in very calm water, preferably anchored.

Figure 4 shows the computer properly mounted on a 3 inch/50 caliber gun. The process of mounting is as follows:

1. Adjust computer on sight yoke for most convenient position for sightsetter.

2. Make sure that no interference exists between the computer Mark 12 and the gun mount.

3. Using the computer mounting bracket as a template, drill the three mounting holes in the sight yoke. Care should be taken to have the long edge of the mounting bracket parallel to the axis of the gun.

4. Mount the computer on the sight yoke with the mounting bolts provided.

5. Boresight the gun.

6. With the sights kept on the horizon by the pointer, adjust the computer by means of the two mounting holes in the backing plate or shims under the mounting bracket until the pointer on the arm is at zero on the position angle scale.

The computer should now be ready for use. The only care it needs is an occasional oiling of the arm to keep it swinging freely. The arm should be kept in the locked position at the left side of the data plate when not in use.

DISCUSSION

Regardless of whether the Tracking Method or the Spotting Method is used it must be borne in mind that the objective is to establish a line of sight barrage in which every burst is intended to obscure the target. In any solution (assuming perfect pointing, sightsetting and fuze operation) wherein the first burst appears low all subsequent bursts will appear low, and they will continue to draw lower. The solution is to spot up to a higher line on the data plate. When one burst obscures the target, every succeeding burst should obscure the target if the target maintains course and speed. Any maneuvers of the target must be countered with an appropriate change of class letter. Thus it appears that either method will ultimately depend upon spotting.

In case it becomes impossible to get on the target because the engraved data is all too high or too low, this situation may be corrected by altering the angle of dive on the computer to an arbitrary setting which will produce the desired results. This should be done with very small and cautious changes of angle of dive.

The computer is suitable only against a bomber target which is actually attacking your own ship. It has limited application only and should never be considered as a cure all for all the problems of gunnery. It will not solve the problem against bombers attacking some other ship. It will not solve deflection against a bomber target attacking your own ship. Deflection must be spotted separately and must be spotted directly to the target. Spotting drill is necessary for any gun's crew whether they use this predictor or not. All types of gun drill are

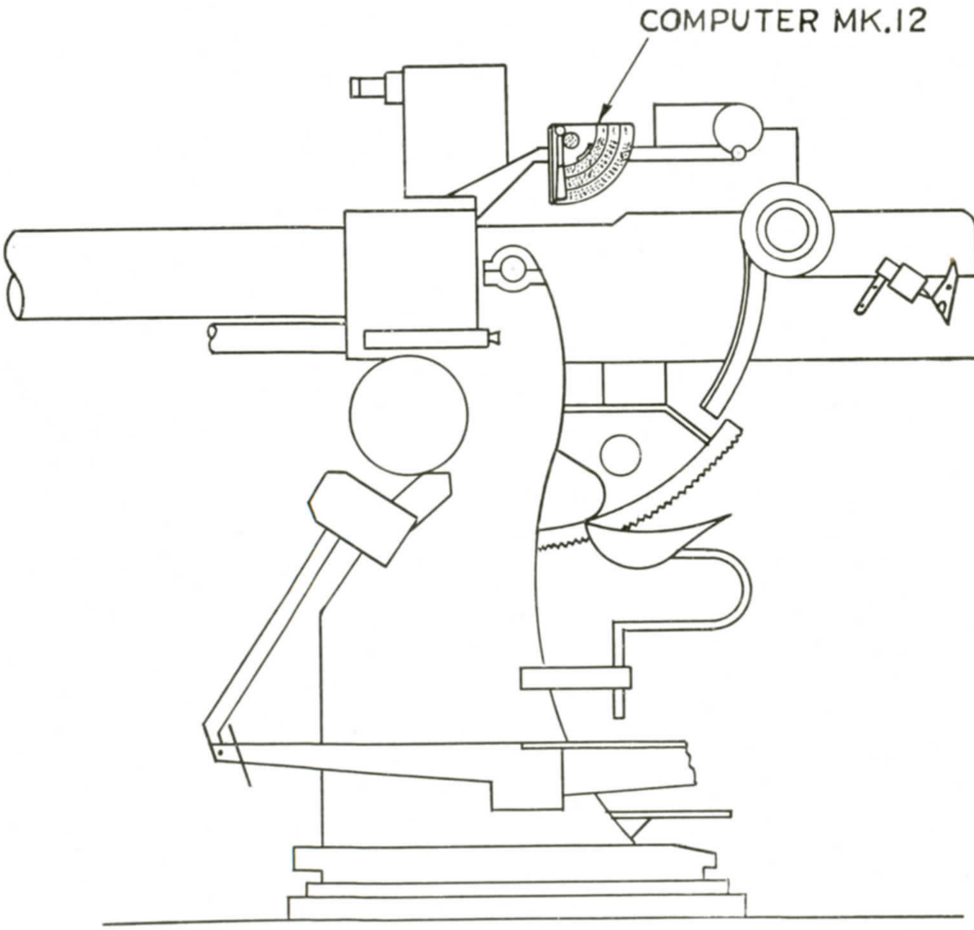


Figure 4

just as necessary as without the use of this unit. It will not solve the problem against a torpedo plane. It will not be of any value unless the sightsetter receives a great deal of drill in its use.

The computer solves the problem for targets having relatively high elevation rates. The rates chosen were values which it was believed might be met in battle against planes of modern design. In some cases the computer may not achieve a rate sufficiently low to effectively control fire against a very slow-moving high-flying target, for example a towed sleeve making 80 knots at 6000 ft. However, it will generally take care of plane speeds in excess of 100 knots. A burst target, now in popular use by auxiliaries of the fleet, has an elevation rate of approximately zero. The computer positively will not solve this type of fire. If used, it should cause the shots to go radically above the burst target. The autogyro and the balloon are about the only types of aircraft which can remain stationary in the sky. Military targets will normally have high elevation rates, and it therefore seems desirable to point out that the gun's crew which has spent all of its time firing on stationary targets is very likely to be baffled in action. Practice firing against towed sleeves or towed flares is recommended at every opportunity.

Attention is invited to the following which should be stressed once more: When a target passes through one barrage, the proper procedure is to shift to a closer barrage, that is use ammunition with lower fuze settings. If you were firing successfully using an 8-H barrage with the bursts actually appearing on the line of sight to the target and possibly silhouetting the target and you decide to shift to a 4-second barrage, the proper procedure is to order 4-H resume firing. That is, the same class letter will apply in any of the three barrages. The class is a characteristic of the type of run which that particular target is making. It should be further noted that ships not mounting stereo antiaircraft rangefinders may experience considerable difficulty in determining when a target has transmitted the barrage. If you are positive that you can see bursts actually obscuring the target from your view, then the barrage is perfect and you should let it ride that way. If you are positive that you can see bursts silhouetting the target then the target is inside and your barrage has now become worthless. Bursts must be short in order to produce hits. If in doubt, come all the way in to the 4-second barrage.

DRILL PROCEDURE

The gun captain conducts the drill. He directs the pointer to follow some specific target or to elevate the gun at some suitable rate. He then orders a class letter and number. After ten or fifteen seconds he commands "Stop." Upon this command the pointer is required to stop elevating and the sightsetter is required to stop setting sights. The barrage sight angle data showing through the window of the pendulum is read and recorded. The existing sight angle set on the sights is also read and recorded. If the two figures agree within ten minutes the sightsetter is considered to have performed well. Continual practice will enable the sightsetter to sense the proper rate at which to crank his dial to get a high score using any class letter. This drill should be held quite frequently, preferably three times weekly or oftener. It should be pointed out that the sightsetter can not be expected to have his eyes on the computer data plate and on his sights simultaneously. He must sense a certain rate at which to crank the sights in order to keep them matched against the data plate. His eyes should continually rove back and forth from sights to computer and he must continually check the two in order to insure that his hand is cranking the sight angle at the proper rate. Drill over a long period of time on various ships of the fleet has established the fact that this procedure is practicable. Any sightsetter who continually exhibits an incapacity to solve the problem by arriving at a proper rate at which to crank his sight-angle hand wheel should be replaced by a person with quicker reflexes. It is doubtful that there is any value in stationing one person to read and call off the sight angles, while a second person sets them. In fact, this procedure defeats one of the objectives sought in the design of the predictor, namely, extreme simplicity.

TABLE 1

3″/50 cal. AA Gun

TIME IN SECONDS TO INCREASE POSITION ANGLE 10°

First Pos. Ang.	Class Letter										
	A	B	C	D	E	F	G	H	I	J	K
10°	29	32	37	42	49	53	58	65	73	84	97
11°	25	28	32	36	42	46	51	57	64	73	85
12°	22	25	28	32	37	41	45	50	56	64	74
13°	20	22	25	28	33	36	40	44	49	57	66
14°	18	20	22	25	29	32	35	39	44	50	59
15°	16	18	20	23	26	29	32	35	40	45	53
16°	14	16	18	21	24	26	29	32	36	41	48
17°	13	14	16	18	22	24	26	29	32	37	43
18°	12	13	15	17	20	22	24	26	30	34	40
19°	11	12	14	15	18	20	22	24	27	31	36
20°	10	11	12	14	17	18	20	22	25	29	34
21°	9	10	12	13	15	17	19	21	23	27	31
22°	9	10	11	12	14	16	17	19	22	25	29
23°	8	9	10	11	13	15	16	18	20	23	27
24°	7	8	9	11	12	14	15	17	19	22	25
25°	7	8	9	10	12	13	14½	16	18	20	24
26°	6	7	8	9	11	12	13	15	17	19	22
27°	6	7	8	9	10	11	12	14	16	18	21
28°	6	7	8	9	10	11	12	13	15	17	20
29°	5½	6½	7	8	9	10	11½	12	14	16	19
30°	5½	6	6½	7½	9	10	11	12	13	15	18
31°	5	5½	6½	7½	8	9	10	11	13	14	17
32°	5	5½	7	7	8	9	10	11	12	14	16
33°	4½	5	6	6½	8	8½	9	10	11	13	15
34°	4½	5	5½	6½	7	8	9	10	11	13	15
35°	4½	5	5½	6	7	8	9	10	11	13	14
36°	4	4½	5	6	7	7½	8	9	10	11	13
37°	4	4½	5	5½	6	7	8	9	10	11	13

TABLE 2

Ranges Corresponding to Fuze Settings

3 INCH 50 CALIBER GUN

Fuze	Range
8 sec.	4650 yards
6	3800
4	2800

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