C & D Staff — Operations

RESTRICTED

MACHINE GUN BULLETIN NO. 2

JUNE 1942

THE

TWENTY MILLIMETER

MACHINE GUN

UNITED STATES FLEET

HEADQUARTERS OF THE COMMANDER IN CHIEF

RESTRICTED

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UNITED STATES FLEET
HEADQUARTERS OF THE COMMANDER IN CHIEF
NAVY DEPARTMENT, WASHINGTON, D.C.

June 18, 1942

This Bulletin contains pertinent information derived from extensive firing of 20 mm. guns at Antiaircraft Training and Test Center, Dam Neck, Virginia, using aim-off method of control, tracer control, and Mark 14 sight control.

W. A. LEE, Jr.,
Assistant Chief of Staff.

DISTRIBUTION: (Standard Navy Distribution List No. 1, June 15, 1942.)

List 1 - less u,v,w.

List 2 - less c,j,k,l,m,n,s,u,v,x,y.

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List 4 - Same as List 3.

List 6 - less River Commands.

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ANTIAIRCRAFT MACHINE GUN TRAINING CENTERS

There are now in operation seven (7) antiaircraft training centers available for training antiaircraft machine gunners in all types of automatic weapons. These stations are:

(1) ANTIAIRCRAFT TRAINING AND TEST CENTER, DAM NECK, VIRGINIA

This station, located south of Virginia Beach, about 40 minutes by truck from Norfolk, can house and mess 200 men.

Training facilities now include: one synthetic machine gun trainer; four 20 mm. machine guns; one 1"1/75 quadruple mount; one 40 mm. twin mount; eight caliber .5C machine guns; numerous caliber .30 machine guns; one 3"/50 double purpose gun.

(2) ANTIAIRCRAFT TRAINING CENTER, PRICE'S NECK, NEWPORT, R.I.

This station, located about 2 miles from Newport, can berth and mess 200 men.

Training facilities now include: six 20 mm. machine guns; one 1"1/75 quadruple mount; one 40 mm. twin mount; six caliber .50 machine guns; six caliber .30 machine guns.

(3) ANTIAIRCRAFT TRAINING CENTER, POINT MONTARA, CALIFORNIA

This station, located about 28 miles south of San Francisco on main coastal highway, is now constructing facilities for berthing and messing 200 men.

Present facilities include: four 20 mm. machine guns; one 1"1/75 quadruple mount; one 40 mm. twin mount; six caliber .50 machine guns; six caliber .30 machine guns.

(4) ANTIAIRCRAFT TRAINING CENTER, PORT ANGELES, WASHINGTON

This station, located at the entrance of the Strait of Juan de Fuca near Port Angeles, is now constructing facilities for berthing and messing 200 men.

Present facilities include: four 20 mm. machine guns; one 1"1/75 quadruple mount; one 40 mm. twin mount; six caliber .50 machine guns; six caliber .30 machine guns.

(5) ANTIAIRCRAFT TRAINING CENTER, GUANTANAMO BAY, CUBA

Facilities similar to those available at Price's Neck, Rhode Island, are now under construction and it is expected that the station will be in full operation by July 1. Facilities are at present available for .30 caliber, .50 caliber and 20 mm. firing.

(6) ANTIAIRCRAFT TRAINING CENTER, WAINAI

An antiaircraft training center, duplicating in general the facilities at Dam Neck, Virginia, has been constructed at Wainai, Oahu Island. This station is to be operated under the Commandant, Fourteenth Naval District. This antiaircraft training center is now in commission.

(7) ANTIAIRCRAFT TRAINING CENTER, PACIFIC BEACH, CALIFORNIA

An antiaircraft training center with facilities similar to those at Price's Neck, is being constructed near Pacific Beach, north of San Diego, California. This center, when completed, will be available for armed guard training and refresher firing.

Establishment of additional antiaircraft training centers in the following locations is under consideration: New Orleans, La., Great Lakes, Ill., and Bermuda.

At all of the foregoing stations it is intended that as soon as new type machine guns and directors appear in service these also will be installed, specifically 40 mm. twin and quadruple mounts with associated directors. It is also planned to install a rolling platform for training of machine gunners under firing conditions, simulating the motion of a ship at sea.

The purpose of these stations is three-fold:

(1) To make available to crews of ships of new construction facilities for indoctrination firing and instruction in the use of automatic antiaircraft weapons, particularly new types, now being installed in vessels of the Fleet.

(2) To permit indoctrination and training of officers and men from ships undergoing overhaul and repair during which new type heavy weapons are installed, permitting these ships to depart from yards with crews of automatic weapons sufficiently trained to overcome the disadvantages incident to changes of weapons.

(3) To provide training for machine gunners from ships in the vicinity, armed guard crews, and other personnel requiring both training and refresher firing.

All ships are enjoined to take advantage of these facilities.

CONSTRUCTION

Construction is completed at Dam Neck and is nearly completed at Price's Neck. $176,500 has been allotted for completion of the Point Montara project. $194,790 has been been allotted for the Port Angeles project. $245,000 has been allotted for Price's Neck. In addition to the above, $10,000 was authorized by the Secretary of the Navy on March 7th for the construction of an armed guard antiaircraft training center in the San Diego area, to consist of minimum facilities as follows:

Concrete ramp for installation of four 20 mm., six caliber .50, and six caliber .30 machine guns, small magazine and armory, and repair shop containing berthing facilities for a security watch.

AMMUNITION ALLOWANCES

Ammunition allowances at the present time are dependent a great deal upon availability of ammunition due to current shortages. An ammunition allowance of 20,000 20 mm. per month is established for each center, except Dam Neck and Price's Neck where the allowance is 30,000. The allowance of 1"1 ammunition will be 15,000 per month to May 1st, when target practice ammunition is expected to become available. After that date the allowance will be 30,000.

No fixed allowance of caliber .50 or caliber .30 can be made at this time due to current shortages. As much ammunition as can be spared will be allotted from time to time to these activities.

COMPLEMENTS

The Bureau of Personnel has established the following complements for antiaircraft training centers, except the armed guard training center for which no complement has as yet been established:

1 Lieutenant or Lieutenant, junior grade, as Officer in Charge
1 Ensign, assistant

1 CBM	1 Y3c
1 CGM	1 CSK
2 GM1c	1 SK1c
4 GM2c	1 SK2c
4 GM3c	1 SK3c
1 FC1c	1 PhM1c
5 Sea1c	1 CCStd
5 Sea2c	1 SC1c
1 EM2c	1 SC2c
1 MM2c	1 SC3c
1 CY	1 Bkr1c
1 Y2c	

An additional 10 seamen second class have been requested from the Bureau of Personnel since experience at Price's Neck indicated the necessity of this increase for proper functioning of the training center.

Each training center has been furnished 6 trained instructors who are counted as part of the complement of gunner's mates.

Dam Neck has its full complement of officers.

Price's Neck has two officers, one of them for temporary duty only.

Point Montara - A lieutenant has been ordered as officer-in-charge and an ensign has been ordered as assistant.

Port Angeles - A lieutenant has been ordered as officer-in-charge.

Guantanamo - A lieutenant, junior grade, has been ordered as officer-in-charge of the Antiaircraft Training Center, Guantanamo Bay, Cuba, after undergoing a course of training at Dam Neck, Virginia. Nine (9) trained instructors have also been ordered to that activity.

The Bureau of Personnel expects the personnel to be furnished insofar as possible by the District Commandant concerned, with requests for absolutely necessary ratings which can not be supplied. Many substitutions of lower ratings will necessarily be made.

The Bureau of Personnel has been requested to order the full complement of officers to these activities at the earliest possible moment. No request for the personnel of the armed guard unit at San Diego has been made, and none will be made until recommendation of the Commandant, Eleventh Naval District, is received upon that subject.

The Bureau of Personnel has been requested to detail a Supply Officer for each antiaircraft training center in order to relieve the commanding officer of the burden incident to rapid turnover of personnel in training.

Two lieutenants have been ordered to Dam Neck for two weeks intensive course in training and operating A.A. training and test centers, then to take over operation of training centers on the west coast.

Two towing planes have been provided for exclusive use of each A.A. training center, and arrangements for the necessary towing equipment are now being made.

Antiaircraft machine gun training facilities are also available at:

(1) Puuloa Point (Pearl Harbor area), now operating under Commander in Chief, Pacific Fleet.

(2) In U.S.S. WYOMING, operating under Commander Service Force, Atlantic Fleet.

REFERENCES

The following references are available and should be consulted:

20 mm. A.A. gun and mount Mark 4 and Mark 2..... O.P.813

Extracts from O.P.813..... O.P.826

Gun Sight Mark 14 and Mark 14 Mod. 1.....O.D.3733

FIGURE I

NOTES ON OPERATION OF 20 mm. ANTIAIRCRAFT GUN

I. GENERAL

The 20 mm. antiaircraft gun, classed as a heavy machine gun, is the latest antiaircraft weapon put in service by the Bureau of Ordnance. It is simple in operation, rugged, and extremely effective. Figure No. 1, on the opposite page, is indicative of the lack of vibration and smoke. Note particularly the freedom from vibration of the muzzle and of the gunner.

The gun has been classified as the largest free swinging machine gun available, and the smallest machine gun firing explosive projectiles.

II. GUN CREW

The 20 mm. gun can be fired effectively by one man but should have a normal "General Quarters" complement of four.

The duties assigned are:

NUMBER 1 (GUNNER)

The gunner should take a firm stance with legs spread about 2-1/2 to 3 feet apart, shoulder strap fitting snugly so the gunner's chest is well up against the braces, allowing the weight of the upper part of his body to rest back on the strap. The knees should be slightly bent, or just about to bend. The right hand should hold the grip firmly and be used in guiding the gun while the left hand should be used partly as a guide, but primarily for operating the trigger.

NUMBER 2 (TRUNNION OPERATOR)

The trunnion operator is assigned the duty of keeping the gun at the proper height for the gunner, regardless of angle of elevation. Improper operation of this trunnion height adjustment may make it impossible for the gunner to get on the target. It has been found that the trunnion operator can keep the trunnion at the right height by adjusting so that the gunner's knees are very slightly bent, therefore, the trunnion operator simply watches the gunner's knees and turns the adjusting wheel slowly to keep the gunner in proper stance. In order to impress on the trunnion operator the necessity for proper operation of trunnion, he

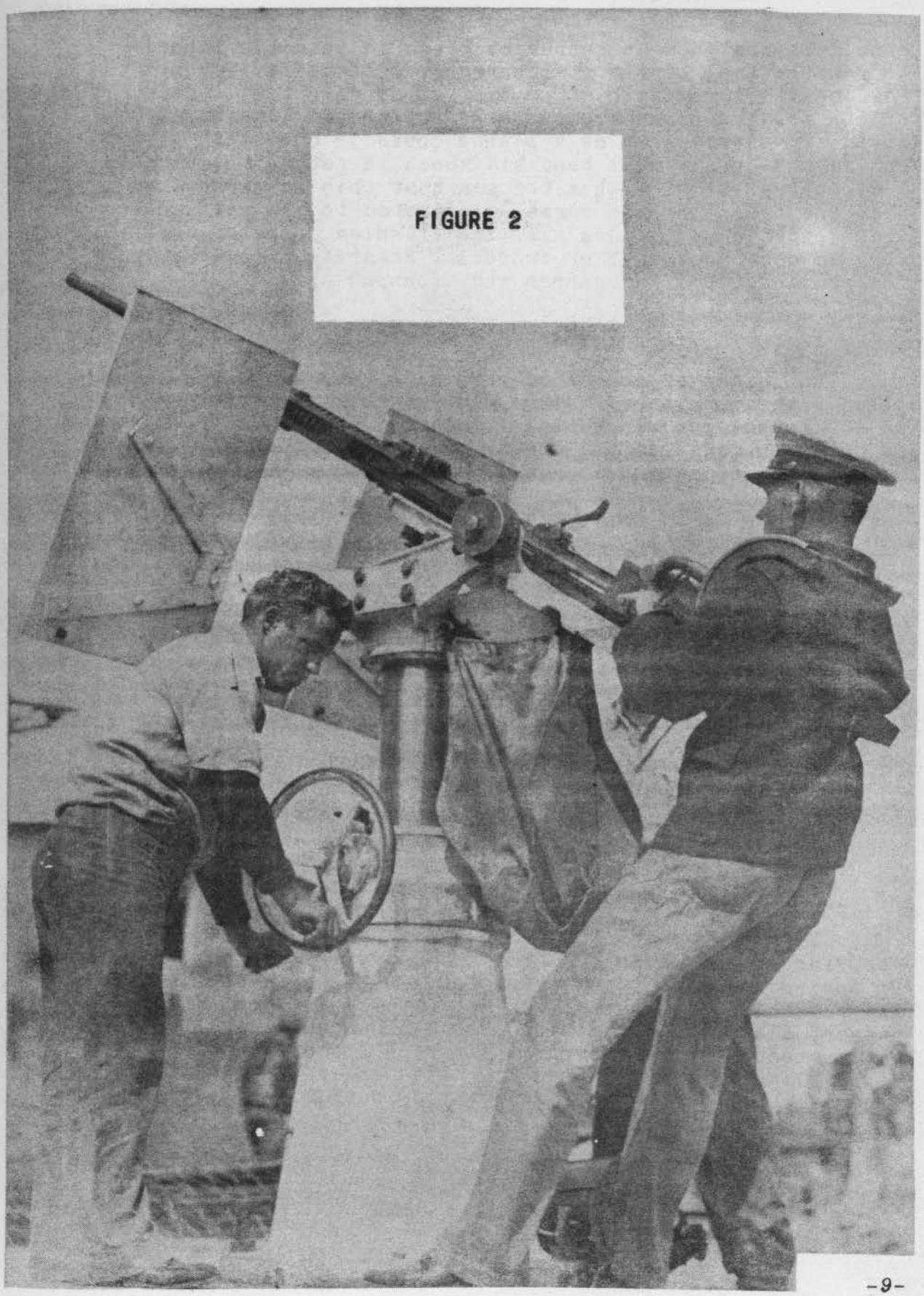


FIGURE 2

should be assigned as gunner as often as possible in order to get the feel of the stance required of the gunner and to realize it is impossible for the gunner to get this stance unless the trunnions are operated properly. (It should be noted, however, that as a planes comes in from very high angles the gunner *must* bend his knees to get on the target. A demonstration will show the men that this is natural and that the trunnions are normally elevated to the maximum for such conditions.) *Above all, the trunnion operator must not turn to observe target or tracers.* Refer to figure No. 2 for proper stance for gunner and trunnion operator.

NUMBER 3 (LOADER)

The loader is concerned only with keeping the gun supplied with ammunition. Since the rate of fire of the gun is 480 rounds per minute and a magazine holds only 60 rounds, it is essential that the loader be adept in changing magazines. The operation is simple:

(a) The magazine should be tilted slightly with forward end down and the forward guide lugs slipped *all the way forward* flush against the magazine receiving slot.

(b) Next, the rear of the magazine is put smartly into place with a sharp downward motion.

(c) Loader should check and see that magazine is firmly locked into place by shaking magazine with handles. If locked there will be no motion of magazine.

Figure No. 3, showing the loader removing a magazine is an excellent example of the proper way both to load and unload.

NUMBER 4 (AMMUNITION PASSER)

The fourth member of the gun's crew is responsible for removing loaded magazines from the ready service box, setting up spring tension if necessary, passing them to the loader, and returning empty magazines to the clipping room. The passer, also, between firings, should remove brass from the bag suspended below the gun into which the gun empties. As with all automatic equipment careless and rough handling of magazines can deform and derange them sufficiently to result in a serious stoppage.

Figure No. 4 shows numbers 1 to 8 in their proper positions in a ready condition.

FIGURE 3

The stations described above will be subject to some change with the introduction of the Mark 14 sight. This will be further discussed in the section devoted to "Control."

III. CONTROL OF FIRE

To date lack of sufficient firing experience with the 20 mm. prevents drawing firm conclusions as to the most effective methods of control and the limiting effective ranges under the several methods. Indications are however that the gun is not effective beyond the following ranges:

METHOD OF CONTROL	LIMITING RANGE
Forward Area Sight Tracer	1200
Mark 14 Sight	1700

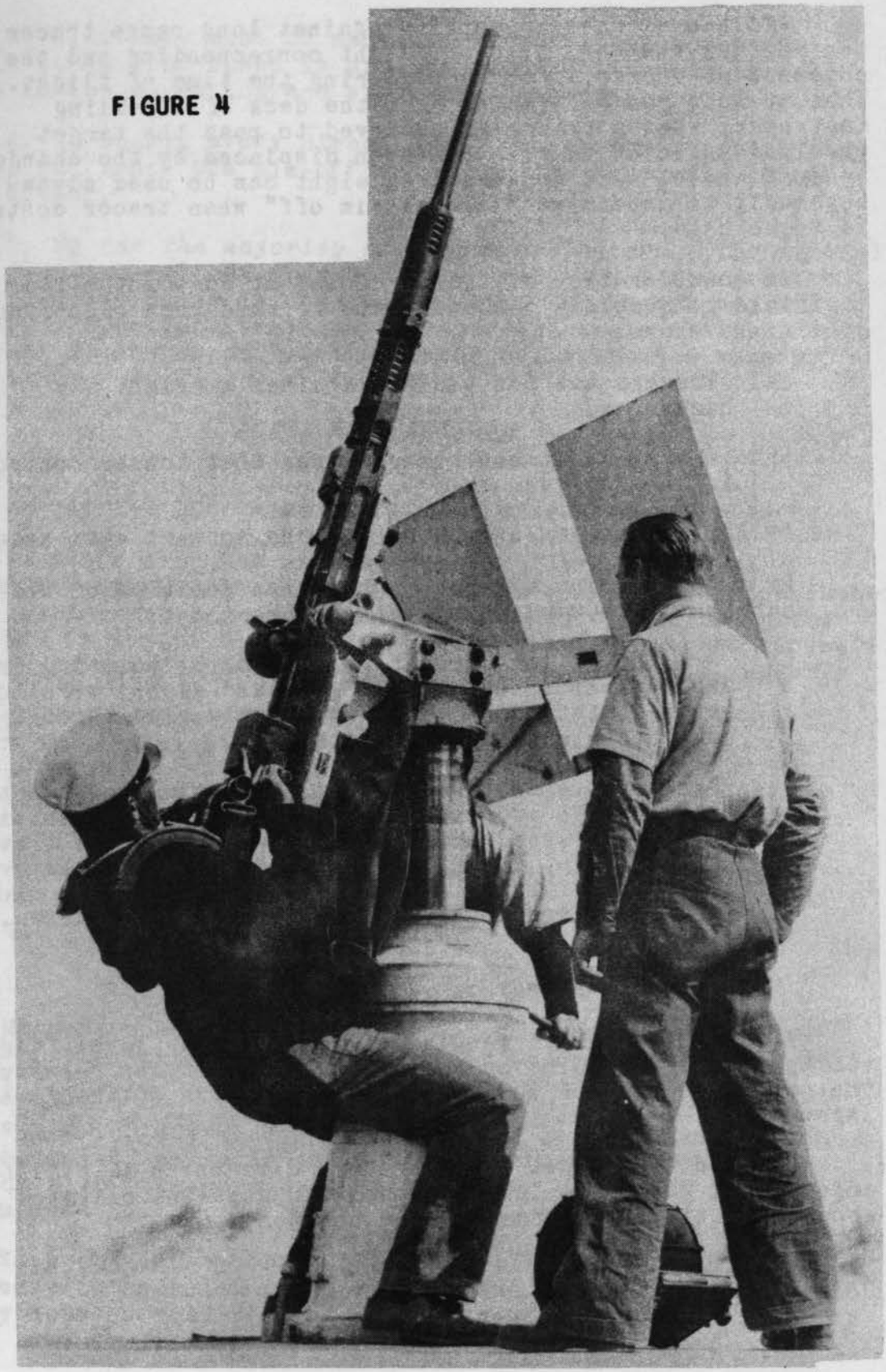
Conventional forward area sights are supplied with each gun. Because of the years of experience in the U.S. Navy with tracer control of the caliber .50 machine gun most ships remove the sights after a short trial and go back to tracer methods. Since, regardless of what automatic aiming devices are supplied later, either tracer control or forward area sight control must always be a standby method, some consideration should be given to the subject of "sight versus tracer" with this weapon.

It has been well established that the limit of unaided stereo vision for an individual of normal eyesight is not over five hundred yards. This fact has an important bearing on tracer control.

By far the majority of caliber .50 hits are obtained at ranges under five hundred yards where it is possible for the normal gunner to follow the instruction, "Observe the tracer stream only at the range of the target, disregarding all other parts of the trajectory." Since the caliber .50 firing has been at these ranges experience with this gun does not permit conclusions as to methods to employ at longer ranges with the 20 mm. gun.

The little statistical data that is available indicates that at ranges of about 1500 yards there is little to choose between the sight and the tracer, both methods giving less than one percent hits on small Mark 7 sleeve targets with tracer control having the slight advantage of about one hundredth of one percent. Since this is true, the forward area sight should not be disregarded without consideration.

FIGURE 4



Additional factors working against long range tracer control are the long time of flight corresponding and the movement of the ship (and gun) during the time of flight. Thus at long ranges, firing from the deck of a rolling destroyer, when a tracer is observed to pass the target the lead angle of the gun has been displaced by the change in deck angle. The forward area sight can be used advantageously to determine "initial aim off" when tracer control is to be used.

In consideration of the foregoing it does not appear desirable to completely abandon the forward area sight under conditions where:

(a) Tracers are not visible against a bright sky background.

(b) Firing is at such long ranges that tracer control is ineffective.

THE PRINCIPLES GOVERNING CONTROL BY THE FORWARD AREA SIGHT

In order to point the gun at a future position of the target such that hits will result, the gunner must:

(a) Aim-Off in the Correct Direction, by pointing in such a manner that if the gun (and sight) were to be held stationary the target would pass through the center of the fore sight.

(b) Aim-Off the Required Amount, by estimating the target's speed; approach angle; and from these obtain an aim-off speed sufficient to allow for the travel of the target during the time of flight of the projectile. With the aim-off speed selected the choice of speed rings in the forward area sight follows.

IMPORTANT POINTS IN SIGHT CONTROL

1. When the air target is in level or near level flight (low glide, low bombing or torpedo attacks) it can be assumed that the direction of motion is along the axis of the fuselage.

2. When the target is in a steep dive there is a "lift" effect that makes the target travel along a line elevated above the axis of the fuselage by about 5°.

3. Allowance must be made for wind. Since the target is air borne, wind speed is applied in direction and in full value to the direction and speed of the target.

4. In nearly every direction of attack the approach angle, and hence the aim-off speed, increases as the target gets closer.

5. *By far the majority of misses are astern.* The initial lead should be either correct or too great. If too great a lead is taken there is some chance that the target will fly through the bullet stream as its approach angle changes. There is no chance of hitting if the bullet passes astern.

DON'T MISS ASTERN!

THE PRINCIPLES GOVERNING CONTROL BY OBSERVATION OF TRACER

In control of the machine gun fire by observation of the tracer stream an initial lead angle may or may not be estimated first by forward area sight. Once fire is opened the gunner attempts to adjust his fire in such a manner that the stream of tracers intersect the target *at the range of the target.*

As has been pointed out two features of antiaircraft fire operate against tracer control. These are:

(a) Errors introduced when firing from a fast rolling deck.

(b) Limit of depth perception of normal vision at 500 yards.

HANDLE BAR VERSUS SHOULDER CONTROL

Many recommendations have been received suggesting removal of the shoulder rests and their replacement by the more familiar handle bars.

While it is probably true that the handle bars make control easier by reduction of smoke interference in the gunner's line of sight the permanent installation of handle bars is not recommended.

With the introduction of the Mark 14 sight it will be necessary to restrict the gunner's head position which is most easily done by holding his body against the shoulder rests by

the back strap. Since the Mark 14 sight will be standard equipment for the 20 mm. gun, and since control by this sight is far more effective than any other means devised to date, it is recommended that shoulder rests be retained.

THE MARK 14 SIGHT

The Mark 14 automatic lead computing sight is not yet in general service. It will however make its appearance shortly and should make the 20 mm. gun one of the most effective anti-aircraft weapons, at short range, that is in existence today.

The details of the sight are well covered in Ordnance Pamphlet 3783 to be issued with the sight. Some pertinent information is here included. Refer to figure No. 5 for further detail.

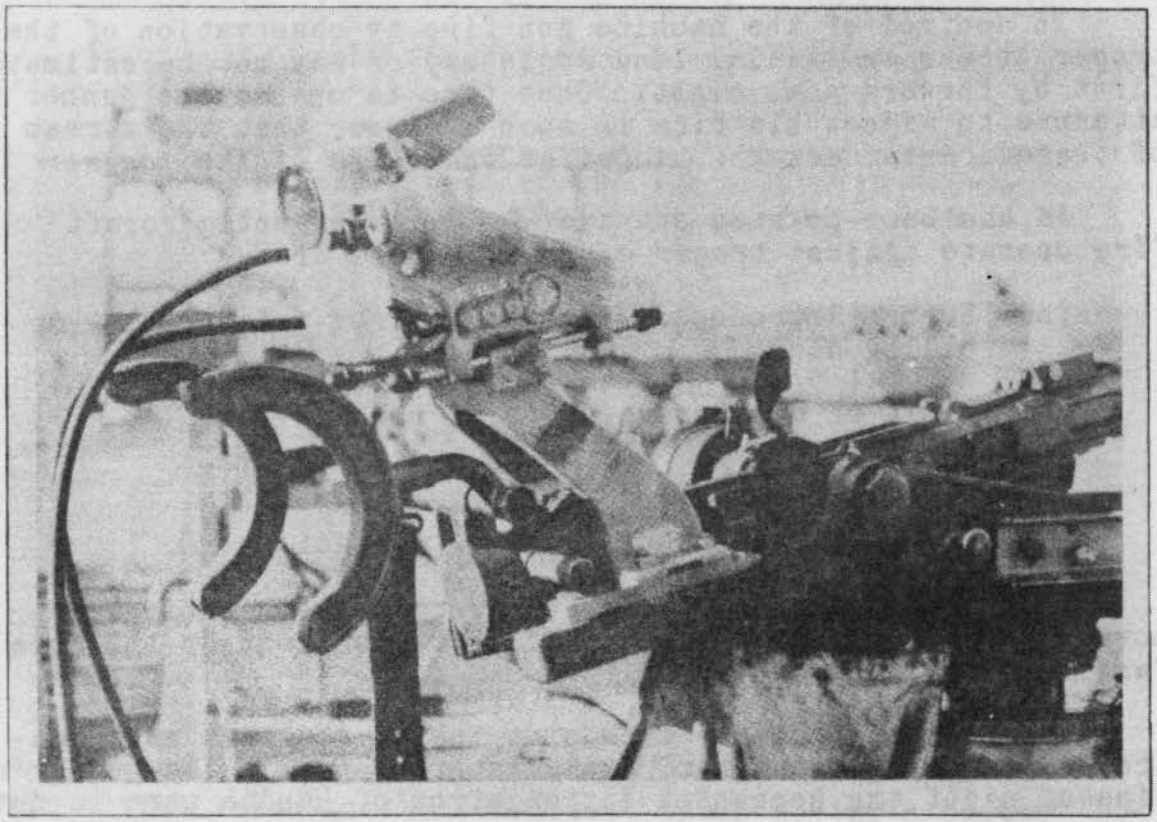


FIGURE 5

The sight is simple to install and can be placed in service on the gun in not over four hours after receipt.

The sight mechanism requires fifteen minutes to come up to *speed* and *temperature* but is sufficiently rugged to withstand long hours of operation.

Speed of gyros is less important in operation of the sight than is temperature. A change in gyro wheel speed will have a corresponding proportional effect upon the lead angle resulting from range corrections which is of relatively minor importance within reasonable limits. A change of temperature within the sight will have a large effect upon the sensitivity which is of major importance.

The most important maintenance item is lubrication of the power unit.

CONTROL BY THE MARK 14 SIGHT

Since the sight predicts the correct lead angle *for the range set*, after a short period of observation of the angular rates presented by the target, it is essential that the correct hitting range be set into the mechanism. It is not necessary that the true range be known but only that the hitting range be set. This can be accomplished in two ways.

(1) By setting one fixed range short of the actual range of any approaching target, opening fire and allowing the target to pass through the barrage.

(2) By observation of tracers and manipulation of the range setting so that the tracer stream passes through the target.

FIXED RANGE CONTROL

This method is the normal one to employ in an attack that develops when less than the full gun crew is at the gun. The range may be set at near 1,000 yards, fire opened at 1,500 yards, and the results should be satisfactory unless the target takes avoiding action.

SPOTTER CONTROL

This method requires a well trained spotter who by observation of tracers sets range to make the tracer stream intersect the target. The principle is based upon the following factors:

(1) It is a reasonable assumption that the Mark 14 sight will generate the correct lead angles for the range set after a short tracking period.

(2) If tracers are not passing through the target due to insufficient lead then, following paragraph (1), it is reasonable to assume that the errors are the result of an error in range only.

(3) By observing the tracer stream to determine whether or not the tracers are silhouetted against or eclipsed by the target the correct hitting range may be determined. If silhouetted throughout flight the range is too short. If eclipsed at some point in the trajectory the range is too long.

(4) By adjusting the range setting at short intervals, using the foregoing considerations, a well trained spotter and gunner may force the target to pass through more than one *hitting range* during the approach.

In the foregoing discussion the effect of wind on the projectile has been disregarded as it usually may be in the short time of flight that exists in firing this gun.

If conditions are such that wind must be taken into consideration then correction for wind should be preset on the spot knob.

When spotter control is employed the gunner need not be as well trained as the spotter since his only task is to keep the cross wires at all times on the target.

Note particularly that spots are applied in range only to correct improper range setting. Spots to correct faulty alignment, effect of wind or errors of unknown origin, may be applied by turning the elevation and deflection spot knobs.

BRINGING THE MARK 14 SIGHT ON THE TARGET

It will be noted that when observing the motion of the cross wires in the Mark 14 sight, that against a target presenting fast rates of elevation and/or deflection the cross wires seem to settle on the target quite rapidly.

On the contrary when the gun is swung smartly to a slow moving target the cross wires will drift at a decreasing rate for several seconds before settling. This is characteristic of the mechanism.

To overcome this characteristic, it is necessary whenever the gun is swung through a large arc rapidly to take under fire a target of low rates such as a dive bomber or torpedo plane, to swing the gun past the target direction. This method will allow the cross wires to settle on in about one second instead of requiring as much as five.

IV. RANGE AND OPENING FIRE

The 20 mm. gun has a cyclic rate of 480 shots per minute. It has a magazine capacity of 60 rounds. The magazine can be emptied in 7-1/2 seconds. It requires about 5 seconds to shift magazines.

It does not require much deduction to observe that if fire is opened too soon the gunner will be caught with an empty magazine at the time the target has closed to the hitting range of the gun, which also is a good release range for bomb or torpedo.

Further, unless fire discipline is good, one gunner with an itchy trigger finger can start the entire 20 mm. battery going at extreme range, draining all ammunition from the guns and presenting to the target a five second period of peace for release of its bombs or torpedoes.

It is essential that the gunner wait for the target to come to him; wait coolly by his gun until he *knows* that it will be effective!

V. RANGING DEVICES

There will shortly be available two types of ranging devices to aid in the determination of "Commence Firing Range." These are:

(1) The Mark 1 Antiaircraft Range Indicator.

(2) Two types of short base optical range finders that will be sent to service, in limited quantities, for trial. If either one proves a success, large scale production will result.

Both types of equipment have the same purpose, i.e., to fix the range with sufficient accuracy to allow judgment as to when to open fire.

DON'T THROW AWAY BULLETS TOO EARLY - AN EMPTY GUN WON'T STOP AIRPLANES!

To these two features may be added a third. It is easy to observe the tracer stream at some point between the gun and the target where the line of sight is tangent to the trajectory and place this part of the stream in line with the target. When this occurs all bullets miss astern.

To effectively use tracer control it is essential to -

(1) FOCUS THE EYES AND ALL ATTENTION ON THE TARGET AND IGNORE ALL PARTS OF THE TRACER STREAM EXCEPT THAT WHICH IS VISIBLE AT THE TARGET.

(2) Remember that when bullets are hitting the tracer stream will appear just at the nose of the target.

(3) Remember that it is easier to start with too much lead angle and drop back than it is to start with too little lead angle and then try to overhaul the target.

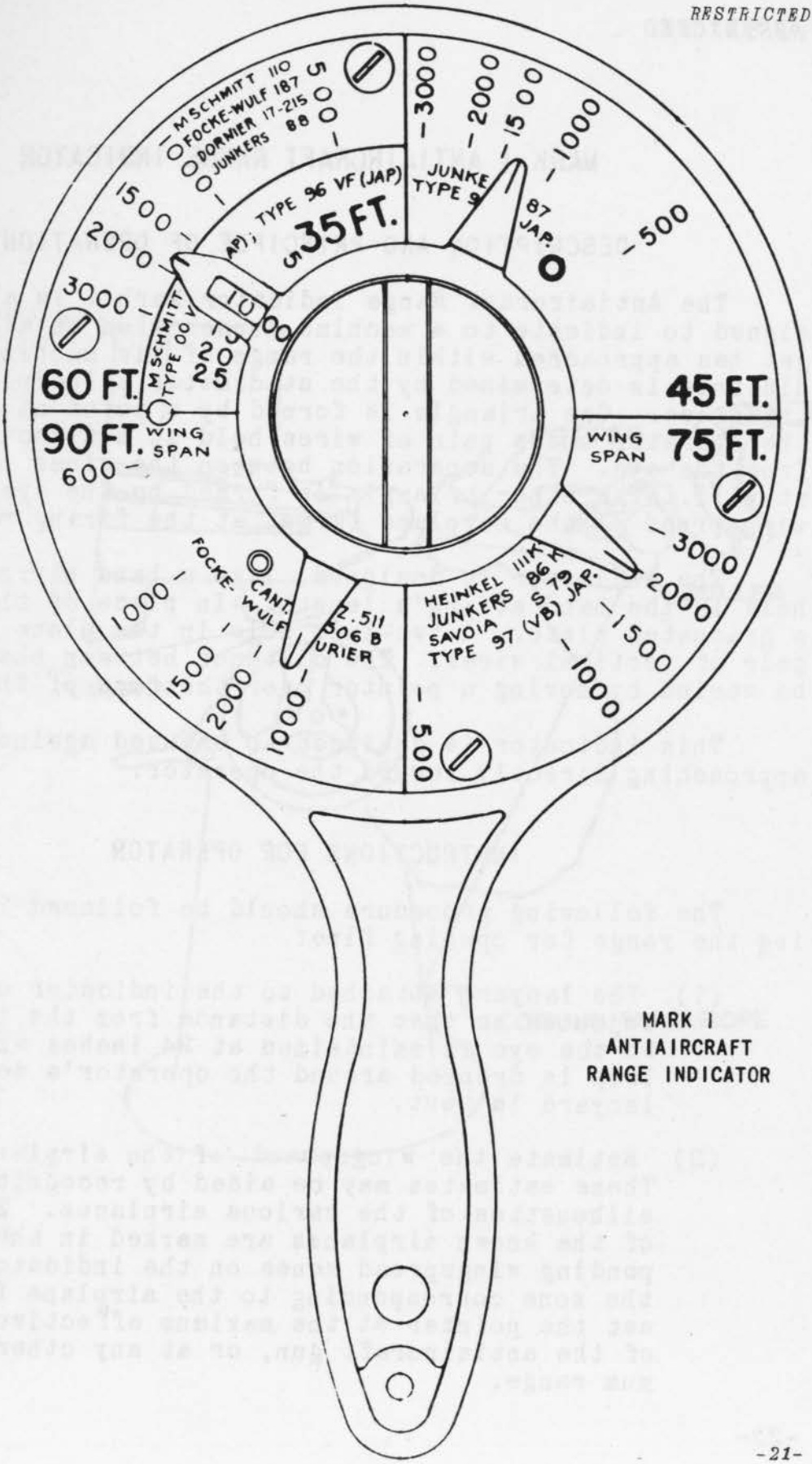
(4) Never stop the motion of the gun. Always keep it swinging in the direction of the target advance making adjustments by change in the rate of swing.

(5) *DON'T MISS ASTERN!*

In general it may be said that in using these two foregoing methods -

1. Forward Area Sight Control
   (a) Is hard to learn and teach.
   (b) May be practiced by artificial training aids.
   (c) Requires a great deal of concentration on the part of the gunner.

2. Tracer Control
   (a) Is a more "natural" method, hence is easier to teach.
   (b) Is hard to use effectively without extensive practice.
   (c) Requires less concentration on the part of the gunner.



MARK I
ANTIAIRCRAFT
RANGE INDICATOR

MARK I ANTIAIRCRAFT RANGE INDICATOR

DESCRIPTION AND PRINCIPLE OF OPERATION

The Antiaircraft Range Indicator Mark 1 is a device designed to indicate to a machine gunner when an airplane target has approached within the range of his machine gun. This distance is determined by the stadimeter principle of similar triangles. One triangle is formed by a point at the eye of the operator and a pair of wires held at a fixed distance from the eye. The separation between the wires is adjustable at will. The other triangle is formed by the eye and the wingspread of the airplane target at the firing range.

The indicator is designed, like a hand mirror, to be held in the hand at arm's length. In place of the mirror is a graduated plate. A two-inch hole in the plate exposes a pair of vertical wires. The distance between these wires may be varied by moving a pointer over the face of the plate.

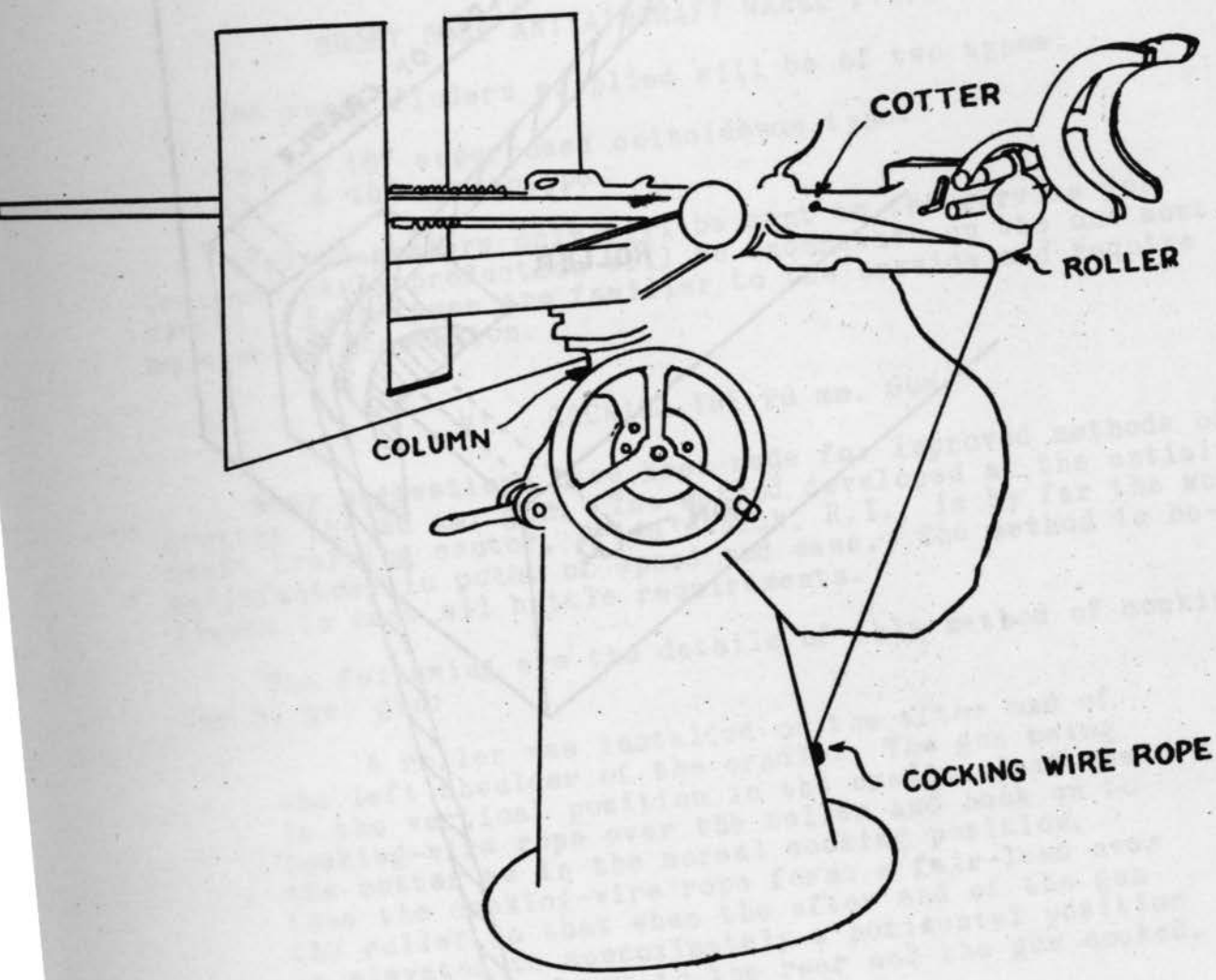
This indicator is designed to be used against targets approaching directly toward the operator.

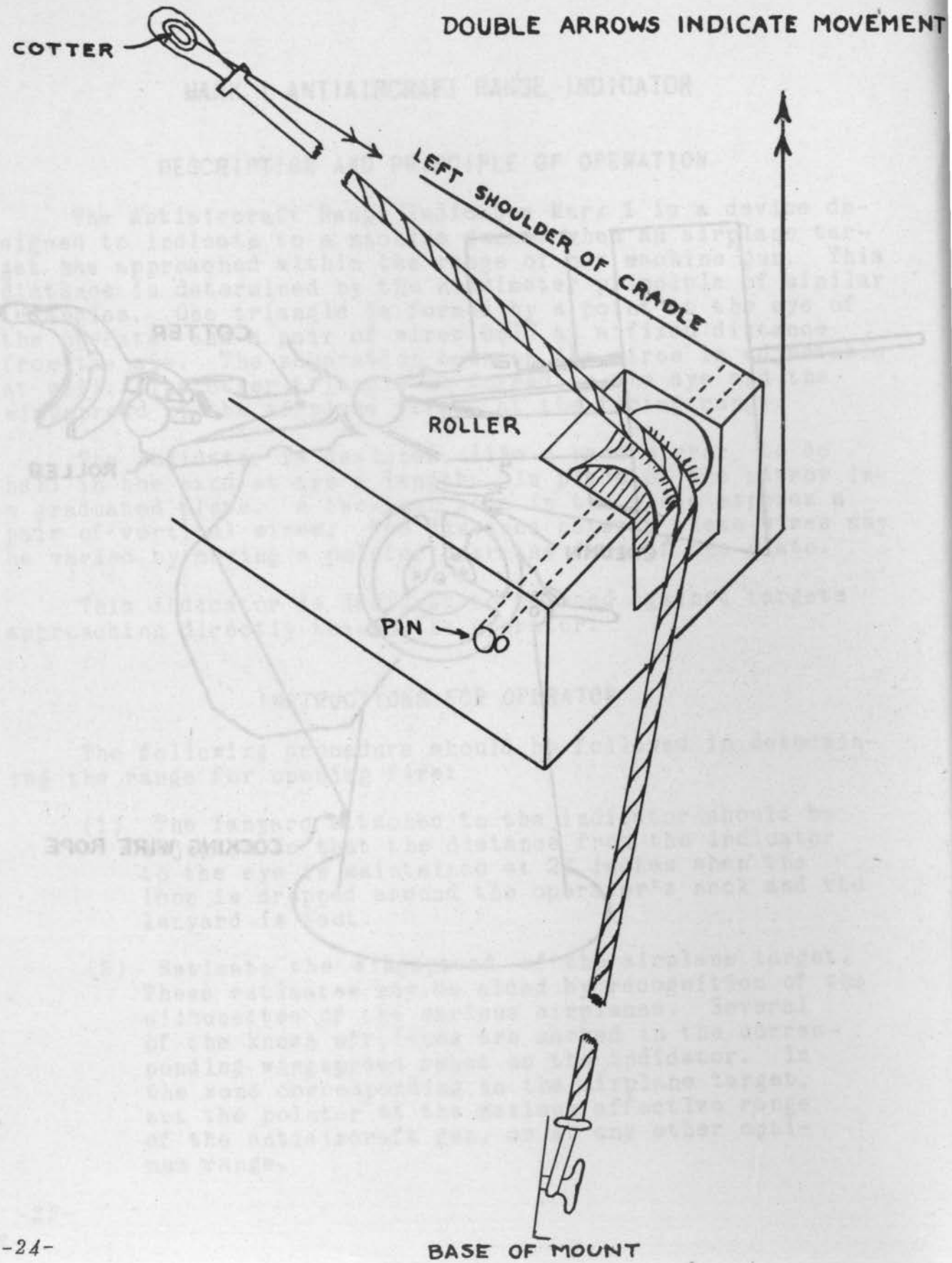
INSTRUCTIONS FOR OPERATOR

The following procedure should be followed in determining the range for opening fire:

(1) The lanyard attached to the indicator should be adjusted so that the distance from the indicator to the eye is maintained at 24 inches when the loop is dropped around the operator's neck and the lanyard is taut.

(2) Estimate the wingspread of the airplane target. These estimates may be aided by recognition of the silhouettes of the various airplanes. Several of the known airplanes are marked in the corresponding wingspread zones on the indicator. In the zone corresponding to the airplane target, set the pointer at the maximum effective range of the antiaircraft gun, or at any other optimum range.


COTTER
ROLLER
COLUMN
COCKING WIRE ROPE


DOUBLE ARROWS INDICATE MOVEMENT
COTTER
LEFT SHOULDER OF CRADLE
ROLLER
PIN
BASE OF MOUNT

(3) Sight at the aircraft through the vertical wires, holding the indicator perpendicular to the line of sight.

(4) When the gap between the vertical wires is bridged by the wingspread of the aircraft, the signal for opening fire should be given.

SHORT BASE ANTIAIRCRAFT RANGE FINDERS

The range finders supplied will be of two types:

(a) A 15" superposed coincidence type.
(b) A 48" stereotype.

Limited numbers only will be sent to the service for test and early production will be undertaken on the one most useful. Both types are familiar to the service and require no special discussion.

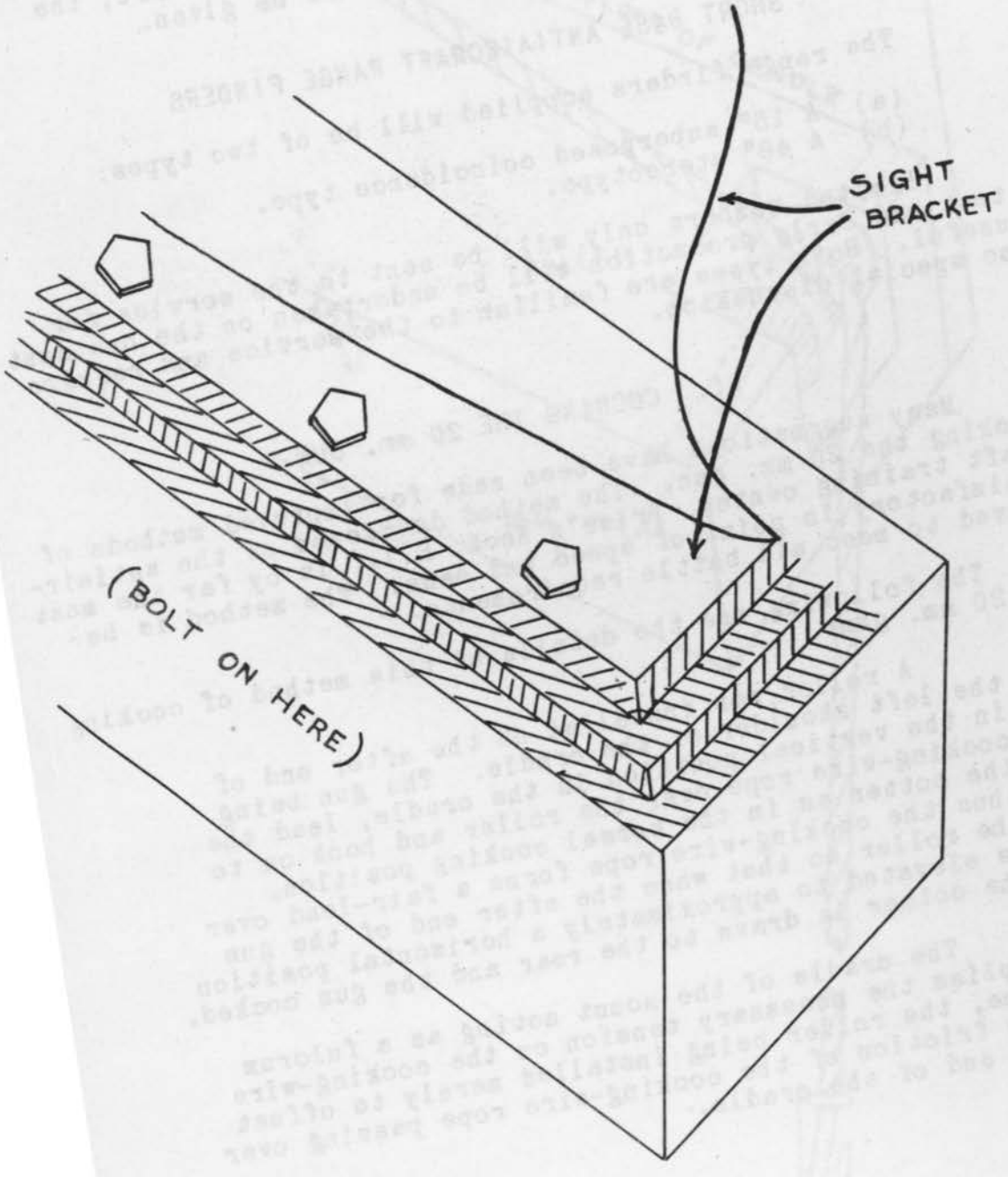
VI. COCKING THE 20 mm. GUN

Many suggestions have been made for improved methods of cocking the 20 mm. gun. The method developed at the antiaircraft training center, Price's Neck, R.I., is by far the most satisfactory in point of speed and ease. The method is believed to meet all battle requirements.

The following are the details of this method of cocking the 20 mm. gun:

A roller was installed on the after end of the left shoulder of the cradle. The gun being in the vertical position in the cradle, lead the cocking-wire rope over the roller and hook on to the cotter as in the normal cocking position, thus the cocking-wire rope forms a fair-lead over the roller so that when the after end of the gun is elevated to approximately a horizontal position the cotter is drawn to the rear and the gun cocked.

The cradle of the mount acting as a fulcrum applies the necessary tension on the cocking-wire rope, the roller being installed merely to offset the friction of the cocking-wire rope passing over the end of the cradle.


SIGHT
BRACKET
(BOLT ON HERE)

With the gun in the normal cocking position it has been found that one man can cock the gun by grasping the lower forks of the shoulder rest and heaving upward. By using this method a gun crew can put the gun in action from an uncocked position in 4-1/2 seconds.

There is one disadvantage in this method of cocking. When the Mark 14 sight is installed the bracket holding the sight will foul the roller and destroy the fair lead of the cocking-wire. This condition is not too serious and should be corrected after the first few sights are in service. Sketch following illustrates this point.

VII. BORE SIGHTING THE MARK 14 SIGHT

1. Bore sighting the Mark 14 sight presents some difficulties to shipboard gunners. By far the easiest method consists of firing single shots at a fixed target on the surface of the water. This will be accurate only if the ship is nearly motionless, a condition that as a rule obtains only in port. At sea it is possible to use a method developed at an A.A. training center, called the "flight of tracer method," discussed hereafter:

A "FLIGHT OF TRACER" METHOD OF BORESIGHTING THE 20 mm. MACHINE GUN WITH THE MARK 14 SIGHT

Bore sighting based on observation of tracer, using the technique described in the pamphlet on the Mark 14 sight, insofar as applicable, can be accomplished as follows:

FOR ELEVATION

Set the desired range on the sight (the method herein described is for a range of 1,200 yards).

Place a deflection spot of about ten mils on the sight with the deflection spotting knob so that the trajectory can be most easily observed in relation to the horizontal crosshair.

Move the illuminated reticle up 12 mils in the sight by use of the elevation spotting knob, and see that it remains there during subsequent operations.

Train outboard and maintain continuous aim on the horizon with the horizontal crosshair.

Fire one tracer round while maintaining such aim and observe the high point of the trajectory in relation to the horizontal crosshair.

When the reticle is properly adjusted by means of the elevation bore sighting screw, the trajectory should rise exactly to the horizontal crosshair and then fall below it.

Set the spotting knob back to zero.

FOR DEFLECTION

Set a range of 1,200 yards on the sight.

Calculate the effect of the apparent wind on the trajectory at this range and set the compensating deflection on the sight with the deflection spotting knob.

Train the gun outboard, elevate it to ten degrees, and lock it in this position.

Fire one round of tracer ammunition and observe the flight in relation to the upper portion of the vertical crosshair.

At the instant of firing commence counting seconds (ONE THOUSAND - TWO THOUSAND) or measure 2-1/4 seconds by a stopwatch.

The path of the tracer should merge with the vertical crosshair at approximately 2-1/4 seconds after the instant of firing.

The deflection bore sighting screw will be used to move the illuminated reticle to the right or left until it is in proper relationship to the vertical crosshair.

Remove the windage spot previously set on with the deflection spotting knob.

2. In bore sighting for range, this method eliminates any consideration of an artificial lead generated in the sight due to angular velocity imparted by the roll of the ship. The 12-mil spot in elevation set on the sight in the process of bore sighting is the spot computed to bring the high point of the trajectory in conjunction with the line of sight to this point. A spot of more or less than 12 mils at a range of 1,200 yards would necessitate an estimate in bore sighting as to how much above or below the horizontal crosshair the trajectory should appear.

3. In bore sighting for deflection, it is apparent that the trajectory should lie along the line of sight at any range close to 1,200 yards, except in winds of very high velocity. Consequently, the time of flight need not be measured exactly. The momentum imparted to the projectile in the direction of the ship's movement can be seen as sufficient to bring the trajectory into the line of sight at the hitting range.

4. Best results by this method will naturally be obtained when the roll and pitch of the ship, and the wind, are at a minimum. The ship must be on a straight course, as any angular velocity imparted to the sight would introduce a proportionate artificial lead in the sight. Two to ten rounds of tracer ammunition should suffice for bore sighting in both elevation and deflection. It is felt that some benefit to the gunner should result from his bore sighting his own gun by this method.

VIII. NOTES FROM TRAINING CENTERS

NOTES ON USE AND UPKEEP ABOARD SHIP

(a) The following gear should be near the gun:

(1) Spare part kit.
(2) Rammer with backing out slug.
(3) Line for recocking the gun.
(4) Spare barrel.
(5) Asbestos gloves.

(b) If ammunition comes packed in mohair separators wipe clean of grease and hair and then regrease each cartridge.

(c) It is recommended that all magazines be kept filled with ammunition and that tension be kept on magazine springs of one half the magazines; no tension on the other half. Process should be reversed daily.

(d) If a live round sticks in the gun, use backing out slug *with grooves cut on inside of conical surface to grip the nose of the projectile, twisting rammer so that nose fuze is unscrewed.* After *removal of fuze,* projectile may be *forced out with rammer and backing out slug.*

(e) Do not tamper with clock spring as it has been set properly to compensate for weight of the gun.

(f) Keep gun moving parts as free as possible from salt.

(g) In case live round is left in gun use rammer and backing out slug in accordance with procedure of (d) above. If this fails to clear the jam, shift barrels at once without wasting time on jammed barrel, cool barrel with water and treat as hang fire.

(h) An ordinary manila line, about six feet long, with an eye to fit over the cocking cotter can be used for cocking the gun instead of using the trunnion raising method prescribed in the pamphlet. Three men can heave on this line and cock the piece much more rapidly than it can be done by the method described in the pamphlet.

(i) Loaders should be cautioned to check each magazine to see that there is tension on the magazine spring before loading the gun.

(j) If for any reason gun "runs away" loader should remove magazine immediately.

(k) In changing barrels use asbestos gloves.

(l) Each barrel should have an index mark painted on it to indicate proper angle of rotation at which to insert new barrel when barrel springs are already compressed. This is a time saver, in that it eliminates necessity of releasing springs to insert another barrel.

(m) If stoppage occurs, look for casualties in this order:

(1) Jam due to dirt in gun.
(2) Failure of double loading stop to function.
(3) Improper loading - look at magazine.
(4) Failure in trigger group - broken part.

DISCUSSION OF CASUALTY DRILLS

With the strong possibility of there being no experienced gunner's mates at hand at the 20 mm. batteries, drills are held at Point Montara to teach the three men on the gun to replace the most commonly broken parts. Below are times taken on an experienced crew.

BROKEN REAR BARREL SPRING, OE-1320

Gun uncocked, manned, loaded and elevated 60 degrees. Simulated discovery of broken spring. Gun removed from mount, spring removed and replaced, gun recocked, bore inspected, loaded and elevated to 60 degrees. Time: 1 minute, 36 seconds.

BROKEN HAMMER

Gun uncocked, manned, loaded and elevated to 60 degrees. Simulated broken hammer which generally leaves the breech forward, and striker pin dents the primer but does not fire the live round in the barrel. Safety put on, magazine removed, gun recocked, cleaning rod *ejector* assembly passed down bore, simulating removing of live round. Live round backed out and over the side in 18 seconds. Gun then uncocked, removed from mount to deck, broken down, hammer replaced in 1 minute, 10 seconds. Gun assembled, mounted, cocked, bore inspected, loaded, manned and elevated to 60 degrees. Total time: 2 minutes, 50 seconds.

PARALLELOGRAM LEVER AXIS BOLT - TOP FRONT, OE-1207

Gun uncocked, manned, loaded, elevated to 60 degrees. After checking rear barrel spring, double loading stop, and magazine tension to eliminate possibility of casualties there, it was assumed that the trouble was in the trigger mechanism. Safety on, gun unloaded, gun backed off enough on the cradle to allow removal of handgrips, but left on mount. All Point Montara guns use a small cotter pin to secure sleeve (OE-1208) to the above axis bolt, instead of the spacing sleeve pin (OE-1272). Axis bolt was removed in 44 seconds, replaced, gun locked in cradle, manned, cocked, bore inspected, loaded and elevated to 60 degrees. Total time: 3 minutes, 12 seconds.

BREECH FACE PIECE - OE-1305

Gun manned, loaded and elevated to 60 degrees, gun assembled with breech lock half way forward, breech face piece caught on fired cartridge slow in being ejected into sack. Safety on, gun recocked, unloaded, assumed live round partly in barrel, backed out and thrown over the side in 22 seconds. Gun was then uncocked, removed from mount to deck, broken down, face piece replaced in 1 minute, 55 seconds. Gun reassembled, mounted, manned, cocked, bore inspected, loaded, and elevated to 60 degrees. Total time: 3 minutes, 41 seconds.

Similar times would be clocked to replace a broken breech pawl (OE-1108, 1104); broken ejector (OE-1045); broken locker washer for OE-1055 (OE-1081); broken trigger crank (OE-1228).

IX. CASUALTIES TO THE GUN

The large number of casualties hereinafter listed in no way reflect on the reliability and high quality of this gun, but indicates the large amount of shooting that has been conducted in a relatively short time. All casualties have been listed only to indicate what is to be expected in performance from those guns, recently sent to service.

CASUALTIES - REPORTS OF

U.S.S. TENNESSEE

1. Run 2. Gun 3 had stoppage after firing 3 rounds out of ammunition allowance of 20. Failed to feed.

ANALYSIS

Caused by insufficient tension on magazine. Loader failed to set tension up to last notch; consequently, the magazine failed to feed.

2. Run 1. Gun 14 had stoppage after firing 18 rounds out of ammunition allowance of 20 rounds.

ANALYSIS

Projectile loose in case. Faulty ammunition.

3. Run 2. Gun 6 had stoppage after firing 6 rounds. Failure to feed.

ANALYSIS

Caused by insufficient tension on magazine. Loader did not set tension up to last notch; consequently, there was a failure to feed.

SHIP'S ACTION

Intensive loading drill supervised by experienced personnel.

FURTHER ACTION RECOMMENDED

It is constantly repeated in instruction books on 20 mm. machine guns that tension on magazines be set to 60 rounds. The scale on the magazine is not calibrated to insure that when scale reads sixty maximum tension is set. In other words the scale is worthless. Instruction should always be to set tension up to maximum and ignore the scale readings.

U.S.S. NEW MEXICO

1. On round No. 2, round failed to feed properly, bolt face catching side of cartridge case, ripping it open and leaving round in barrel.

ANALYSIS

On breaking magazine down and reloading for target practice, gunner forgot to renew his tension on magazine spring. The gun was fired by stand-by tension.

SHIP'S ACTION

Further indoctrination of crew in loading methods and checking magazines.

A.A. TRAINING AND TEST CENTER, DAM NECK, VA.

20 mm. GUN, SUMMARY OF CASUALTIES, BREAKAGES, STOPPAGES AND GENERAL OPERATING EXPERIENCE WITH

1. Approximately 30,000 rounds of ammunition have been fired with 20 mm. guns at A.A. Training and Test Center, Dam Neck, Virginia. All except 2,000 rounds of this firing was done with the four guns indicated, with the 2,000 rounds being fired by four guns which were removed from the test center to supply a ship after the guns had been installed here only a few days.

2. All broken parts, together with tags, indicating history of failures, have been forwarded to the Naval Gun Factory, Washington, D.C.

3. Summary of failures as of January 20, 1942, is as follows:

GUN No. 40132

At 850 rounds	Live round forced in chamber in front of carrier groove of bolt face piece.
3876	Broken tips both front and rear barrel springs. Broken bolt face piece carrier groove.
3902	Broken striker pin.
3922	Barrel seating ring damaged; renewed.
5760	Broken rear barrel spring (after 1911 rounds use).
6945	Broken hammer.
	Total rounds to date - 7269

GUN No. 40145

At 265 rounds	Broken carrier groove of bolt face piece.
1268	Same (after 1008 rounds use).
4852	Broken rear barrel spring.
6760	Broken front barrel spring.
	Total rounds to date - 7754

GUN No. 40146

At 300 rounds	Bent carrier groove of bolt face piece.
1053	Same (after 758 rounds use).
2434	Broken hammer.
3274	Broken trigger crank.
5800	Broken rear barrel spring.
7437	Broken rear barrel spring (after 1867 rounds use).
	Total rounds to date - 7437

GUN No. 40147

At 2080 rounds	Broken rear barrel spring.
5352	Broken parallelogram (pin).
5517	Broken rear barrel spring (after 3437 rounds use).
	Total rounds to date - 5817

4. Following is summary of rounds fired by barrels:

BARREL NUMBER	ROUNDS FIRED
65249	660
65253	5536
65259	810
65286	4477
65287	2020
65321	7505
65429	8028

Note: There is no sign of appreciable wear in any of the above barrels, no change in the trajectories has been noted, and no "tumbling" has yet occurred.

5. In observation of the firing at this range it has been found that the majority of stoppages are caused either by insufficient recoil or by the double-loading stop gear.

(a) The greatest number of stoppages are caused by two types of jams, both of which are the result of short recoil. Short recoil may be due to the lack of adequate grease on the

cartridges in the magazines, mohair packing not properly removed, or excessive sand, dirt or other foreign matter in the chamber.

The two types of jams due to short recoil are very different in nature. In the first, the short recoil causes the ejector toe to strike the base of the empty case with only sufficient force to cant its forward part downward, but not completely eject the case. When the bolt goes forward again, the mouth of the empty case strikes against the forward part of the recess in the gun casing which is meant to allow the ejected case to pass out of the gun. This will often cause the carrier groove in the bolt face piece to bend or even partially break off, thus incapacitating the gun.

The second type of jam due to insufficient recoil occurs with a loaded cartridge just out of the magazine. The bolt face does not come back far enough to allow the base of the cartridge to slip in to the carrier groove. As the bolt thus goes forward the top of the bolt face piece digs into the lower side of the casing of the cartridge about one-half to one inch from its base, thus canting the projectile downward and causing a jam. Often the upper part of the bolt face piece actually pierces the case of the cartridge. Sample cases illustrating these jams have been sent to the Naval Gun Factory.

There appears to be no way in which these two types of stoppages can be eliminated other than proper greasing of the cartridges and eliminating the foreign matter in the chamber, thereby allowing the bolt full recoil.

(b) The double loading stop gear has also caused numerous stoppages by sticking in the down position when there is no case in the chamber. This appears to occur only after the double loading stop, part No. 4, (see OP804) has been out of shape by normal working of the stop gear. In other words, the double loading stop, part No. 4, works correctly until the stop gear functions once as it is meant to - to prevent the loading of a new cartridge when there is already one in the chamber. But once this heavy blow of metal to metal contact by the stop lugs on the side bars and the stop arms on the double-loading stop, part No. 4, has occurred (probably one such contact is enough) the double-loading stop, part No. 4, is bent definitely out of shape and will usually cause stoppages thereafter.

The cause of this deformation of the double-loading stop, part No. 4, appears to be due to two factors. First, there is a difference of several thousandths in the rearward projection of its stop arms. Thus, when the stop lugs on the

side bars contact the stop arms mentioned above, the right hand stop arm contacts its stop lug first and twists the double-loading stop, part No. 4, out of shape.

The result of this hard contact of metal to metal is as follows:

> The flat upper rear surface of part No. 4 (just forward of the stop arms) is dipped downward on the center part as much as one-sixteenth of an inch (due to steel of insufficient strength or thickness to withstand the force of the contact); the inner topmost edges of the forks of part No. 4 are pushed together and the lower inner edges are forced outward. This causes the topmost edges to bind against the barrel locking lever and make free vertical movement of the double-loading stop, part No. 4, difficult or even impossible. Thus part No. 4 will stick in the down or stop position as a result of this binding and a stoppage will occur. Even when this difficulty has been removed with a file and hammer, subsequent metal to metal contact of the double-loading stop arms and stop lugs on the side bars will cause a renewal of the binding and further stoppages occur.

These defects can probably be remedied by careful measurement during manufacture of the rearward extension to assure that both arms will contact the stop lugs simultaneously. It further appears that the flat upper rear surface of part No. 4 should be of a harder steel or thicker so that dipping of this area will be eliminated.

A.A. TRAINING CENTER, POINT MONTARA, CALIF.

The following is a memorandum of the casualties experienced for approximately two months. Most of these occurred on the two guns, which now are both in excellent operating condition. The two newest guns received by this center have been firing very well, with casualties only to the rear recoil barrel spring, item 26R, OE-1320, and the larger forward barrel spring, item 26L, OE-1321. These continue to break off at the end, for one to three turns.

1. BREECH (BLOCK) FACE PIECE, ITEM 11, OE-1305
(Refer to Chapter II, paragraph 20, O.P.804)

A total of six face pieces were broken, each time causing the gun to jam and necessitating replacement before fire could be resumed. All six of these were broken in the first few days of firing, and over a period of firing 4,000 rounds,

approximately 2,000 per gun. It was believed that the face piece, as the bolt went forward, struck a fired cartridge case which was slow in ejecting. The lip of the face was bent up and cracked in the middle and there was a curved dent below the lip. All cartridges were wiped free of the felt hairs, and greased with No. 758 mineral grease. Light castor oil was used experimentally, and two broken pieces occurred during firing of magazines so prepared. Casualties occurred on guns No. 40229 and No. 40280. During the firing of approximately 40,000 rounds on approximately 40 different guns, no further casualties have occurred. It is suggested that fifty rounds be fired from a new gun and then a careful examination be made for any burrs, which should then be stoned down by an experienced gunner's mate. Further firing of 2,000 rounds apiece on the above numbered guns has resulted in perfect functioning of this particular part.

2. TRIGGER CRANK, LEFT, ITEM 153, OE-1223

One trigger crank was broken, the projection at the end crack and dropping off. This may have been caused by hurried and inexperienced replacement of the trigger casing (item 26) before aligning all the trigger group carefully. An extra trigger crank should be included in the spare parts kit.

3. BOLT AXIS, PARALLELOGRAM LEVER (TOP), ITEM 131, OE-1207

Several of these pins have cracked in half during firing. Often this casualty has been discovered upon completion of the day's firing and during the cleaning of the gun. The hole drilled in the bolt axis to hold the pin (item 176) for the sleeve (item 132), weakens it considerably. This center has had replacements made locally and is experimenting with a threaded hole and tapered set screw to hold the sleeve on the axis bolt rather than a pin going through it completely.

4. SLEEVE FOR AXIS BOLT (TOP), ITEM 132, OE-1208

One sleeve cracked, at the time one item 131 and one item 176 were broken. Spares should be included in the spare parts kit.

5. PIN FOR SLEEVE FOR AXIS BOLT, ITEM 176 OE-1272

The pin is jarred out whenever item 131, above, is broken. It is found flattened out some place in the trigger casing.

6. BARREL SPRINGS, ITEMS 26L AND 26R, OE-1320, OE-1321

The springs break at the tips, for one or more turns at first, particularly the short rear one. The gun will continue to function but after further firing, there is usually another break of two or three complete turns, necessitating replacement. There should be two complete spare sets of springs per gun in the kit. There is a noticeable tendency toward overnight rust, because too much oil or grease for preservation causes excessive smoke during firing. Experience has shown that powdered graphite is fairly satisfactory. Springs must be checked occasionally during firing.

7. SLEEVE, BARREL SPRING, CENTER, ITEM 43, OE-1325

This spring sleeve (separator) cracked on one gun after approximately 4,000 rounds, probably a defect in the metal. A spare is provided per gun kit.

8. PINS, ASSORTED

Extra pins to secure item 186, trigger, and item 602, handle locking barrel should be included, as these suffer the wear and tear of field stripping. The center is experimenting with a split cotter pin for the former.

9. OTHER CASUALTIES OBSERVED ON OTHER SHIPS' GUNS

A. Breech pawl, right, item 35: Cracked and broken off during firing, causing considerable burring of bolt mechanism.

B. Breech pawl, left, item 36: Found to be bent and burred at the same time item 35, above, was found broken.

C. Barrel, item 1: One was surveyed after a projectile exploded in it, past the anti-double-stop. Cleaning rod head ejector tool, item 9, approximately 20 mm. diameter would not pass through the barrel, and closer examination found portions of the exploded projectile "fused" into the grooves.

10. CONCLUSION

This center would welcome, as undoubtedly would any ship armed with 20 mm. guns, further information on casualties, in order to anticipate and keep on hand replacement spare parts. It is hoped this memorandum will prove of some value, and it should be added that during the firings of approximately 40,000 rounds, between January 20th to March 6th, at Point Montara, no casualties have been experienced except to barrel springs and axis bolts (parallelogram), the latter easily made locally.

A.A. TRAINING CENTER, PRICE'S NECK, R.I.

A summary of the parts returned and the number of parts is indicated:

DESCRIPTION	NUMBER OF PARTS
Barrel springs (rear)	6
Hammers	6
Bolt faces	2
Strikers	3
Securing pin for OE-1805	1
Double-loading stop	1

The rounds fired on each part up to breakage are as follows:

(a)	Barrel spring	3,667 rounds
	" "	8,934 "
	" "	7,121 "
	" "	5,906 "
	" "	2,100 "
	" "	3,694 "
(b)	Hammer	904 "
	"	2,000 "
	"	5,821 "
	"	2,000 "
	"	1,340 "
	"	2,051 "
(c)	Bolt face	2,520 "
	" "	3,330 "
(d)	Strikers	3,330 "
	"	7,864 "
	"	1,400 "
(e)	Securing spring for OE-1805	3,045 "
(f)	Double-loading stop	5,846 "
	" " "	2,753 "

A.A. TRAINING CENTER, PORT ANGELES, WASH.

The following information on the functioning of the gun in relation to breakages is considered pertinent:

(a) BARREL SPRINGS

The most serious and frequent breakage is that of the right (rear) spring. It is difficult to tell by visual examination whether or not these breakages are due to defects in the metal or a result from normal wear. However, it will be noted that some of the rear springs have held up during the firing of 5,000 rounds; others breaking after firing less that 100. The tapered ends of the springs chip off progressively in use and the complete breakdown usually occurs when a considerable part of the ends have chipped off. None of the left (front) springs have broken down completely, although the ends chip, but after about seven or eight thousand rounds they lose enough of their strength to make it advisable to replace them. The right springs do not seem to last as long if used with a left spring that has been weakened.

(b) BOLT FACE PIECE

The number of breakages of these parts depends on the frequency of stoppages in which the ejected case does not clear the port in the casing and fouls the bolt.

(c) BOLT AXIS FOR ITEMS 128 AND 129

The parts occasionally break at the hole which receives the pin locking the bolt axis sleeve. In some cases it appears that the locking pin slips out, permitting the bolt axis pin to move longitudinally until it fouls the trigger crank, causing the break.

(d) TRIGGER CRANK

The breakages of these parts were caused by the bolt axis moving out as described in paragraph (c).

(e) STRIKER PIN

No breakages occurred until after approximately 5,000 rounds had been fired which is not considered excessive. One gun has fired over 11,000 rounds with its original striker pin.

Gun No. 40228 has fired 10,226 rounds and gun No. 40281 has fired 11,342 rounds. Except for replacement of barrel springs and minor parts the original parts are still in use and functioning as designed. The bores show signs of wear but it is not considered sufficient to affect the ballistic properties of the guns appreciably.

In order to complete firing courses for approximately 400 men in a comparatively short time, it has been necessary to fire the guns in such a manner as to result in an excellent service test. Usually, on firing days, the guns are hot for a period of two hours in the morning and two in the afternoon. Repeated assembly and disassembly of the guns, for instruction, by inexperienced personnel has also contributed extensively to the wear of the parts.

U.S.S. WYOMING

A summary of material failures follow:

GUN MOUNT No. 70007

ROUND NO.	FAILURE	REMARKS
1944	Broken hammer	First round
3300	Rear barrel spring	After misfire
5870	Rear barrel spring	After misfire
10220	Forward barrel spring	After misfire
10280	Rear barrel spring	

GUN MOUNT No. 70006

384	Broken carrier lip on bolt face piece	Failed to extract
3240	Rear barrel spring	After misfire
5700	Forward barrel spring	After misfire
6070	Broken carrier lip on bolt face piece	
8250	Broken hammer and hammer plate	

Stoppages other than failure of material follow:

GUN MOUNT No. 70007

STOPPAGE	CAUSE
(a) Ruptured cartridge case	Insufficient magazine tension; personnel
(b) Misfire	Faulty primer
(c) Ruptured cartridge case	Sluggish injection

GUN MOUNT No. 70006

(a) Double-loading stop functioned	Brass in double stop mechanism
(b) Misfire	Faulty primer

GUN MOUNT No. 70006 (cont'd)

STOPPAGE	CAUSE
(c) Ruptured case	Sluggish ejection
(d) Misfire	Primer fired - no powder in cartridge

In summation, the two guns have fired a total of 20,000 rounds. There have been 16 stoppages attributed to material or faulty gun action, or an average of one stoppage per 1,250 rounds per gun. To break down further - this is a stoppage about every twenty-first magazine.

One stoppage is directly attributed to personnel.

Broken barrel springs occur about every 3,500 rounds, broken hammers every 10,000 rounds and broken face pieces every 10,000 rounds. Barrel spring tips break off regularly on all springs. This failure has not resulted in stoppages but may indicate faulty material.

U.S.S. WYOMING

A. IDENTIFICATION OF STOPPAGES

1. FAILURE OF GUN TO FIRE WHEN TRIGGER IS PRESSED:

(a) It is possible to ship a loaded magazine without pushing the magazine catch lever to its extreme forward position. If a magazine is shipped in this manner the magazine interlock lever will remain uncocked and consequently the trigger pawl disengaged.

(b) This stoppage can be readily recognized by the fact that the trigger can be pressed easily without causing the bolt to move forward.

(c) To remedy, push the magazine catch lever to its extreme forward position (while steadying the magazine).

(d) To avoid, the gunner must push the magazine catch lever fully forward and the first loader see that magazine catch is in the cocked (up) position before loading a magazine.

2. IMPROPER FUNCTIONING OF DOUBLE-LOADING STOP MECHANISM
(Refer to plate 3, O.P. No. 804)

(a) Part 1 can be held in the raised position due to foreign matter or grease under its shoulder.

(b) This stoppage is recognized by the recoiling assembly being held to the rear due to engagement of the stop plates with stop part No. 4, although the channel is clear.

(c) To remedy - change barrel.

(d) To avoid - see that recess into which the shoulder of part 1 fits, is free of foreign matter and avoid *excessive* grease or foreign matter on cartridges. The cartridge case should contain just enough grease on its entire surface to be perceptible to the touch.

3. JAM DUE TO INSUFFICIENT MAGAZINE SPRING TENSION

(a) Magazines loaded with 60 rounds should be given tension until the indicator reads 60 and the loading lever can be turned no farther due to the positive stop. If this is not done, insufficient tension will remain near the end of the run with the result that a cartridge case may be sheared off by the bolt face piece and the *projectile* rammed into the chamber.

(b) To remedy - Clean up spilled powder and change barrel if projectile cannot be backed out readily.

4. JAM DUE TO SHORT RECOIL

(a) This stoppage can usually be recognized by the presence of an empty cartridge case jammed between the bolt face piece and the live cartridge. It is due to short recoil resulting in sluggish injection.

(b) To remedy - Eliminate excessive friction between the recoiling assembly and the gun casing or see cartridge cases uniformly covered with thin film of grease.

5. STOPPAGES DUE TO BROKEN HAMMER

(a) This stoppage is recognized by bolt moving forward without firing when trigger is pressed.

(b) To remedy - Change barrel (unless cartridge and projectile can be easily backed out) strip and replace hammer.

6. CHIPPING OF BARREL SPRINGS

(a) Two small pieces of barrel springs have broken off tips of springs during gunnery school firing. In both cases the gun continued to function without replacement of springs. Probable cause of failure was metallic fatigue.

(b) To avoid - Lubricate barrel spring and outside of barrel frequently with graphite.

7. BREAKAGE OF BARREL SPRINGS

(a) Two rear sections of barrel springs broke after having been in service about the same length of time and after having fired 3,300 and 3,240 rounds respectively. Both failures occurred immediately after a misfire.

(b) This casualty *may* be recognized by an unusual noise after last shot.

(c) If the spring is broken in only one place or perhaps two, the gun may continue to function. If broken into small sections, the sections may jam the action or too much tension may be lost.

(d) To avoid - Keep barrel and springs lubricated frequently and, whenever practicable, during a lull in firing.

(e) To remedy - Inspect *immediately* after a misfire. If continuance of fire is urgent and gun action is not jammed, attempt to continue the fire. Otherwise replace spring.

X. ADDITIONAL COMMENTS BASED UPON TARGET PRACTICE

U.S.S. NASHVILLE

A. PREPARATION AND TRAINING

1. Twenty-four men regularly stationed on the 20 mm. machine gun battery in one or more conditions of readiness, fired 100 rounds per man on January 6, 1942, at the Rifle Range, Dam Neck, Va., where they spent one day receiving instruction in the service and control of the 20 mm. gun.

2. Structural test firing on each of the ship's eight mounts were fired by the eight condition I gunners on January 10, 1942

3. Tracking drills on task groups and base planes have been conducted whenever practicable.

B. CONDUCT OF THE PRACTICE

1. The practice was fired at anchor using the four starboard mounts. Nine runs including one remnant run were fired with favorable weather conditions.

2. Condition I, II-1/2 and III-afirm crews were fired with no gunner firing twice.

C. CONCLUSIONS AND RECOMMENDATIONS

1. There was a distinct tendency on the part of some column raisers, to take their eyes off the gunner and follow the tracer stream. This prevented the team work, between column raiser and gunner, necessary for the successful firing of this type machine gun.

2. Due to past training on .50 caliber machine guns using tracer control throughout, some gunners found the shift to sight and tracer difficult. The tendency to shift immediately to tracer after the first burst can only be corrected by frequent firing to indoctrinate gunners for use of aim-off, in sight control.

U.S.S. ST. LOUIS

20 mm. AND .50 CALIBER MACHINE GUN BATTERY

This was the first firing by condition I crews of the 20 mm. battery at a sleeve target. The gunners were instructed to use the ring sights for initial aiming and to shift to tracer control as soon as tracers reached the vicinity of the target. In general, this procedure was followed with fair results. Much more actual firing experience is believed to be necessary in order to give these crews the desired degree of proficiency in the use of ring sights and tracer control.

U.S.S. MARYLAND

20 mm. MACHINE GUN PRACTICE

This practice was essentially in accordance with machine gun practice "Afirm," Orders for Gunnery Exercises. Firing was by groups of three or four guns; group I consisting of guns 1, 3 and 5; group II of guns 2, 4 and 6; group III of

guns 9,11,13 and 15; and group IV of guns 10,12,14 and 16. Guns 7 and 8 were designated for the boat cranes but have not been installed. A low ceiling on the day of the firing prevented the plane from attaining the desired altitude and all runs were fired with the target towing at 1,000-1,200 feet. The ammunition allowance was 20 rounds per gun. Tracer control was used in accordance with the recommendations of the machine gun school established at Port Angeles. One hit was made. Twenty founds of ammunition affords very little opportunity for the gunner to correct the tracer stream, and the low percentage of hits under the circumstance is not surprising. Two casualties were experienced.

(a) One broken bolt pawl due to faulty assembly of gear, and
(b) One jammed round caused by case failing to extract properly.

U.S.S. NEW MEXICO

20 mm. MACHINE GUN A.A. BATTLE PRACTICE "AFIRM"
FIRED 20 FEBRUARY, 1942

This practice was fired in accordance with the rules laid down in section 1J4 of O.G.E. Target was Mark XIV sleeve towed at 2,000 feet with a 7,000-foot towline. All guns on a side fired on each run, each gun firing twice, ammunition allowance 20 rounds per gun on each run fired. First run on each gun was fired by the regular gunner with a pan of 20 rounds. The second run was fired by a condition watch using two pans of 10 rounds each. The practice was explained to the crews and thereafter no commands given except to announce the firing run. Full sight control was utilized.

In general, the gunners performed well. Fire was held until an effective range was reached and the cone of fire was well centered. On the condition watch run the cone of fire was more dispersed, several guns making errors in "aim-off." Pans were shifted without delay, averaging about 5-6 seconds for the shift. One personnel casualty, marred an otherwise perfect battery performance. The sleeve was not recovered hence no factual check on performance is possible.

Coupled with extensive use of shore based machine gun ranges this training is considered satisfactory. If restrictions on use of the shore based range become necessary more extensive firings at sea will be required. Attention is invited to the fact that the opening range of the "Afirm" practice of 2,400 yards is well beyond the maximum effective range on the 20 mm. gun. Furthermore, the magazine capacity of these guns is so limited (7-1/2 seconds firing time) it is mandatory that they be held until an effective range is

reached. With control of a purely local nature, all training and firing must stress the fact emphatically. Accordingly, half of an "Afirm" run with a 7,000-foot towline and the sleeve at 2,000 feet is wasted. The maximum effective advance range of 1,000 yards is readily obtained with ship's planes and a 1,500-foot towline and the maximum use of these planes should be made to relieve the load on utility plane services.

Some concern is felt over the practice or necessity of formation firing restricting the approaches to the beam. While the control problem is essentially unchanged, the fire distribution is extremely artificial. Frequent warnings have been given in intelligence reports that a strict fire distribution plan must be indoctrinated in all machine gunners in order not to cause a concentration in the sectors of first attack at the expense of others. It is considered highly desirable when conditions permit to increase the number of runs made and to vary the direction of approach from all sectors to permit the doctrine of fire distribution to be maintained.

U.S.S. PENNSYLVANIA

Handlebars, similar to those used on shipboard installations of .50 caliber Browning machine guns, have been installed on most of the 20 mm. guns on board this ship. Firing has proved to be more effective with this method of control since this not only enables the gunner to keep his eyes above the smoke interference, but it also gives him easier control and permits the gun to be elevated to higher angles. Furthermore the guns may be serviced with less men in event of casualty to part of the gun crews.

NOTE: Handlebars are not satisfactory with the Mark 14 sight. For this reason consideration should be given to the probable delivery of these sights before any shipboard alterations to the mounts are undertaken.