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GUNNERY INSTRUCTIONS

U. S. NAVY

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The following Gunnery Instructions, U. S. Navy, 1913, are approved and issued to the service.

This volume was compiled in the office of the Director of Target Practice and Engineering Competitions. The Gunnery Instructions, 1905, formed a basis of compilation, which included a revision of such matter from the 1907 edition of Ship and Gun Drills as dealt with practical naval gunnery.

In the preparation of this manual it was the aim to seek assistance from as many officers as it was possible and practicable to reach; many officers contributed and collaborated, and reports of target practice were freely consulted. Finally, the manuscript was revised by the 1913 Board on Revision of Ship and Gun Drills, 1907.

Particular attention is called to article 713, Naval Instructions, 1913, regarding the care to be exercised with this publication.

JOSEPHUS DANIELS,
Secretary of the Navy.

CONTENTS.

CHAPTER 1.

HANDLING MEN.

"Historically, good men with poor ships are better than poor men with good ships."—Mahan.

1. Importance of proper handling of men.—Of far greater importance to officers than any material or tools committed to their charge is the personnel with which they are concerned. The spirit and training of the men has always been a more important factor in winning battles than the characteristics of the ships or of the weapons employed. Success in training and in the cultivation of this spirit depends to a very considerable degree on success in handling men.

2. Self-training on the part of officers.—It is not fair to the ship or to the men under the control of an officer to make them bear the brunt of personal deficiencies existing because of a neglect of self-training, which is incumbent on all officers. If satisfactory results in handling a command do not appear to be forthcoming, an officer should make a study of himself, his methods, bearing, and attitude. The cause of the difficulty may be discovered.

3. Force of example.—Men will take just as much interest in their duties and work just as hard as the officers who are placed over them. Example appeals strongly to men, and officers must bear in mind that their bearing, manner, and language in dealing with seniors, as well as juniors, are all copied by their subordinates. An officer must at all times set an example of industry, zeal, initiative, and punctuality, as well as neatness of dress and correctness of bearing, if he is to expect these from his men.

4. Criticism of superiors.—Hostile criticism of authority will ruin any organization and completely destroy unity of action. A subordinate is seldom in a position to judge of the actions of his superiors intelligently and should not be prone to criticize until aware of all circumstances and facts. Destructive criticism which is born in officers' messes is contagious, and will soon spread through the ship and completely kill ship spirit Cooperation is essential on the part of all hands. Each individual must be assured that his own part and task are thoroughly accomplished and in a way which will best assist others working toward the same end and while yielding unqualified support to authority. This is essential to success in any organzation, where many men are employed, as a fundamental of discipline.

5. First attributes of an officer.—Good manners, coolness. and self-control are the first attributes of an officer and are just as important in dealing with juniors as with seniors. Leadership is an essential. It is fundamentally based on proved superiority. The officer must be first in everything at all times.

6. Importance of understanding individuals.—A most important thing is to know men thoroughly, their peculiarities, abilities, weaknesses, character, etc.

7. Methods of handling men.—Praise will frequently better promote interest and efficiency than censure or punishment. Be strict, but not harsh. Remember that you are dealing with individuals as sensitive and jealous of their rights as yourself. Fairness and impartiality in dealing with them are essentials. But little good and often great evil is accomplished by unnecessary shouting. Nothing is more discouraging to an individual than the finding of fault with him when he is using his best endeavors.

8. Importance of interesting men in work.—No one objects to useful work. Interest your men in what they are doing. Be sure that they understand what it is intended to accomplish and why. At drill, when teaching certain details, explain why these details are necessary. Point out the difficulties and the methods for overcoming them.

9. Suggestions from crew.—Never disregard, but welcome, the suggestions from your petty officers and men. Give all consideration, and if suggestions are not practicable explain why. Such an attitude on the part of an officer will always help to promote and encourage a live and personal interest in their work on the part of the crew, and frequently many helpful ideas will be offered.

10. Seizing opportunities.—Take full advantage of opportunities as they are presented. There is too much to be done to expect unlimited time to attend to all the details of training and development separately. The best organization is not one in which a single individual directs all details. It must be such that subordinate leaders are given specific tasks for the accomplishment of which they are given the necessary authority and for which they are held rigidly responsible. The leader must organize his forces and arrange his program accordingly, taking full advantage of every opportunity that occurs. Many of the complaints regarding lack of opportunity come from those who fail to recognize opportunities as they occur and do not fully avail themselves thereof. Facilities, conveniences, and opportunities are seldom the best, but be sure to make the most of such as are presented.

11. Petty officers.—Petty officers are indispensable assistants. They must be able to realize and to exercise their responsibilities. Expect the same loyal support from them that you afford your superiors. Endeavor to handle the junior ratings of your division through their own petty officers, and train your junior ratings to obtain information and instruction from ther own petty officers.

12. Smartness and cleanliness essential.—A division that is smart in infantry, boat, and other drills is more apt to be smart in gunnery than one that is generally slack. Cleanliness of uniform, person, and of ship are all important. No one is proud of a dirty ship or a dirty shipmate.

13. Competition.—Stimulate competition by all legitimate means. Arouse a desire to beat the other fellow, but only *by honest and fair* means. Analyze and post all records and scores.

14. At quarters and drills.—At quarters set an example yourself in military form and manners and your division will imitate you. Do not hold men at "attention" longer than necessary; but when the command is "attention," enforce it.

15. Inspections.—At daily inspection at quarters avoid arguing with or questioning the men while in ranks as to delinquencies in uniform. Make a mental note of each case and overhaul the man about it after quarters. The best form is to inspect your division without allowing yourself directly to address a man in ranks about deficiencies in his personal appearance. To call a man down in the presence of others about his personal appearance does not nourish his self-respect, which if destroyed ends his usefulness.

16. Particular care with young men.—Many young men are discharged as undesirable or with bad-conduct discharges who might have been saved to the Navy had they had more official interest and encouragement bestowed on them by the division officer. Youngsters who are inclined to be shiftless require forethought on the division officer's part to keep them from delinquencies. The more a young man is inclined to be delinquent in petty matters the more often a cheering encouragement will bear fruit. When a man is bracing up, commend him.

17. Commendation, censure, and reports.—Commendations might well be heard by others and when merited should be prompt. Censure should not be public. Reports of a trifling nature are undesirable. Never report a man unless there is ample and good reason for believing that he has intentionally committed an offense deserving of punishment.

18. Giving commands.—Much depends on the manner in which a command is given. The voice and tone employed and method of expression are of importance, as well as the character of the command. All uncertainty is to be avoided, and the manner should carry with it the impression that obedience is expected. Clearness to the person to whom the command is given is essential. No command should be given unless it can be obeyed, and when given it must be obeyed. The giving of unnecessary commands should be avoided.

19. Comforts of men.—Carefully look out for the comforts of the men. The successful ship is the happy ship, and the men must feel that their ship is their home. The Navy owes every man reasonable comfort in a place to sit, to eat, and a billet that will afford a night's rest. Look out for these. Details, often trifling, in controlling the uniform, berthing, messing, and living arrangements may greatly contribute to their welfare and contentment. It is an essential part of an officer's duty to care for such details. On Saturday, Sunday, and holidays, and after working hours, initiate recreation for your division, such as sailing parties, swimming parties, and the like.

20. Avoidance of petty annoyances.—Guard your people from petty annoyances, such as interference with meal hours. If any are away at meal time, be sure they are provided for on their return. When men have been exposed to bad weather or have had unusually hard work, as is not uncommonly necessary on board ship, be sure that their well-being is looked out for.

21. Importance of minor details.—These small matters have a great influence. Once the men of a ship realize that the officers have their interest at heart the success of the ship is assured. In no other way can a strong ship spirit be developed, and a slight effort in this direction on the part of officers will accomplish great results.

CHAPTER 2.

GENERAL PRINCIPLES OF TRAINING.

22. Training for war, the first principle.—The first principle to remember in training is that war should be considered a contingency that is likely to occur with but little warning. A second is that the closer the training exercises in time of peace resemble the conditions to be expected in battle, the fewer will be the derangements and the less will become the influence of danger and of these derangements on the moral qualities of the crew.

23. Training more important than material.—Unless the naval officer, in time of peace, devotes thought and study to the important feature of his profession—making the most out of his command, whatever it may be—he can not prepare himself for the duties that will come to him in war. In times of peace it is natural for other matters, such as features of administration, material, and design to occupy first place in the minds of those who will be called upon in war to use weapons and ships. Preparations for war can not be adequately accomplished after hostilities have begun, and unless the training has been correct and sufficient the officer will, when called upon for a demonstration of his proficiency, find himself in the position of the indifferent workman who invariably complains most bitterly of his tools. *Success will depend to a far greater degree on the spirit and morale of the personnel, and on the training and ability of all to coordinate their efforts, than on any features of administration or material.* The proper bearing and zealous efforts of every officer are directly reflected in the interest and enthusiasm with which the crew carries on the hard work necessary on their part. The importance of retaining the interest of the men is sometimes not fully appreciated. The successful and happy ship is the one in which the men are encouraged to have a knowledge, interest, and pride in their work. These can only be aroused by intelligent and cheerful zeal on the part of all officers.

24. Character of system.—The system of training herein prescribed begins with the selection of the units of the gun crews and describes the training necessary to render each expert in his individual duties. The gun crew is then perfected as a team, and when this is accomplished the training is for the development of the ship's battery as a whole, and finally for the collective fire of the batteries of more than one ship.

25. Utilization of the spirit of competition.—This requirement is fundamental. The natural desire of one man to excel another in any test of skill is an incentive to thorough training that may be regarded as the basis of all real success. However complete may be the system or the apparatus, or however diligent and faithful the officer, unless the *desire to excel* is excited the result will be mediocre. Perfunctory training will never produce as good an oarsman as boat racing. This spirit should be fostered and utilized in the daily drills by pitting individuals and crews against one another. Care should be taken to avoid all questionable or unfair methods.

26. Final purpose of training.—The final purpose of competitive training, *battle efficiency*, must not be lost sight of. The competition is but the means to that end. What is desired is a state of efficiency or a condition which will enable a vessel to make a good score under any circumstances and not only under the peculiar conditions of a particular problem.

27. Permanence in stations.—The skill of the ship in gunnery depends directly upon the skill of each officer and man in his individual duties. Neither officers nor men can reach their maximum skill if they are frequently shifted from one station to another. Members of crews should, however, be exercised in stations other than those they habitually fill, in order that casualties to personnel shall not silence the fire.

28. Casualties.—Any training that does not prepare for and fully anticipate casualties to both personnel and matériel is incomplete. It should be remembered that in preparing for casualties no methods or devices should be allowed that would not be practicable in action. Many casualties probable in battle can not be ordered at the times of target practice without introducing an element of danger or interfering with competitions. These must be prepared for at other times.

29. Service conditions on drill.—In conducting drill the regular battle system of communications should always be employed. Turrets should be closed as would be the case in service. The conditions during drill should be made harder than they would be at target practice and, if possible, as difficult as would be the case in action. Then when unforeseen contingencies arise men and officers will be schooled in steadiness. Though dummy charges are used, the safety orders must be carefully observed. A carelessness on the part of officers, begotten by either ignorance or failure to appreciate their duties is immediately copied by the men.

30. Investigation of unsatisfactory performances.—An unsatisfactory performance at drill should always be carefully investigated and the cause definitely determined and removed.

CHAPTER 3.

GENERAL PRINCIPLES OF NAVAL GUNNERY.

31. Final objective.—The final objective of all naval gunnery training is the development of an ability to hit an enemy rapidly, at varying ranges, and under different conditions of sea, weather, and light. The subject is a broad and comprehensive one. In its final stage the training becomes that of the fleet, and involves the development of units to the highest efficiency.

32. Final stage of training.—The gunnery training in this final stage becomes closely merged with tactical development, as it is not sufficient to have good weapons and to be able to use them at target practice, they must all be brought into action and maintained there properly. Unless a maximum of effective fire delivery with both guns and torpedoes is maintained from each vessel of a force engaged in battle, the gunnery training can not be said to have been complete. The different classes of ships must be so trained that they may all effectively operate together.

PROFICIENCY WITH GUNS. (Fired individually).

33. First essential.—It is imperative that each ship be able to hit, with rapidity, a target under favorable conditions. To make this possible, when all guns are firing, it is necessary that the vessel be able to do so first with each individual gun firing singly.

34. Analysis of principles.—An analysis of the principles of naval gunnery must therefore first reduce itself to an analysis of the principles involved in excellence with the individual gun.

35. Excellence, how measured.—Excellence in gunfire is measured by rapidity of hitting. It is evident that however large a percentage of hits a gun may make, if these hits are not made with the *greatest possible rapidity*, the gun will have failed to attain its highest efficiency. Rapidity of fire with inaccurate pointing is useless and demoralizing, and entirely prevents control of the fire of the gun when fired individually, and makes impossible the successful control of a group of guns when fired collectively. The following may be regarded as the two essential elements of excellence in gunfire: (A) *Accuracy of fire;* (B) *Rapidity of fire.*

36. (A) Accuracy of fire.—This depends upon:

I. The accuracy of pointing.

II. Satisfactory sight setting.

III. Elimination or reduction of errors of gunfire as mentioned in chapter 19.

37. I. The accuracy of pointing depends upon:

1. The skill of the individual pointer, which is developed by—

(*a*) Continued practice at his own gun or type of gun with mechanical targets, in port or at sea, when other methods are not available.

(*b*) Using a check telescope at sea.

(*c*) Firing with subcaliber.

(*d*) Actual firing at target practice.

2. The condition in which the sight, the gun, the mount, and the various appurtenances which affect accurate shooting are kept, together with the degree of excellence in their design and manufacture. Unless the design is satisfactory, and unless the gun, mount, sights, and accessories are maintained in such condition that the difficulties in aiming and firing are

minimized, the accuracy of pointing will be affected. This applies to the facility of operation, and to the proper functioning of each individual part. A neglected mount renders pointing difficult and hence conduces to inaccuracy. Neglected sights always invite failure. If they are out of adjustment they insure great dispersion and misses. If they are weak and liable to derangement, they may jar out of adjustment while firing is taking place and thus invite disaster. Neglected firing connections, locks, etc., promote hangfires, misfires, or prolong firing intervals, all of which militate against good pointing and are serious hindrances to rapidity of hitting.

38. II. Satisfactory sight setting depends upon:

(*a*) The adjustment of the sight. The sight must travel with the gun at all angles of elevation. Lost motion is almost sure to appear in time in the older types of sights, and careful supervision and frequent checking up of the adjustment thereof are essential. (See chap. 13 on boresighting.)

(*b*) The accuracy and precision of the orders given to the sight setter concerning the setting of sights. This depends upon (1) the accuracy with which the sight-bar range has been determined, which may be regarded as the most difficult problem in naval gunnery; (2) the arrangement and condition of the system of communications, together with the skill with which it is used.

(*c*) The promptness and precision with which these orders are obeyed. It is manifest that however perfect the gun, the mount, the crew, and the ammunition, unless the sights are correctly set, the projectile will certainly miss the target. Great care must be exercised in the selection and training of sight setters, and the accuracy with which the setting of the sights is accomplished should be carefully checked up after, and, if possible, during each run at target practice.

Whatever the form of firing, the sight setter's duty remains the same. It is to set the sight as accurately and as quickly as possible, both laterally and in elevation, each time a new deflection or range is ordered. The pointer always aims at exactly the same place, and all errors are corrected by altering the sights.

39. III. Elimination or reduction of errors of gunfire.—These errors are discussed at length in chapter 19.

40. Uniformity of loading.—Precision of fire depends to a considerable degree on the uniformity with which the operations of loading are completed. In B. L. R. guns the shell must invariably be seated, the ignition ends of sections of the charge must be to the rear, and the ignition end of the last section of the charge must be close to the mushroom face.

41. Necessity for elimination of errors.—It is manifest that as the ranges increase, and the danger spaces are diminished, the necessity for reducing and, if possible, eliminating anything which may produce errors in the accuracy of gunfire should be carefully investigated. To a considerable degree investigations along these lines are possible only at proving grounds, but officers afloat should carefully study all data which may have a bearing on these errors. Such data may be obtained from the Range Tables, and other ordnance pamphlets and works on ballistics. As these errors are reduced, the possibilities of increasing the effective range are vastly increased.

42. (B) Rapidity of fire.—This depends upon:

I. The rapidity of loading.

II. The promptness with which the pointer fires after the gun is ready, or the firing signal has been given; or, briefly, rapidity of pointing.

III. The facility with which fire may be controlled.

43. I. Rapidity of loading with modern guns depends upon:

(*a*) The rapidity with which each member of the gun crew performs his duty.

(*b*) The precision with which each one performs his allotted portion of the drill.

(*c*) The "team work;" that is, on each member of the gun crew performing his duty at exactly the proper time and in exactly the proper sequence, and the elimination of interferences between individuals of the crew.

Accuracy and thoroughness in every detail are requisites to rapidity of loading. Eagerness for excessive rapidity may result in interference, confusion, and casualties that can be avoided only by precision in every movement. Certain of these delays, such as the raising of a burr, the jamming of a cartridge case, or the breaking of a powder bag may more seriously interfere with the rapidity of fire than the deliberation necessary to surely avoid them.

44. II. Rapidity of pointing, like accuracy of pointing, depends upon:

(*a*) The skill of the pointer.

(*b*) The condition of the material.

A skillful pointer will, under ordinary conditions, keep a gun of intermediate or secondary caliber, on a modern gun mount installed in a vessel that is a good gun platform, practically continuously pointed at the target, provided the mount is maintained in a perfect condition. The gun is therefore aimed and prepared to fire shortly after the instant the pointer is notified that the gun is "ready." If to this degree of skill of the pointer and excellence of mount is added a firing mechanism in such efficient condition that the gun will fire when the pointer presses the firing key, ignoring for the moment questions of fire control, the rapidity of aimed shots is made practically equal to the rapidity with which unaimed shots may be fired. So long as this degree of rapidity is possible with any gun, it is evident that any time which elapses between the word "ready" and the firing of the gun, when not firing on order or on salvo signals, is a loss. A lack of adequate rapidity of pointing may result in a failure to fire when the signal is given, which lessens materially the fire delivery of the ship, on the efficiency of which depends the value of the vessel as a battle unit. It must be remembered that rapidity of pointing is never to be obtained by the sacrifice of accuracy.

45. III. Facility of fire control.—At short, measured ranges, when firing guns singly, the spotting of shots other than the first shot in a string should be unnecessary. At long ranges the delays incident to spotting are of greater moment, as the time of flight and intervals of time necessary for the spotter to decide on his correction and to have this correction appear on the sights, are all appreciable. Effort should be constant to lessen these delays.

The above remarks refer to day firing. They apply, however, equally well at night. Gunnery at night is further complicated by—

(*a*) The necessity for illuminating the target.

(*b*) The difficulties of properly controlling searchlights.

(*c*) The annoyances incident to blast of guns and glare of lights, which are increased by the gases of discharge.

(*d*) The difficulties incident to setting sights with artificial illumination and of working about the guns under unfavorable conditions of illumination.

46. Necessity for cooperation.—From the above it is apparent that skill in gunnery depends not upon the pointer alone, but upon every person participating in the practice—on the ship-control, fire-control, and searchlight-control parties, the division officer, the gun captain, pointers, the sight setter, and on each individual member of the gun crew. The greatest rapidity of hitting can be attained only by the united efforts of each person concerned, working in complete harmony with every other member of the crew. A failure in the slightest detail, on the part of any one participant, may materially reduce the rapidity of hitting, and thus nullify the greatest possible excellence on the part of others.

CHAPTER 4.

DETAILS OF TRAINING—INDIVIDUAL GUNS.

47. Ordnance pamphlets.—Attention is invited to the numerous pamphlets published by the Bureau of Ordnance containing descriptions of material and methods of operation.

48. Ordnance Instructions.—Particular attention is called to Chapter 26, Ordnance Instructions, Navy Regulations, and Naval Instructions, 1913. These instructions must be understood by all officers in any way concerned with the ordnance outfit.

49. Selection of crew.—There are now sufficient trained men in the service so that it should be very seldom that a gun's crew has to be selected entirely from new hands. With men who have been in the service for some time their previous experiences, service, gunnery, and torpedo records should be considered when assigning them to battle stations.

50. Stationing the gun crew.—The division officer should first select the gun captain and members of the gun-pointer group and then the others of the crew, taking into consideration mental and physical qualifications and the requirements of the respective stations. This first assignment is, of course, tentative and subject to change when qualifications are better known. Attention is invited to article 2501 (2) (3), Naval Instructions, regarding the selection of gun pointers and the stationing of gun captains and pointers.

51. Selection of gun captain.—The general requirements for a qualified gun captain are thorough practical knowledge of the gun, mount, and various appurtenances, also of the drill gun, and a system of training, together with the executive ability to drill and command the crew. He should be a man of resource and quick action, for in battle he may be called upon to act upon his own responsibility. The man's executive ability and general intelligence should be given the greatest weight, as these, combined with zeal, will quickly develop the necessary knowledge. As a rule, petty officers, being initially a class selected for these qualities, will be the men best fitted for these positions. A seaman who is qualified for gun captain generally possesses the qualifications that entitle him to promotion to petty officer, third class.

52. Selection of gun pointers.—Men with the proper qualifications may be trained as gun pointers quickly and easily. In selecting gun pointers, division officers should give weight to the man's ability to shoot straight, as indicated by his record with small arms, in connection with good eyesight, nerve, and a cool, nonexcitable disposition. The importance of these latter qualities may not appear in preliminary training, but they are essential and should receive first consideration. Men whose nerve and physical training will withstand the exhaustive tests incident to battle are those to be desired. A man's rating, general knowledge, or executive ability should not be allowed to have weight in his selection as a gun pointer.

53. Selection of sight setter.—The requirement that the sight setter receive regular training and act as second pointer for turret guns necessitates that the same care be exercised in the selection of candidates for this position as for pointers.

54. Expiration of enlistment.—An important point to be considered in connection with the selection of gun pointers is the expiration of the candidate's enlistment. A man who has already qualified as gun pointer will not be deprived of his position at the gun (and hence of his extra pay) on this account alone, but, when practicable, no new man should be selected for training if the expiration of his enlistment will not permit him to serve as a gun pointer for at least one year after qualifying for that position. The longer a man has to serve, the greater his desirability as a pointer, other considerations being equal. After a practice each division officer should ascertain how many of his pointers will remain until the next practice, and immediately put men in training to replace those who will not be aboard. In several instances ships have been called upon to hold practice very shortly after commissioning, and have demonstrated that where intelligent effort was made in stationing and exercising crews creditable performances were quickly possible.

55. Spare set of pointers.—A spare set of pointers and sight setters will be kept in training for each gun at all times.

56. Bunching of shot.—The value of a pointer should be judged by the way he bunches his shots. A man may show aptitude by bunching, while another may demonstrate by scattering his shots that he has not profited by training and is undesirable as a pointer. In forming his judgment the division officer should be sure that the scattering of shots has not been due to inaccurate sight setting or to other causes.

57. Training pointer.—The training pointer occupies a most responsible and difficult position, and particular attention should be given to the development of men for this station.

58. Devices for training.—The following mechanical devices are used for training members of gun crews. Success attained with them depends to a considerable degree upon the accuracy with which the apparatus is installed:

(1) The dotter.
(2) The Morris tube.
(3) The check telescope.
(4) Subcaliber attachments.
(5) The loading machine.

Having developed skill individually, the following develops the skill of the crew as a whole:

(6) Drill at gun.
(7) Target practice.

The individual function of these will be explained in the order mentioned. This explanation is made in considerable detail for the benefit of inexperienced officers.

59. Features taught by training with mechanical targets.—The following features of training gun-pointer groups are particularly developed with mechanical appliances:

(*a*) **Position of pointer at the gun.**—Unless the pointer assumes an easy position at the gun the best results will not be forthcoming. Pointers will sometimes select cramped positions, with wrong eye at the telescope, hands improperly placed on the elevating wheel, etc. All of these must be corrected. It may not be sufficient for the pointer to say that his position is the easiest for *him*.

(*b*) **Continuous aim.**—Continuous aim does not mean that the line of sight is necessarily held on the target during the *complete roll* of the ship, but it means that the gun is held accurately pointed throughout the firing interval; that the wires are on the point of aim and not *moving across* it when the firing key is pressed. This is essential to accuracy whenever a gun is fired from a rolling platform. The feature of maintaining the aim during the complete roll is an element affecting *rapidity* but not *accuracy* of fire. An expert pointer will usually hold the horizontal wire of intermediate and secondary guns on the target while the gun is being loaded, and will be ready to fire the moment he receives the signal. The necessity of attempting continuous aim must be impressed upon all pointers, together with the difference between maintaining the aim during the *complete roll* and during the *firing interval* only.

(*c*) **Method of operating gun.**—The elevating pointer of a turret gun, where it is necessary, should receive training in laying his gun in the loading position after each shot, so that he will do it instinctively, and then resume his position at the sight, ready (the moment gun is loaded) to pick up the target; the trainer maintains his aim at all times.

(*d*) **Sight setting.**—Hitting is impossible unless the sight setting is accurate; rapidity of fire is also impossible without promptness in sight setting; hence, it is essential that careful attention be given this matter. In setting sights there should be no wasted effort or time due to the sight setter raising and then lowering the sight, and vice versa. The correction should always be started and completed in the direction in which it has been ordered. When a correction to the sight has been accomplished it has been found advantageous at elementary practice to have the sight setter call out "set." In all exercises of the pointer group, sight setting and range transmitting should be practiced, and the sights should be changed without the knowledge of the pointer.

(*e*) **Joint training of members of the gun-pointer group.**—In view of the fact that two men are required to point each broadside gun of 3-inch caliber and above, and three men constitute a set of pointers for a turret, it is important that these men receive as much practice as possible when working together.

60. Advantages of the mechanical devices.—Guns rigged with mechanical targets generally work with greater ease and nicety of movement than others. Several mechanical targets should be rigged for each caliber, and these should be shifted from one gun to another. In some cases the difference between a mount which has had considerable mechanical target work and others is so great that the exercise loses much of its value when the trained pointer fires his own gun on which a mechanical target has not been rigged. In so far as practicable, a pointer should receive all training at his own gun. It should be borne in mind that the continuous use of one gun for the dotter and mechanical targets will be apt to eventually produce lost motion in the gears.

61. Advantage of one device over another.—Officers generally express a strong preference for one or another of the devices herein mentioned for training gun pointers. The strong arguments that are heard in favor of each show conclusively that there are good reasons for the employment of all of these devices. There are many times, however, when one may be utilized to far greater advantage than another. The value of any of these methods depends on the intelligence with which it is used.

DISADVANTAGES OF TRAINING WITH MECHANICAL APPLIANCES.

62. Pointers trained with mechanical appliances failing on target practice.—Some pointers who consistently make good scores with the Morris tube and dotter sometimes fail to make good scores at practice. This is due to a variety of reasons, and these should be carefully considered by the division officer in deciding whether or not the pointer should be continued in his position.

These reasons may be enumerated as follows:

63. (*a*) **Mechanical targets do not test the nerve.**—Skill in pointing consists in always, not sometimes, having the gun accurately pointed when fired. The pointer whose mind is occupied with dread of the discharge will never succeed in making a good score when firing from an unsteady platform.

(*b*) **Mechanical targets do not test the obedience.**—Implicit obedience in regard to the point of aim is essential to consistent hitting. The temptation for a pointer to aim at some other point than at the point designated, in order to correct an error made in the preceding shot, is very great, and may not appear to a great extent in training.

(*c*) **Perfunctory training.**—The training will become perfunctory if the division officer does not exercise vigilance. Training with mechanical targets may be carried out in such a manner that the pointer may make excellent scores by firing "on the fly"; that is, when the line of sight is moving more or less rapidly across the target. Good scores are made more readily with mechanical appliances than with the gun, on account of the shorter firing interval, and also because the motion of the target can be easily anticipated. Pointers are very often assisted by a fixed background which acts as a plane of reference on which to estimate the motion of the target.

(*d*) **Regularity of motion.**—A ship's motion in a seaway is irregular, whereas, pointers are sometimes trained with a mechanical target on which ingenuity has been expended to make motion uniform. The target is rarely moved in a manner which reproduces the motion of a ship. The loss in both accuracy and rapidity of fire is frequently due, not so much to the difficulty of the elevating pointer holding on, as to the fact that the irregular lurching motion interferes very greatly with the trainers. Mechanical targets should have separately operated training and elevating gear. Successive rolls should not be of the same amplitude. Yaw should become quick and irregular as the training progresses. At practice with mechanical target no pointer should ever be allowed to fire when the target is steady at the end of the roll. The ship's period, both for roll and for pitch, should be carefully timed, and the period for the mechanical target established from the data obtained. The period for roll, for the mechanical target, should be less than that of the ship. Pointers should, if practicable, be trained to fire at all times during roll.

(*e*) **Failure to follow through.**—It is frequently the case that a pointer who practices successfully with mechanical targets will, when firing, follow only until he wills to fire, and fail to follow throughout the firing interval, thus insuring a miss when there is any considerable motion. A delayed action in the firing circuit will assist to correct this fault. This delayed action should be variable.

64. Extreme accuracy in pointing.—Attention is again particularly invited to the necessity for carefully training pointers to the highest possible degree of accuracy in pointing. Unless the pointers have been so trained that we can always rely upon them to hit within a small space when all of the conditions are known, it will be impossible to develop an accurate fire under battle conditions, where we may have to depend very largely upon the accuracy of the pointers to determine the most difficult of all of these conditions, viz, the sight-bar range of the enemy.

65. Result of firing when not on.—The pointer should be made to realize that if he fires when not exactly "on" and following, he will certainly miss, causing a delay until the gun is reloaded, and giving the spotter an incorrect impression. When the gun is finally reloaded it will then be in exactly the condition as it was before he fired. The pointer has, therefore, lost the entire time required to load, aim, and fire one shot, not to mention having wasted the ammunition, and interfered with fire control.

66. Necessity for skill with mechanical targets.—Until a man has acquired skill through practice with mechanical devices, there is little use in his attempting to fire from a rolling platform. Progress must be judged by results and not by the hours of training. Some men acquire expertness quickly, while others soon show that it is a waste of time to attempt to train them as gun pointers.

67. Necessity for accurate mechanisms.—Accurate, quick work with mechanical targets is impossible with faulty mechanism; division officers should devote the greatest attention to eliminating the lost motion in their mounts and sights. Before attempting drill it is essential that the adjustments be exact. Gun should be weighted at breech in order to compensate for the absence of the weight of the projectile and charge. Otherwise undue load is thrown on the elevating gear, which results in wear, and the pointer may be improperly instructed in the manipulation of his mount. (Placing a projectile in the gun is sometimes an easy way to overcome this difficulty.)

68. Progressive training.—The dotter and Morris tube are intended to train men to a high degree of manual dexterity in handling their guns. The motion given to the target should always be kept slightly in advance of the skill of the pointers until they have attained proficiency. It must, of course, be slow and regular in the beginning, but before a pointer is expert he should be able to make a good score on a target whose motion is both irregular and rapid.

THE DOTTER.

69. Advantages of the dotter.—The advantages of the dotter as an instrument for the training and practice of gun pointers are:

(1) Training with it may be carried on at practically any time, especially in port (or at sea when check telescopes can not be used, see art. 77).

(2) Small inaccuracies in aiming are made apparent because of the size of the impression made by the dot.

(3) If well designed and made, the instrument is exceedingly accurate.

70. Variety of design.—Because of the number and variety of designs, it is not deemed necessary to describe in detail the various types of dotters used on board ship. Some are somewhat complicated in their details, and all require careful adjustment and attention.

71. Delayed action.—Attention is invited to the desirability of so rigging the dotter as to cause it to delay firing after the key is pressed, which necessitates keeping "on" the target during the firing interval.

THE MORRIS TUBE.

72. Function.—The Morris tube affords a ready means of exercising the pointer group. It is cheap, easily rigged, and readily adjusted, but is not as refined an instrument as the dotter. If the rifle is properly mounted the sight setter may be given drill as well as the pointers.

73. Design and rig.—While a diversity exists in the method of rigging, the diagram shows the essential features of the most common form.

Briefly, the appliance consists of:

(*a*) A miniature target carried on a target frame, E, at the muzzle of the gun, which is capable of both vertical and lateral motion, while remaining always at approximately the same distance from the pointer's eye at the telescope, D.

(*b*) A small rifle, B, is rigidly secured to the great gun, and in such a position that the axis of its bore and the line of sight of the great gun intersect at the miniature target.

(*c*) A bullet stop, A, secured to the muzzle of the great gun.

74. Turret devices.—In turrets having sights mounted otherwise than on the trunnions of the gun the Morris tube rifle must move parallel to the line of the telescope. This somewhat complicates the design of the device for turret mounts.

75. Essential features.—The following are essential features of a successful Morris-tube target:

(1) Elimination of vibration.

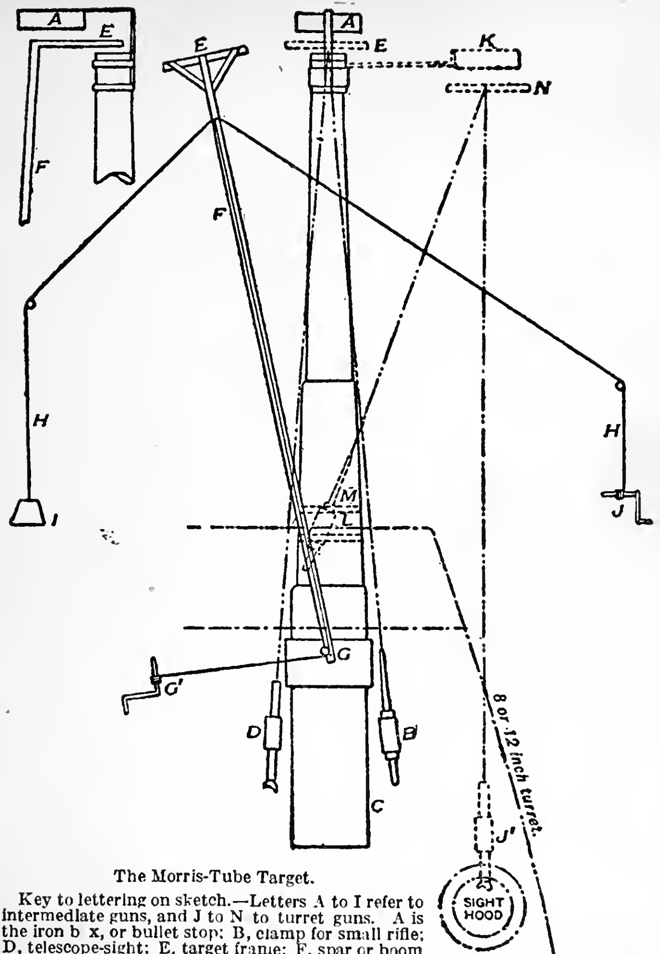
(2) Every part of the target frame, boom, weights, etc., should be heavy and substantial. Weight is essential in order to secure a steady motion.

(3) The elevation and train of the target should be entirely independent of each other.

(4) The guys should be so rove off that they will not cause a jerky, irregular motion.

(5) The target should move very slightly for a considerable movement of the cranks, giving the vertical and horizontal motion.

(6) The target sheets should be so secured as to minimize the effect of vibration caused by wind.



The Morris-Tube Target.

Key to lettering on sketch.—Letters A to I refer to intermediate guns, and J to N to turret guns. A is the iron b x, or bullet stop; B, clamp for small rifle; D, telescope-sight; E, target frame; F, spar or boom carrying target; G, small pulley for boom topping lift; G′, reel for boom topping lift; H-H, transverse guys passing over pulleys, one to weight I, the other to reel J; J′, turret telescope; K, bullet stop on turret guns; L, bands on the chase of turret guns for securing small rifle; M, small rifle mounted on turret guns; N, target frame for turret gun.

(7) The small rifle should be so rigged that the regular firing key of the gun may be used.

(8) The rifle should be mounted so as to permit it being quickly moved, both in elevation and in azimuth, a certain definite amount in order to afford exercise for the sight setter. In this case the bullet stop must be large enough to catch bullets fired from any position of the small rifle, the motion of which should be limited by stops. Reports of target practice show that one of the chief causes of poor shooting is that the sight setters had been instructed, but not sufficiently trained in their duties.

(9) The electromagnet should be so fitted as to delay the fire by a variable amount after the firing key is pressed, in order to force the pointer to practice continuous aim.

(10) The minature target should be about 25 per cent smaller than the smallest projections of the target which it is intended to represent.

(11) The bore of the small rifle must be kept clean.

THE CHECK TELESCOPE.

76. **Advantages of check telescope.**—The check telescope is a most excellent means of training and of discovering the abilities of gun pointers. The advantages of this method are that—

(*a*) It may be utilized at sea if ships are cruising in company.

(*b*) No special apparatus has to be rigged.

(*c*) By observing the principles carefully a division officer should be able to find out fairly exactly the abilities of his pointers, and what he may reasonably expect them to do at target practice before a shot is fired.

77. **Check telescopes in connection with mechanical targets.**—Training at Morris tube and dotter may be regulated at will to simulate, to some degree, any desired condition of

motion. With check-telescope training, only the motion on a particular day is available. As on many days at sea there is practically no motion in big ships, every opportunity for rough-water check-telescope work should be taken advantage of. Telescopes with check eyepieces are very valuable when used together with the dotter. By utilizing the check sight the division officer is enabled to watch and control the operation of the dotter, and to study the methods and progress of his pointers.

78. Types of check telescope.—In the later ships the pointers' telescopes are provided with eyepieces, to be used in checking the pointer's work. In older ships attachments have been secured to the sights and auxiliary telescopes mounted for use on the larger guns. With the secondary guns it is sometimes necessary to use bore sights for checking purposes.

79. How mounted.—Check telescopes may be mounted outside on the turret guns themselves, or attached to the pointer's sight. A method is to mount three telescopic sights as follows: One on each gun on a horizontal arm projecting inward, and a third on a vertical stand on top of the turret for use in checking up the trainer. This third check has been found exceedingly useful. These "checks" should be fitted with easily adjustable thumbscrews to bring the cross wires on with the pointers, and should be protected from the weather and spray by suitable coverings. By means of the adjustable thumbscrews the checks can be brought on and bore sighted with the pointer's sights at any time, and with very little trouble; of course, a change in range will throw the checks out, but this, however, can be adjusted in a very short time. It is important for the officer at the check telescope to be in easy communication with the pointer so that he may coach him. A flexible tube should be so rigged that the officer may speak into one end of it while looking through the check telescope. The other end of the tube should be close to and opposite the pointer's ear. A buzzer attached near the check telescope outside, and connected to the firing key, announces to the officer the instant when the trigger is pulled. When the officer is in direct communication with the pointers, as, for instance, when inside the turret, the voice tube is unnecessary.

80. Necessity for firing signal.—It is desirable to connect a buzzer in the firing circuit which the pointer sounds when completing his contact on firing and when properly laid on the target. Signals to fire should be given at proper part of roll. When there is an excessive roll, it is not possible to be "on" at all times with present gear, but there will come a time of comparatively easy motion when the signal should be made. Signals should not be given at regular intervals of time and should not be given oftener than the time required to load the gun. The interval between stand-by and fire should not be constant.

81. Conducting exercise.—In conducting the training with check telescopes vessels should steam on parallel courses, each hoisting a target of predetermined size laid out in rectangles. The division officer, by carefully observing the work of his pointers and by assigning a definite value to certain rectangles in the pointer's target, is able to assign definite scores to his men. Three officers should be present at turret check telescope drill. If this is not practicable, a reliable petty officer may perform the duties of an officer in checking up and scoring. Individual score cards should be kept for each man, the result of his strings accurately recorded, and results, with a mark of efficiency, posted on the bulletin board.

82. Necessity for keeping scores.—By keeping scores carefully, like batting averages, and by posting them on the bulletin boards, interest and competition are stimulated, and a very good idea may be gained of the work of the pointers and what may be expected of them with the ship rolling and pitching under various conditions of sea and weather.

SUBCALIBER PRACTICE.

83. Value of subcaliber practice.—This practice is of great value after a certain amount of skill in pointing has been attained. If carried out with untrained pointers, it will be found of less material benefit than otherwise. Subcaliber is a method supplemental to and advanced beyond those previously described, but, as mentioned above, it is an essential part of battle training. Subcaliber furnishes an agency permitting practically a dress rehearsal of a battle practice, exercising simultaneously the fire-control parties, spotters, sight setters, and others concerned, as well as the gun pointers. Casualties may be simulated and drill made very realistic. This practice can be held at any time two or more ships find themselves together at sea, practically without regard to weather or speed.

84. Necessity for accuracy in adjusting pieces.—A first essential in subcaliber work is that the smaller pieces should be accurately bore sighted with the larger ones to which they are attached.

85. Firing connections.—The subcaliber pieces should be fired by direct attachment to the ordinary firing connection. If this is not possible, a reliable, quick means of giving the firing signal to the man firing the piece should be arranged.

86. Table for subcaliber.—The following table shows the ranges at which the angles of fall of the 1-pounder correspond to those of the larger pieces at 10,000 and at 1,800 yards.

Gun.	Range.	Service I. V.	Angle of fall.	Corresponding 1-pounder range.	Reduced I. V.	Angle of fall.	Corresponding 1-pounder range.
	Yards		° ′			° ′	
14″/45	10,000	2,600	6 41	1,975	2,000	11 52	2,600
13″/35	10,000	2,000	15 12	2,950	2,000	15 12	2,950
12″/50	10,000	2,900	5 21	1,750	2,100	10 42	2,500
12″/45	10,000	2,700	6 15	1,900	2,100	10 42	2,500
12″/40	10,000	2,400	8 04	2,150	2,100	10 42	2,500
10″/40	10,000	2,700	6 54	2,000	2,100	12 05	2,650
8″/45	10,000	2,750	7 50	2,125	2,100	13 52	2,800
8″/35	10,000	2,100	13 52	2,800	2,100	13 52	2,800
14″/45	1,800	2,600	0 48	600	2,000	1 22	825
13″/35	1,800	2,000	1 26	850	2,000	1 26	850
12″/50	1,800	2,900	0 38	500	2,100	1 14	750
12″/45	1,800	2,700	0 45	575	2,100	1 11	750
12″/40	1,800	2,400	0 57	700	2,100	1 14	750
10″/40	1,800	2,700	0 45	600	2,100	1 16	775
8″/45	1,800	2,750	0 44	600	2,100	1 18	800
8″/35	1,800	2,100	1 18	800	2,100	1 18	800

THE DRILL GUN.

87. Function.—The drill gun performs four distinct functions:

(*a*) **Physical training.**—It is intended primarily as a means of physical training for the loaders of intermediate guns, so that muscles and wind will be equal to the strain required in battle.

(*b*) **Precision.**—Incidentally it trains individuals to expertness in the best and quickest method of handling the ammunition and in loading.

(*c*) **Team work.**—After the individual loaders are expert it affords an excellent method of training the gun crew in precision of movement and in the avoidance of interference, or in "team work" while loading.

(*d*) **Saves the gun.**

88. Method of use.—In the primary training the shellman is instructed how to hold the shell, how to place it in the breech, and how best to utilize his strength in shoving the projectile home.

89. Character of drill.—The shellman, having received individual instruction and training in what may be termed "form," should then be exercised with the gun crews. In the beginning strings of 20 shell, the usual number loaded in a string, may prove excessive; however, shorter strings do not give the desired training in endurance, without which rapidity will decrease appreciably after a few rounds. In all exercises with the drill gun the time of loading the strings should be taken.

90. Importance of precision of movement in loading.—Unless strict attention is given to the details of the drill of each individual shellman at the drill gun the desire for rapidity will cause them to neglect precision. Precision of movement must at all times be insisted upon; it will be obtained only by constant attention to the details and in gradually eliminating small delays in the various operations of loading.

91. Removing burrs.—A small half-round file should be provided at the gun for the purpose of removing burrs when firing, and members of the crew must be previously instructed where to look for them and how to carefully remove them without damage to the breech mechanism.

92. Loading drill for turret guns.—The drill gun is inapplicable to turret guns; hence for these the training must be obtained by loading the actual gun, using drill and target shell, dummy charges, and fired primers.

93. Drill shell.—The issue of brass drill shell has been discontinued, target shell being furnished in their stead. These shell are furnished with bands which may be removed if so desired. Spars are furnished for both turret and broadside guns, which are used to prevent shell dropping through the bore when the muzzle is depressed, and also for backing out shell which may stick.

94. Dummy charges.—Dummy powder charges filled with small pieces of hardwood, beans, or other similar material, should be used. In order to afford the necessary training and experience in loading, these dummies should be made to represent as nearly as possible, in weight, shape, size, and flexibility, the actual charge.

95. Loading drill in connection with pointing exercises.—Loading drill in connection with Morris-tube and check-telescope training may be advantageously practiced.

DRILL AT THE GUN.

96. Joint exercise of crew.—As the members of the gun crews become skillful in their individual duties, the entire crew must be exercised at its own gun. After details have been trained independently, turret-guns crews, handling-room crews, ammunition passers, and all details concerned with the operation of the turret unit must be drilled and exercised together in their duties.

97. Lost motion in training gear.—It frequently happens that the lost motion in the training gear of guns of intermediate caliber is so great that in closing the breech the plugman throws the pointer's aim off the target, thus delaying the fire. This lost motion should be diminished as much as possible, and the pointer should accustom himself to it by frequently requiring the plugman to open and close the breech plug after each shot at Morris-tube practice. The plugman should be trained to close the plug with the least possible derangement to the train of the gun.

98. Necessity for giving accurate ranges.—Though for the purpose of instruction fictitious distances may be necessary in connection with the objects used as a target, they should never be employed if their use can be avoided. The valuable power of judging distances comes and improves with practice, and officers should seek to improve their powers in this direction, as well as to instruct the men by estimating the correct distance of the moving objects employed as targets.

99. Point of aim.—The point of aim communicated to the gun pointers should be well defined and thoroughly understood by all concerned. Such a point is the intersection of the horizon and the stem or stern of the enemy. These points should be generally plainly visible to all guns. It is desirable to standardize the point of aim, and in firing at ships, unless another point is designated, the intersection of the stem with the water-line will be considered as the point of aim. Pointers must be carefully instructed not to fire wildly if they have lost the object, but in the case of firing at an enemy who is enshrouded in smoke the horizontal cross wire of the pointer's telescope can be kept on the horizon and the vertical wire kept on the center of the cloud of smoke, or on a mast if one is showing above the smoke.

100. Necessity for actually laying gun and setting sights.—When at drill, men must never be allowed to pretend to lay a gun. Correct sight setting is of the first importance, and accuracy in setting sights must be given great attention.

101. Gravity of mistake in target.—Officers must bear in mind, and must impress upon the men, the gravity of the mistake of aligning the sights of a gun on a wrong target.

102. Target practice—Function in the system of training.—Target practice at short ranges, while necessary to the final development of a gun crew, must be regarded as a test of the proficiency which has been attained rather than as a method of training. It is a method only in the sense that after a thorough preliminary training experience at actual firing is necessary. It is quite possible for crews which have received thorough training to make a perfect score at their first elementary practice. Until target practice has been held the pointers and the members of the crew have not had the experience requisite for their assurance under service conditions. Division officers should take advantage of firing to note the men who become unduly excited, who appear gun-shy, etc., with a view to assigning them to duty where failings will have the least detrimental effect. The first elementary target practice after commissioning should be of great value in removing from the gun men who are so affected. Especial attention should be given to the demeanor of the pointers.

103. Elemntary target practice.—Elementary target practice is held at short ranges with screens of such size that all properly directed shots will hit. While the practice is primarily a test of the pointers it also is a test of the entire gun's crew and to a considerable degree measures the organization and efficiency of the ship. Spotters, other officers, and members of the crew are given experience and a practical demonstration of fire control in its simplest form. Material, communications, and efficiency of gun crews are tested under conditions more severe than is generally the case at longer ranges.

104. Development of elementary practice.—In the beginning of our modern development, and for some years, this form of practice was the only one in which ships competed, and it was held in smooth water. In order to assure ourselves of our abilities, and to develop skill in loading, handling, and pointing the guns, and to thoroughly test materials the conditions of elementary practice should be severe. Rough-water conditions, which are not altogether possible with our present target equipment, are desirable.

105. Unsatisfactory performances.—The cause of every unsatisfactory performance at target practice should be definitely determined. Only by such investigations may the sources of trouble be discovered and eliminated and progress assured. Further progress in gunnery depends, to a considerable degree, on the seeking out and eliminating of errors heretofore, perhaps, neglected as unimportant. Information regarding shots that miss the target is as important as that regarding those that hit, provided the amounts by which they miss are definitely ascertained and the causes of failures to hit determined. (See U. S. Navy Regs. 1913, art. 1609 (b).

CHAPTER 5.

TRAINING FOR COLLECTIVE GUN FIRE—INDIVIDUAL SHIP.

The best protection against an enemy's fire is a well-directed fire from your own guns.—Farragut.

106. Historical.—The history of wars indicates that duels or fleet actions may begin at high ranges which may be reduced because of the desire of one or both antagonists to reach distances which will be "decisive."

The manner of approach and the question of ranges can only be decided according to the conditions existing.

107. Character of training.—Gunnery training must be with the idea of making hits at all stages of an action, i. e., (1) at the highest ranges, (2) when the range is rapidly changing, and (3) when the range has been decreased. Casualties must be anticipated and demoralization avoided in any and all of what may become the phases of battle.

108. Protection afforded by well-directed fire.—Much will depend upon the gaining of the "initial advantage." There can be no question of the superiority of the protection afforded by a "well-directed fire" at all stages of the battle. If sufficiently well directed and sustained it will surely result in victory.

109. Collective gun fire (individual ship).—Excellence in individual gun fire having been attained, a consideration of the principles governing collective gun fire for a single ship follows. This becomes a question of utilizing to the best advantage a number of individually perfected gun crews, which resolves itself into the following: (1) Fire control; (2) avoidance of interference of guns and interferences incidental to mixed calibers; (3) ability to sustain fire despite the casualtes which may be expected in action; (4) ammunition supply.

110. Necessity for coordination.—Success on the day of battle will not necessarily come to one who has good pointers, torpedo crew, or an excellent fire-control or ship-control party. All of these must be not only skilled individually but they must be so coordinated and schooled that they will operate together efficiently under any or all of what then may become conditions.

111. Fire control.—This involves a knowledge of the sight-bar ranges, of the individual errors of gun and indices of powder, and the prompt transmission of the range and battle orders to the battery. A sufficient supply of ammunition to the guns and ability to sustain fire despite casualties and a proper handling of the ship are also essentials to proper fire control.

112. Notes on spotting and fire control, published by the department of ordnance and gunnery at the Naval Academy, contains a description of the apparatus and methods employed in the fire control in battleships at the present time. While change and constant improvement may be expected in methods as material is developed the principles will remain the same.

113. The sight-bar range.—A first essential to successful fire control is that the range finders, or means of discovering the range, should be accurate and reliable. The errors of gunfire should be reduced to a minimum and allowed for in assigning the sight-bar ranges. This latter would probably be accomplished by firing trial or calibrating shots when expecting and preparing for a battle. In determining the ballistic corrections, the loss of velocity due to erosion as well as the corrections for temperature and height of barometer should be considered.

114. Dispersion.—Proper fire control is impossible if the dispersion is excessive. With excessive dispersions the spotter is helpless. A proper percentage of shots may be kept falling in front of the target, and but few hits made. If in such cases the deflection is good and the dispersion is in range, the short shots will obscure the others and nothing definite can be determined by those charged with the fire control regarding the ship's performance.

115. Point of impact.—It is fundamental that all pointers that are under the same control use the same point of aim, which must be well defined. The point of aim may be considered to be the point at which the pointers lay their pieces. It should be distinguished from the point of impact, which is the point at which the projectiles fall. By varying the range or the deflection on the sight, the point of impact may be made to differ widely from the point of aim. The point of aim should be well-defined and visible at all times and remain unchanged. It might be exceedingly undesirable to direct the pieces at the point of impact as then the interference due to splash, bursting of shell, etc., would have a very considerable influence on the rapidity and accuracy of the fire.

116. Procedure in opening fire.—It is absolutely essential in collective fire that a definite program which has been thoroughly drilled for and rehearsed should obtain. When it is decided to begin ranging, ranging shots should be fired by guns in succession as rapidly as sight corrections may be obtained and applied, and the fire should be proceeded with without loss of time, every effort being exercised to get on the target without delay. Conditions of atmosphere, sea, weather, etc., will determine the range at which fire may be opened. The sequence and methods of firing the ranging shots should be thoroughly understood. The sight setting must be quick and accurate, the sights of all guns being kept set together and the entire battery kept in hand prepared to deliver a salvo the instant that the ranging shots indicate that fire may be opened with reasonable expectation of hitting. When once the target is found, the training should be such that rapidity of hitting will be assured.

117. Importance of the initial advantage.—The first salvo delivered into an opponent inspires confidence on the one side, and consequent coolness and deliberations in all the details of fire control and of serving the guns, together with steadiness, and rapidity in pointing. On the other hand, the ship hit hard in the early stages of an engagement is sure to be thrown into more or less confusion, and thereafter labors under a great disadvantage.

118. Rapidity of hitting.—*In the training for battle the importance of the rapidity of hitting with turret as well as other guns must not be overlooked.* In long-range target practice with a small ammunition allowance there is a natural tendency to hold the fire in order to permit the spotting of each salvo. This practice might be objectionable in battle. The fire should be slow until the sight bar range is determined, when the enemy should be overwhelmed with a volume of fire which should be slowed or checked when spotting again becomes necessary. Excessive spotting is objectionable, as it slows the fire and tends to confuse the fire control.

119. The chief fire-control officer.—The officer controlling the fire must be of quick decision, and have a thorough understanding of the methods to be followed and of what is to be accomplished. It is equally important that battery officers should be perfectly familiar with the plans of the fire-control officer. The control officer should be in touch with the spotter and with what is going on in the stations below, so that he may be assured that the directions for the control of fire are being correctly interpreted. He must be near the captain in order that the fire control may be coordinated with the ship control.

120. Firing signals.—Firing signals are given under the direction of the chief fire-control officer. Their frequency depends upon range, motion of ship, interference by smoke and blast, visibility of the target, and the time required for spotting. and setting sights. The instant for giving firing signals depends upon the roll, pitch, and yaw of the ship. Pitch and yaw are more difficult to contend with in gun pointing than the roll. If it is not desired to wait for one of the periodical intervals when the ship is practically steady as regards pitching and yawing, the signal to fire should be given at that part of the pitch when there is least angular motion of the ship in the vertical plane, and the least yawing. With some ships this time is found to be when the bows are buried in the sea. In this case *the signal to fire should be given just before the downward motion ceases.* In this connection attention is called to the error caused by firing guns when the planes through their trunnions are at varying angles to the horizontal. If there is not much pitching, attention should be concentrated on the part of the roll on which to fire. *The signal to fire should never be given at the very end of the roll. When there is much roll, the proper time to give the signal is just before the motion ceases at the end of the roll.* If a firing signal is sounded at the finish of the roll or pitch the reversal of motion of the ship will surely throw some, or all of the pointers off the target. The salvo signal entends a strong temptation to a pointer to fire whether he is "on" or not. This must not be overlooked in training.

121. Elasticity of control.—The fire control fails if it is not elastic, permitting the fighting of the guns of the ship with a centralized control over several lines of communication. After all these lines fail, the training should permit the guns to continue the fight independently. Probably, in this case, the range will have been greatly decreased. The installation and system of training should enable a vessel to concentrate or to divide her fire, as either or both of these are possibilities of battle.

122. Detriments to fire control.—Irregularities of speed or course are directly felt in the fire control. Both these slow the fire down as well as militate against accuracy. Funnel smoke, splash of shell, noise, sun glare, wind, sea, and motion of ship all have to be considered. Conditions as they exist must be taken into account. Excessive speed may cause difficulties; a ship may be able to fight when running to leeward, when it would be impossible to do so otherwise.

123. Interference of guns.—The interference of one gun or turret with those adjacent is to some degree unavoidable. In the all-big-gun ships this interference generally is a minimum, and it becomes maximum in the vessels with superposed turrets and mixed batteries. The interferences are due to blast as well as to smoke and gas.

124. Method of overcoming interferences.—In order to overcome the difficulties incident to interferences various methods are employed for collectively firing the turret guns at long range at target practice. They may be enumerated as follows:

125. I. Independent fire.—Making the "stand-by" and firing signals at short intervals as the ship steadies at the end of each roll and allowing pointers to fire independently when they are on the target. This method would probably be the only one possible at present, if the ship has much motion or if the salvo-signaling system fails. With it a system of local turret control must be established which will obviate in each turret the interference of one gun with another. With these cared for the interferences of one turret with the next, which may be considerable at times, have still to be considered. Under normal conditions single-barreled salvos should insure a rapid fire which may be well controlled.

126. II. Firing both guns, trusting one pointer to be on.—Firing turret guns on a common firing circuit (double-barreled), one pointer firing both guns and closing both firing circuits, the "off" pointer, having nothing to do with the firing, is able to concentrate his attention on the laying of the piece in elevation. The firing signals may be made at short intervals, but the general practice in ships that have used this system has been to lengthen the periods between signals, and to endeavor to fire as many turrets as possible each time a signal is given.

This method of firing is illogical as soon as the motion is such that a pointer has any difficulty in laying exactly on his target. As a rule the primer firing intervals are sufficiently regular to insure the guns going practically together, and one gun does not kick the other off. With this system salvos of the entire battery become possible.

127. The following objections may be raised to the plan:

(*a*) If the firing signals are given at long intervals, something may occur to interfere with a signal, and so expose the vessel as a target for considerable periods without that protection which is afforded by a well-delivered firm from her own guns.

(*b*) If one or more pointers are unsteady, the efficiency of the control may be seriously impaired. This, however, is true of any system.

(*c*) It may encourage the violation of the first principle of gunnery: "Never fire a gun unless it is exactly and properly pointed."

(*d*) Firing so many guns together may accentuate the rolling of the ship appreciably.

128. III. Firing both guns when both pointers are on.—Firing turret guns on a common circuit so that one or either pointer fires both guns, provided the other has his circuit closed or makes a signal that he is on the target.

This is a more logical plan than the one described above, and more closely follows the principles which are to be always impressed on pointers.

129. Objections to this plan:

(*a*) It necessitates a somewhat complicated firing circuit.

(*b*) There may be an element of danger in this, as in the plan previously described, if efficient salvo latches are not provided which effectively prevent the opening of a breech unless the gun has fired. Otherwise a hangfire or misfire might cause loss of life and disaster.

130. IV. Using a firing pointer.—A plan for firing turret guns which was found successful on a recent practice was that of having the guns fired by an officer when both elevating pointers reported that they were on. An officer looking through a telescope that was correctly set in train fired both guns through a common firing circuit. The regular turret officer should not perform this duty.

131. V. Using cross-connecting device.—In newer ships a cross connection in the elevating gear permits one pointer to lay both guns in elevation. This furnishes the simplest method of laying turret guns for double-barreled salvos.

132. Methods to be followed.—A ship should be prepared to make the best of any condition, and to this end should be trained to fire her turret guns either double-barreled or independently, as well as to control their fire either collectively and centralized or individually and locally.

133. Broadside guns.—With broadside guns in large ships the accepted method of collective fire is in salvo, each pointer firing his own piece if properly on the target when the signal is sounded. Salvo firing reduces to a minimum the mutual interferences which are of particular moment with guns mounted in this way. For torpedo-defense purposes, in some vessels the salvo signals for all torpedo-defense guns are rung from one station. Contact makers at the various defense control stations, thrown in or out by the group-control officers, cause the signals to be sounded or not to be sounded at the guns belonging to their group or groups, according to whether or not it is desired that these guns be fired with the others.

134. Intermediate guns with turrets.—The firing of intermediate guns, together with those of the major caliber in ships of the predreadnaught class, is a question of considerable moment. Data would make it appear that at about 10,000 yards a small percentage of hits may be expected from these intermediate weapons, which increases rapidly as the range is shortened. It would probably not be expedient to attempt to utilize the intermediate battery beyond 10,000 yards, and the crews should be kept in reserve until this range is reached. When fire with the intermediate guns is commenced, these must not be allowed to slow or interfere with the fire of the major calibers. If a long firing interval is used for turrets, the intermediate guns may be fired between turret salvos, otherwise if short salvo intervals are used they should be fired together with the turret guns.

135. Individual control.—The training should permit the control of the fire of broadside guns individually, as well as collectively, by night or day, and gun captains and reliable petty officers, as well as division officers, must understand the methods to be followed in spotting and in fire control.

136. The spotter.—The spotter occupies a most important station, and much depends on the cool, good judgment of this officer, which must be developed by long experience and drill. He should know his range and ballistic data and must also have the heights and lateral distances between conspicuous points and other dimensions of his target fresh in his mind, that these may assist him to quickly find and hold the target. A spotter, in his training, should not lose sight of the differences that will be presented in the methods necessary when fire is directed at a hull and not at a target screen.

137. Ability to sustain fire.—An ability to stand punishment is built into the ship in so far as practicable, and constant effort is being made to improve the defensive qualities of vessels. The deciding factors in coming naval battles, as have been in those of the past, will be accuracy and volume of fire, which will only be insured by the morale of the men engaged. This morale, which will insure the fighting of the ship as long as she remains afloat, is unconquerable, will insure victory, and can be gained only by constant drill and preparation for action. While the primary means and devices for supplying ammunition and for directing guns should receive the greatest attention, the auxiliary devices and methods should not be overlooked.

138. Ammunition supply.—The question of ammunition supply in action should be carefully considered. The supply of shell and powder from the magazine to the gun, the opening of the boxes, and the disposal of the boxes and cases must all be provided for. It may frequently be possible to improve the chains of supply and to facilitate the careful handling of all classes of ammunition. It should be remembered that ammunition must not be permitted to accumulate in exposed positions, as it then constitutes a serious source of danger.

139. Drill of ammunition crews.—There have been numerous instances at target practice where a turret crew, otherwise well drilled, failed to make a creditable performance because of a mistake on the part of the handling-room crew. The use of a wrong index may well cause misses that would result in disaster in action as it has in failure at target practice.

140. Importance of minor details.—*No detail of the drill and development of the fire-control, gun, and handling-room crews is so slight as not to merit attention.*

141. Day individual practice.—The training of the collective fire of single ships is tested at individual ship practice in so far as it is practicable to do so. With the present facilities we may measure performances at various ranges, but it is difficult to devise problems which will test the ability to make hits employing the entire battery, with a rapidly changing range. The ranges prescribed for day individual practices are long in order that training may be with the view of securing the "initial advantage" and in order to make conditions most severe. It must not be assumed, however, that it is necessarily the case that a battle of the future will be finally decided by a cannonade at long range. The conditions of range can not be foretold, and training must anticipate all of what may become the phases of an engagement.

142. Casualties.—Casualties are introduced, as the outcome of battle may depend on the manner in which these are handled as well as on the gunnery.

143. Artificiality.—Constant care should be exercised to avoid artificiality in any or all forms of fire control, ship handling, or dealing with casualties.

144. Collection of data and analysis of results.—As improvement in gunnery is dependent on improvement in the precision of our guns as well as in control of fire, all data bearing thereon should be carefully collected at target practice. The results of practices should be thoroughly analyzed. The time taken to get "on" the target after the order to "open fire" is given, the "dispersion in salvos," and the "distance of the mean impact of salvos from the target" are all matters of importance in measuring a ship's performance at long-range practice as well as the number of shots hitting the target.

CHAPTER 6.

TRAINING FOR COLLECTIVE FIRE—SEVERAL SHIPS.

145. Collective gunfire (several ships).—The effective control of the collective gunfire of several ships is impossible unless the battery of each ship can be handled efficiently. With this attained for vessels individually, the control of the fire of all may be accomplished.

146. Necessity for prearranged program.—When vessels fire collectively there is absolute necessity for a prearranged program of the order and methods of firing, etc., which is thoroughly understood by all officers concerned. The scheme by which the fire of vessels of a force is distributed should form an important part of the battle plan of a commander in chief. Once the general principles are understood and the methods worked out, the control of the fire of individual ships should be left in the hands of the captains, each of whom is in a position to be the judge of how his fire may be directed with the greatest effect.

147. Interferences with gunnery.—Signals and directions from outside sources during an engagement make for confusion. When fleets are locked in gunfire the one that persists with the least interruptions and interferences and compels its adversary to give way, maneuver, or modify its fire delivery, should win, other things being equal. There must always be loss of fire delivery due to rapid changes of course or speed or incidental to a shift of target. From a gunnery standpoint a ship is in position when she is able to make full, effective use of her battery, and does not interfere with the fire of other vessels in the formation. A methodical exactness of position and formation within reasonable limits is unnecessary to this end. Sudden attempts to gain or lose distance invite disaster, in that they may cause shots to miss that would otherwise be effective, and interferences may occur, such as the lifting of a safety valve, excessive smoke, or crowding of another vessel.

148. Firing at the wrong target.—Results at target practice make it appear that there is serious probability of a mistake being made in the targets by a part of the battery of a firing vessel. The likelihood of such mistakes would be enhanced in battle if ships in the enemy's line were similar in appearance. A mistake of target by a turret or turrets would invite disaster, the likelihood of which must be fully appreciated, and the necessary precautions must be taken to avoid such an error. If a ship fire at a wrong target, one of the enemy's ships may be left not under fire, and the spotting of another vessel firing at her proper target wi l be seriously interfered with.

149. Concentration.—When several ships concentrate on a single vessel, the ability of the latter to deliver an effective fire is disturbed by the fact that aside from the destructive effect of the enemy's shot, which rapidly lessens the effectiveness of her own fire delivery as well as reduces her defensive strength, she has several targets at which to direct her guns. Concentration should not be attempted unless all of the vessels of an enemy that may fire are covered. Conditions in the course of a battle may make one force of the two that began the engagement with equal numbers, temporarily, numerically the superior in vessels that may effectively utilize their batteries. On such an occasion concentration should be restored to.

150. Conditions permitting concentration.—For vessels to concentrate effectively at long range, it is necessary that they should fire in salvo. If a maximum of fire is to be delivered, these salvos should be from all the guns bearing. In other words, the maximum weight of metal should be delivered in each salvo. By firing full salvos in rotation in this way ships may identify and so control the fall of their own projectiles, and the target is cleared between salvos. As full salvos are necessary for effective concentration, it must then appear that conditions should permit successful salvo firing. Different parts of a long target may be taken as points of impact for the different vessels that are concentrating thereon. The principles and plan to be followed when concentration is to be employed should be thoroughly understood and form a well-understood part of the battle plan, and not left to be completed after the battle has been begun.

151. Difficulties of collective fire.—In all collective fire, whether for one or several ships, the interference of smoke, blast, and the splash and explosion of shell may be expected. With fleets or divisions the difficulties incidental to maneuvering may also be experienced. These may all be overcome by earnest effort and thorough preparation. It must be remembered that all the difficulties confronting us are also presented to our adversary, and the men and the fleet that have best trained for and anticipated the contingencies of battle will be the least disturbed thereby.

152. Division practice.—The training of the collective fire of several ships is tested in the various forms of division practice that are prescribed. Effort is made to make these practices realistic, and they are varied from year to year in order to cover different phases and conditions. The weight given these forms of practice in the competition is low because of the difficulty of getting the exact scores of individual ships. It must not be assumed, however, that the weights assigned determine the importance of these exercises, in which to some degree competition has been sacrificed to realism. These exercises are perhaps the most important of the year as tests of the training of the battleships for war.

153. Battle Signal Book.—Attention is invited to the "Development of gunfire" given in the Battle Signal Book, 1913.

CHAPTER 7.

TORPEDO DEFENSE.

154. Character of problem.—The problem of protecting capital ships against the attack of torpedo vessels, under the various conditions which may be expected in war, is difficult and is one now giving all navies much concern.

155. Examples during Russian Japanese War.—During the recent struggle between Japan and Russia several of such attacks occurred and while widely different results may be expected in the future, as a result of better training and material, the following figures are illuminating when considered in connection with the character of the personnel and the conditions obtaining in the two navies then engaged in war.

156. First case—Attack on ships at anchor at night (February 8, 1904).—Ten boats attacked eight ships anchored off Port Arthur. Attack was not anticipated. Nets were not rigged and preparations to defeat an attack were not in any sense adequate. Eighteen torpedoes were fired, and three hits were made on *Tsesarevitch*, *Retvizan*, and *Pallada*. The Russian gunfire was ineffective. No Japanese torpedo vessels were struck.

157. Second case—Attack on ships at anchor at night (June 23, 1904).—Fourteen destroyers and sixteen torpedo boats attacked ten ships anchored off Port Arthur. Nets were rigged and the attack was expected. About 60 torpedoes were fired and no hits were made. One destroyer and three torpedo boats were hit, and three men killed and five wounded by gunfire.

158. Third case—Attack on ships under way at night (August 10, 1904).—After scattering of Russian force in the battle of this date, three Russian ships, the *Probeyda, Sevastopol*, and *Presvyet*, all of which had been badly used in day action, were attacked by 17 destroyers and 21 torpedo boats. Probably about 70 torpedoes were fired. No Russian ships were hit. Loss admitted by Japanese, nine killed on one destroyer that had been hit by two shells. One Japanese destroyer struck by a torpedo, losing one killed and eight wounded. This vessel was not sunk.

159. Figures approximate.—The above figures are given by a prominent British naval officer and writer, but may be only approximate. They indicate, however, that the difficulties incidental to torpedo attack at night are by no means confined to the battleship. In studying the question the point of view of the officer of the torpedo vessel, and of the submarine, and of the difficulties to be encountered by them, must be considered. It may have been true to some degree that, in the cases cited, the shots that did not hit the torpedo craft, but came close, may have counted for the purposes of torpedo defense.

160. Rapidity and volume of fire.—In repelling an attack, full advantage should be taken of the rapidity and volume of fire permitted by the type of gun, the number of guns, and the ammunition supply, provided for the purpose. Casualties to material of course must be anticipated.

161. Identical methods impracticable in all ships.—Identical methods will probably not be equally effective in all of the various types of vessels composing the fleet. Zone fire, which has been recommended many times for torpedo defense, has not yet been given a practical test. The training should be with the idea of using to a maximum the battery and facilities for control, but the fact that the peace arrangements will be deranged and modifications of a necessity be introduced in service, should not be overlooked.

162. Artificiality of practices.—All torpedo defense exercises must be to a considerable degree artificial, but in no form of exercise is it more necessary to avoid the false training and artificialities practicable in peace and leading to incorrect deductions and plans for war, than in torpedo defense.

163. Concealment and searchlights.—Essentials for a battleship are concealment, evasion, and change of course if there is likelihood of discovery. The occasion may arise, however, when searchlights will be required. Spotters, searchlight-control men, and pointers in such cases must all see the target. Noises and confusion must be absolutely eliminated. The beams of searchlights must be handled intelligently or more harm than good will result from their use.

164. Necessity for a program.—As in all other exercises, a definite, well-understood program is a first and last essential to success. Attention is invited to the type plan for torpedo defense, chapter 18.

CHAPTER 8.

TORPEDO TRAINING.

165. The end in view.—*The purpose of all torpedo training is the efficiency of the torpedo battery on the eve of war.*

This includes personnel and material, and may be otherwise stated as the problem of getting our torpedoes in contact with the enemy in the most effective way and under the peculiar conditions to be anticipated in war. Everything that is done in peace, every daily task, small or large, should be subjected to this criterion. No matter how convenient or expeditious proposed methods may appear, they should be subordinated to the end in view.

166. Knowledge of material.—One of the greatest deterrents to progress is a tendency on the part of personnel to simply follow general directions and to investigate only where troubles have forced investigations. Results obtained will lead to misdirected effort and erroneous conclusions when the users of material fail to equip themselves with detailed and thorough knowledge of the mechanisms with which they work. The starting point, therefore, on the part of officers is a thorough study and understanding of all the details of the mechanisms assigned to their charge. Through them the necessary knowledge must reach the enlisted personnel. It is important that no attempt should be made to get results until this knowledge is first obtained.

167. Damage the result of inexperience.—The permanent damage done in a single day of experimentation by inexperienced personnel has frequently exceeded that which, with proper care, should be expected during the entire normal life of the material.

168. Full advantage taken of opportunities.—The time which vessels can devote to torpedo firing during a year is limited, therefore full advantage should be taken of all opportunities which are offered for practical instruction and exercise.

169. Coordination.—Successful operation of torpedoes requires cooperation and coordination; in other words, "team work" developed to a high degree of perfection. It is absolutely essential that every member concerned in the preparation of a torpedo and tube for firing should have a good understanding of the duties of every other man, and that the necessary work involved shall be so systematized and organized that nothing will be left to chance. A single detail overlooked can easily ruin a performance or prove disastrous. Permanence in stations is desirable.

170. Instruction.—The instruction of the personnel should commence as soon as the tentative assignments to stations have been made. Due to the lack of permanence in our enlisted personnel, a constant school of instruction on board ship must of necessity be maintained. Courses of instruction should be laid out in detail in advance and executed as planned. After a reasonable time has been devoted to the instruction, rigid and practical examinations of each man on subjects pertaining to his station should be conducted.

171. Sources of knowledge.—Stated in order of importance the following are available on all vessels for the acquirement of a knowledge of torpedoes:

(*a*) Periodic publications of the department, viz, pamphlets, bulletins, correspondence, target practice reports.

(*b*) Working drawings and descriptions.

(*c*) The material itself.

Some one must be responsible for the fact that a complete set of publications and working drawings are kept on hand, corrected to date and available for use. Too often this question is left to care for itself, and nothing is done until delays or troubles develop some specific detail which has been neglected.

172. Nomenclature and methods to be observed.—A strict adherence to the nomenclature and terms used in the instructions, blue prints, pamphlets, etc., must be observed. The use of any names, terms, etc., other than those authorized are indicative of carelessness, and results in confusion and loss of time both on board ship and in official correspondence. The methods approved by proper authorities must be followed until modified or revoked.

173. Routines.—The following tentative routine for the crew of a battleship torpedo room is outlined as a guide:

DAILY.

Tubes: *1.* Unseat sluice-gate valves. Just start off seat and close again quickly. Drain into bilges.

2. Open tube covers wide.

3. Sluice-gate valve must be closed, and the tube cover closed and locked before knocking off work and report made to torpedo officer. One of the chief gunner's mates must be present when this is done.

(Note.—With the exception of the opening called for in par. 1 above, the gate must always be kept closed and locked, and must never be unlocked without permission of the torpedo officer.)

Torpedoes: *1.* Keep all oil cups full at all times.

2. Turn over each torpedo by hand at least six revolutions.

3. Move vertical and horizontal rudders full throw at least six times.

WEEKLY.

Tubes: *1.* Run out spoon slowly twice Mondays and Thursdays, unless other work prevents, and if so on other days, torpedo officer to be present.

2. Thursdays, test out firing circuit and systems of communication from conning tower.

Compressors, Thursdays, turn over and run against a load, unless compressors have been running during the week.

MONTHLY.

Tubes: *1.* (Or after each practice.) Remove toggle gear. Clean and oil with sperm oil, never with vaseline or thick oil.

Torpedoes: *1.* Each torpedo to be run in air slowly for at least five minutes. All oil cups full.

2. (Or after each practice.) Remove and inspect gyro mechanism, and oil gear train through gyro door. Inspect gyros.

The above indicates some of the points a routine should cover.

It is important to eliminate everything which is not to be carried out strictly in accordance with the letter of the routine. The routine should be as brief and concise as possible and written in language which can not be misconstrued.

174. Torpedo officer's notebook.—It is important for the torpedo officer to keep a notebook, not only for his own information, but for that of his relief. The follwing are subjects which should be covered in such a notebook:

All orders, bills, instructions, etc., issued.

Notes regarding permanent installations, such as tubes, air lines, accumulators, director and stand, etc.

Lists of repairs and alterations recommended for navy-yard overhaul period with action taken thereon.

Collation of causes of any abnormal torpedo performance, and measures taken or suggested to remedy same.

All data, correspondence or computations in connection with torpedo department which may be of future value, and thereby save duplication of work.

All notes, opinions or conclusions from work or practice which might prove of value for future work.

175. Importance of records.—The importance of accurately and completely recording all available data and carefully collating same for every shot fired can not be overestimated. This especially applies to torpedo work on a battleship, where at best but little torpedo practice can be expected.

176. Torpedo record books.—These should be kept carefully and accurately and should furnish a complete history of each torpedo. They are the "service records" of the torpedoes and accompany them throughout their existence. It is important to keep these books from deterioration, and it is not advisable to use them habitually in the torpedo room or on deck, but to treat them as the torpedo's smooth log, writing them up after a day's firing or practice.

177. Rough log.—A rough log should be kept which embodies all necessary information. It is unnecessary to repeat in this log adjustments which are permanent, but there is much information peculiar to the ship or work which does not find a place in the record books, but which is important and which should be entered herein. An excellent method is the adoption of a large loose-leaf rough log with separate sheets for each torpedo. Boards, one for each torpedo, should be conveniently hung in the torpedo room and before each day's practice; it should be the duty of one of the crew to get the sheets of the torpedoes to be fired and attach them to the proper boards. It is important that all entries should be made immediately after the data are obtained. The system should be systematically carried out; entries should not be left to memory, or incompleteness tolerated.

178. Entries in rough log.—The following covers the most important entries required for the rough log:

TORPEDO ROOM DATA.

Date.
Shot No. for day.
Serial shot No. for torpedo.
Torpedo No.
Tube.
Predicted speed.
Regulator.
Initial flask pressure.
Final flask pressure.
Changes of adjustment from last shot.
Remarks.

BRIDGE DATA.

Course of firing.
Director set.
Was ship swinging, and which way?
Average revolutions per minute, 5 minutes before firing.
Speed of ship at instant of firing torpedo.
Does engine room report speed was over or under standard revolutions per minute when shot was fired?
Current, direction of set.
Amount in 4 minutes (feet).
Observations and remarks on run as seen from bridge.

REPORTED FROM RANGE.

Time run for 2,000 yards.
Time run for 3,000 yards.
Time run to target.
Natural deflection.
Depth at target.
Total distance run (important).
Remarks.
Sketch of run as observed at target.

REMARKS AFTER RECOVERY OF TORPEDO.

Correct speed of torpedo.
Correct deflection of torpedo.
Director correction for next shot.

179. Responsibility for results.—Whether there be hits, misses, accidents, or losses, rests solely with the ship's force and can not be delegated. Torpedoes should not be fired nor should any tests be carried out unless the equipment is in proper condition and all necessary data can be collected.

180. Assembling and disassembling of torpedoes.—As a general rule, torpedoes should not be disassembled except for very good reasons, such as failures in tests, runs, or for periodic overhauls for purposes of renewing washers, gaskets, cleaning, examination, or for instruction purposes. The cause of every erratic performance should, however, always be definitely determined. On first receipt of a torpedo on board, it should be entirely disassembled, overhauled, and the fact of its being in proper condition verified to the satisfaction of the ship's personnel. The fact that the torpedo may or should have been in proper condition before issue does not relieve the personnel afloat of any responsibility whatever. Unsatisfactory conditions discovered on overhaul after issue should be reported to the department as a matter of information.

181. Handling torpedoes.—A template of a torpedo should be made in a new ship, and a satisfactory method of handling should be developed. The leads of purchases, positions of booms and davits with respect to the vessel's side, and torpedo trunks, obstructions, torpedo rooms, etc., should be carefully noted. It will require considerable practice before torpedoes can be handled quickly and with safety.

182. Precautions before firing torpedoes.—All necessary adjustments, precautions, and tests before firing torpedoes are completely set forth in publications of the department.

The following two causes of losing torpedoes are directly chargeable to personnel:

(1) Sinking due to failure of the torpedo to start.

(2) Sinking at end of run due to leaks in afterbody or immersion chamber.

These are preventable faults. Tube-firing mechanisms can be verified without firing a torpedo. Care must be exercised not to alter the weight disposition of torpedoes, particularly as regards uprightness.

183. Erratic depth and deflection.—Two causes of erratic depth and deflection which are difficult to detect aboard ship, and which are frequently ascribed to other causes with much consequent misdirected effort, are as follows:

(1) Fluctuations in speed.

(2) Torpedo not upright due to alteration of weights, propellers unbalanced, or unbalanced friction in propelling mechanism.

184. Rapidity of fire.—A certain degree of proficiency can be attained by simulating all the conditions of loading except that of actually using the torpedoes, but it is necessary to employ the torpedoes to complete this instruction. Loading drill with torpedoes is just as essential as turret loading drill, and, if properly carried on, can be made to simulate real loading to perhaps a greater degree than does turret drill. After the crew becomes proficient in loading the torpedo into the tube, the start can be made with the tube flooded as if a torpedo had just been fired. During this drill the torpedo officer should always be required to set gyro angles by means of the outside device, to test the device, and to render himself proficient and rapid in this most important duty. The gyro angle after being set should invariably be checked up by a second person.

Rapidity of loading torpedoes into submerged tubes (assuming the torpedoes to be fully charged and completely adjusted, with the gyro index set at 0) depends upon (1) the easy and proper functioning of the tube and all its parts, (2) the use of necessary and efficient means for actually handling the torpedoes, and (3) the manual dexterity and proper coordination of the work of the crew.

In rapid firing one torpedo will be in the tube and ready, the second (charged and adjusted for run) held in the loading position above the tube by half strap, and the other torpedoes resting (charged and adjusted) in chocks near tube. Upon firing the first torpedo, the tube will be blown, cover opened, and second torpedo loaded as rapidly as possible. The third should be placed in loading position, over cover, as soon as second torpedo is loaded, and the fourth and succeeding torpedoes moved into more convenient locations.

185. Procedure for angle fire using outside gyro setting.—Required angle "10 right (left)," etc.; transmitted over voice tubes from the directing station.

After the discharge of a torpedo, No. 1 (see sketch) bring spoon back to battery, using hand gear if necessary.

Torpedo officer sees spoon toggled, and commands "Load."

No. 3 draws back firing rod.

No. 4 reverses bolt, and closes gate while No. 1 blows down.

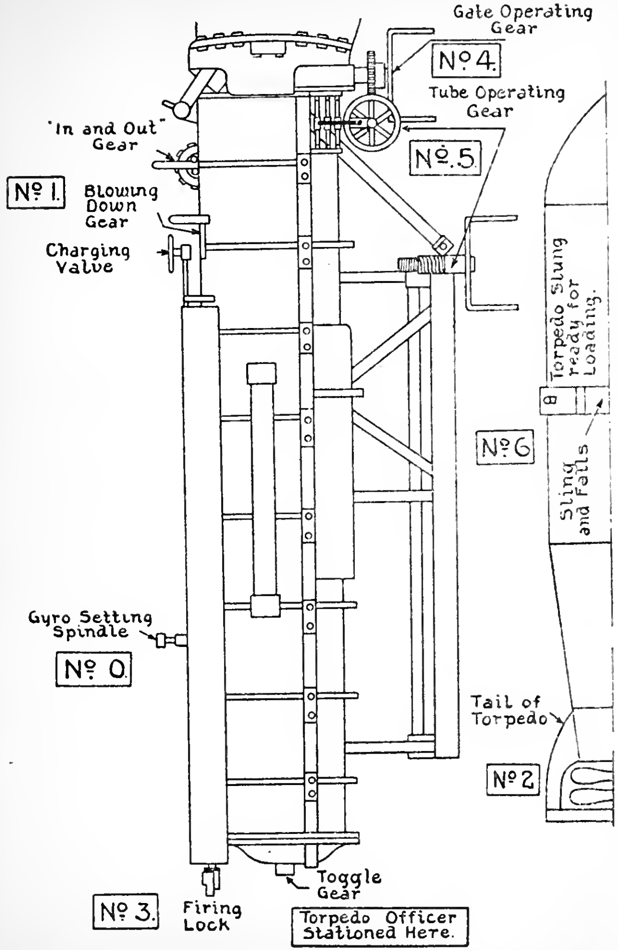
The instant the gate is *closed*, No. 5 opens tube cover, assisted by No. 4.

(Do not wait to drain tube; time will be lost, and a few gallons of water on the deck can do no harm.)

Nos. 2, 5, and 6 load torpedo on tube cover; No. 2 removes propeller lock and *reports having done so* to torpedo officer; No. 5 closes tube assisted by No. 4.

Torpedo officer commands (1) "Flood tube," and (2) "Charge with —— lbs." (The latter is the command to No. 1 to charge the air reservoir for firing.)

No. 2 operates the air release valve while the tube is being flooded.



Sketch showing stations for loading submerged torpedo tubes.

No. 0 meshes the curve fire spindle.

The torpedo officer reports "Ready for angle" to the directing station.

The angle is obtained and set as before, and the instant the tube is flooded the torpedo officer reports "Ready."

Upon "Stand by" from the directing station the curve fire spindle is withdrawn.

186. Care of the outside gyro-setting device.—As the outside gyro-setting mechanism is somewhat frail, care must be exercised with it, as there is some danger of breaking or twisting the shaft extension. This device should be tested, turned daily, and freely oiled. An important feature of easy and accurate angle setting is the freedom of the angle mechanism in the afterbody and in the gyro gear, and the proper amount of friction between the cam plate and outer gimbal ring of gyro. The cam plate and its seat on outer gimbal ring should be both perfectly clean and free from verdigris or any matter which would increase friction; the proper degree of friction is provided for by design of the cam plate friction ring.

187. To use outside gyro-setting device.—Before attempting to use the outside gyro-setting gear be sure that (1) the cam plate is not binding on gimbal ring (the normal spring tension holds cam plate rather stiffly to the ring); (2) that angle gear in gyro housing in afterbody of torpedo works freely (this gearing frequently gets very stiff after a long period of disuse); (3) that angle-setting device is operating freely; and (4) that the pointer on dial of outside setting device (outside of torpedo) is pointed exactly abeam, that is, on 90° for starboard tubes and 270° for port tubes, the dials being graduated from 0 at head to the right.

When putting a gyro in a tube be sure that the pointer on outer gimbal ring exactly coincides with the zero mark or cam plate, and that the gyro index on shell of torpedo reads zero when gimbal is placed in housing, and that the outside angle-setting device reads zero.

188. To engage outside setting device.—When torpedo is in tube and cover locked to engage the outside angle setting gear for a curved run, release shaft lock and press shaft in to within about half an inch of the home position; continue the pressure, turning slightly right then left, and feeling for the engagement of shank of shaft extension with socket in torpedo. When accomplished this engagement can be distinctly felt; push shaft all the way home and lock (press down small lever under dial). Turn handle as required to set torpedo for angle run with all gearing engaged. The outside handle will turn rather stiffly, and care must be taken not to twist too hard or suddenly. To eliminate any possible lost motion in gearing, note reading of large scale on handle when cam plate starts turning; then always turn handle in same direction and use the initial reading as the zero point.

When angle is properly set, withdraw shaft firing, raising small lever underneath to release same. It will be noted that the shaft can not be *turned* as long as the small locking lever is in the upward position. This is to insure exactly the same engagement as before the shaft was withdrawn, in case it should become necessary to reengage and reset angle. So long as a torpedo is in tube and the gyro setting shaft withdrawn, the lever should be kept in the upward position.

189. Precautions to be observed in handling charged torpedoes.—Certain precautions should be observed in rapid handling of charged and adjusted torpedoes. Remember that the stop valve is wide open; after filling fuel flask, the torpedo should be kept upright until ready for loading in order to prevent a possible loss of fuel through check valve. The starting lever must be guarded with the greatest care. To prevent tripping the starting lever some ships use a small wooden wedge pressed into the recess behind the starting lever, and connected by a lanyard to the propeller lock. By this means both wedge and lock are reasonably certain to be removed when torpedo is loaded, and the torpedo is "locked" as long as the wedge is in place.

190. Accuracy of fire.—This depends on an accurate determination of the course, speed, and range of the enemy, as well as on the adjustment of the torpedoes.

191. Importance of correct directing.—Those who in battle would be charged with the directing of torpedoes must appreciate the importance of their duties and frequent exercise should be given them. The system of communication between the director stations and the torpedo rooms must be efficient and the methods for outside gyro setting and the various operations incidental to the firing of torpedoes must all be thoroughly prepared for by exercise and drill.

192. Directing.—The general problem of directing can easily be mastered. The possibility of torpedoes being used suddenly and without much warning, when guns are or are not being used, and of director stations being wrecked must be provided for. Each torpedo must be directed according to its own previous performance in accordance with data obtained on proving practice. Torpedo tubes should be "boresighted" for alignment of directors periodically.

The following are some of the points which must be taken into consideration in procuring the data for directing setting:

(*a*) If a gyro gear has been under adjustment, or a gyro mechanism removed and replaced, the deflection may be different from that of a previous shot, although the gyro is supposed to be in satisfactory adjustment.

(*b*) Speeds are not uniform throughout a run, nor are they exactly uniform for successive runs of the same torpedo.

(*c*) Firing interval may vary.

(*d*) Swinging of ship during firing interval.

(*e*) Unintentionally firing early or late.

(*f*) Variations in speed of ship.

(*g*) Variations in speed of expulsion.

(*h*) Instrumental error of director due to lost motion, springing of telescope mounting, and various kindred errors due to design and mounting of instrument.

193. Requirements for directing.—Some of the requirements for directing torpedoes are as follows:

(1) Station near as possible over the tube.

(2) Clear of gun blast and a clear arc of vision well aft.

(3) Behind armor.

(4) Efficient communication direct to tubes.

(5) Satisfactory range-finder arrangements.

(6) Satisfactory arrangements for obtaining course and speed of enemy.

(7) Communication with captain and fire-control officer. Angles may be transmitted from the director station for curved fire to the torpedo tubes by means of the electric transmitters, one for each tube. Turning a handle lights up the desired angle reading, also rings a bell to attract attention. This transmitter in all cases has not given satisfaction, and the voice tube or telephone are generally used for this purpose.

194. Kinds of torpedo practice.—There are two forms of practice with torpedoes necessary in preparation for target practice. They may be termed "Test practice" and "Proving practice." Torpedoes should not be fired on target practice until these have been conducted.

195. Test practice.—This is held with reduced air pressure. Positive buoyancy of the torpedo should be insured.

Results obtained from Test practice:

(*a*) Test of tubes.

(*b*) Elementary test of torpedoes after their first receipt aboard.

(*c*) Verification of adjustments, etc.

(1) Following extensive overhauls.

(2) To verify stability.

(3) To locate puzzling faults by process of elimination.

196. Proving practice.—Torpedoes fired with full air pressure. This practice is analogous to a calibration practice of guns, and should be carried out between each competition prescribed by the department. Its object is to obtain reliable data as to speed, deflection, and depth performances of torpedoes. Under no circumstances should such an annual practice be omitted. Torpedoes should be fired under similar conditions successively until running normally. It is important that each overhauling for the elimination of faults should be followed by proving practices until a normal performance is obtained. It is inadvisable to lay aside a torpedo which has made an abnormal run, for an indefinite period, as this is discouraging to the personnel and involves a waste of time and energy. Proving practice does not necessarily mean a continuous running of torpedoes. The occasion of this practice is the best for overhauling torpedoes, and a great part of the time set aside will be consumed in overhauling.

197. Conditions for fixed torpedo range.—Ideal range conditions would be as follows:

(*a*) Not less than 15 fathoms of water over at least first half of range, diminishing thereafter to 5 fathoms at end of torpedoes' runs.

(*b*) Comparatively hard bottom. No soft mud.

(*c*) Clear of shipping.

(*d*) Calm sea.

198. Current observations.—Attention must be given on fixed ranges to effects of tide and currents. A successful method to observe current is as follows:

Take observations from boats at target and at firing point immediately preceding each shot as follows:

Gear: Spar weighted to float vertically with upper end just at surface, and mounted with a small flag.

A light line marked as lead line, or in feet, and secured to upper end of spar.

A good compass.

Stop watch.

Procedure: On signal, sufficiently before a run, release spar from alongside of beat and note set and drift in the time of a torpedo run to target. Signal results to the ship for director adjustments.

199. Loss of torpedoes.—If test practice has been efficient and the personnel is reasonably experienced, greater depths than 20 fathoms will result in a reduction rather than an increase of torpedo losses, this with a view of keeping running torpedoes clear of the bottom regardless of their depth performance. The torpedo travels in arcs of circles in the vertical as well as in the horizontal plane. Very few torpedoes will be lost if the following conditions are fulfilled:

(1) Absolute insurance against failure of propelling mechanism to start.

(2) Absolute insurance against shell leaks which may cause negative buoyancy after run and before recovery.

(3) Efficient organization of the observation force aboard ship and on the range.

(4) Practice restricted to forenoons, commencing as early as possible. Under no circumstances ever fire later than four hours before sunset.

200. Proving practice under way.—In time of war and under certain circumstances "Proving practice" over a measured range may be impossible.

Under such circumstances for torpedo vessels, one such form of practice would be as follows: Firing vessel and observation vessel under way, but stopped and distant from each other the desired proving range. Angles, range finder readings, and reciprocal bearings taken at time of firing. It is important that vessels should not move through the water during run of torpedo. This form of practice may also be carried out by battleships using light-draft vessel (tug or destroyer) as target and observation vessel.

201. Proving practice without a regular range.—Another form for battleships at anchor in open roadsteads or harbors where conditions prevent laying out a range is outlined as follows:

B—Battleship at anchor.
(1) Observation party at boom.
(2) Mid-range observation party.
(3) Maximum-range observation party.
(4) Recovery observation party.
(5) Recovery party.

Observation parties should be equipped with signals, stadimeter, binoculars, nose and tail lines, stop-valve tools, and propeller lock.

When ready to fire, B moves (3) by signals until line of sight is on and then fires. (2), (4), and (5) maneuver to keep in position on B and (3). On B firing, (2) and (3) take distance. (2) and (3) must not move through water during run of torpedo. Have observers aloft equipped with glasses. Boats (1), (2), and (3) give chase as soon as torpedo passes; (4) and (5) move as directed by ship to get in torpedo path. All boats resume station as soon as one of them reports by signal that torpedo is alongside.

202. Observation parties.—Parties composed of well-instructed and organized observers to watch the run of torpedoes from the ship and from range boats are essential to efficient development and are also necessary to insure against torpedo losses. Mid-range observers should always be used, and should, if possible, be as accurately located as the target. This procedure will afford valuable information which can be obtained in no other way concerning speed, deflection, heater failures, and depth performances. A boat should be kept near the firing point for observations and instant use in case of emergencies in that neighborhood. Careful organization beforehand and a definite common understanding between torpedo room, bridge, and range are absolute essentials. It should be an established rule that all boats should give chase as soon as a torpedo is sighted. Boats must never assume that another has the torpedo in sight and is going to get it, until they actually see a boat in its immediate vicinity, and taking hold. This may appear to be an unnecessary precaution, but experience will prove otherwise. It is very easy to lose sight of a floating torpedo even in comparatively smooth water.

203. Recovery of torpedoes.—Range boats should be supplied with "nose and tail lines" and marker buoys. Boats stationed beyond the target should also be supplied with a stop-valve tool and propeller lock. The stop valve should be closed and propeller lock put on at the end of a run. Nothing else should be touched in order that all possible evidence will be available for diagnosis on receipt aboard. Diagnosis is important whether the run has been normal or otherwise. Horizontal rudders, starting lever, water tripper, etc., as well as any foreign material which may be foul of tail, should not be touched before delivery aboard. It is important in approaching a torpedo or handling alongside that the boat keep clear of the head, immersion chamber, afterbody, and tail. The air flask can not be harmed, but the other parts mentioned are easily dented or damaged. The great cost and military value of the torpedo make it essential that every effort be made to recover torpedoes. If an erratic run has been made the loss of the torpedo will prevent the investigation and discovery of the cause of the faulty performance. See diagram illustrating arrangement of boats for recovery of torpedoes.

204. Signals and diagrams.—(*a*) Signals.—It is extremely difficult for observers in a small boat 2 miles and over distant to make out signals. As the important signals required for range parties are few, it is advisable to make them with large flags. Portable radio sets in steamers have been found most useful.

Special designating signals for boats on torpedo range should be arranged, as distinguishing pennants often can not be made out and also as boats can better be designated according to their assigned stations on the range which may change according to locality and nature of the practice.

In addition to the General Signal Book, the following code of special signals have been found useful in torpedo practice. When it is desired to signal to any boat on the range, the numeral flag of the position she is then occupying will be hoisted over the signal in exactly the same manner as that used in signaling between ships. Similarly groups will be called by hoisting the international code flag of group desired. The international code flag F will be hoisted in a conspicuous place on a separate set of halliards when using the signal of this code.

A

B Torpedo sunk (flown in bow of boat standing by marker buoy).

C Code flag.

D Hits—indicated by numerals below.

E Half hits—indicated by numerals below.

G Torpedoes all recovered (not yet hoisted on board).

I Torpedoes in sight (bearing may follow).

K Torpedo sunk alongside.

O Torpedo sunk (repeater below to indicate which one; first, second, or third).

P Torpedoes—all hoisted on board—(numeral below to indicate number).

Q Steam to right (number of points indicated by numerals below).

T Torpedoes in tow.

X Steam to left (number of points indicated by numerals below).

Y Steam away from ship.

Z Steam toward ship.

AB Torpedo is making erratic run astern this or ship indicated.

AC Torpedo is making erratic run port quarter this or ship indicated.

AD Torpedo is making erratic run port beam this or ship indicated.

AE Torpedo is making erratic run port bow this or ship indicated.

AF Torpedo is making erratic run ahead.

AS Torpedo is making erratic run starboard bow this or ship indicated.

AH Torpedo is making erratic run starboard beam this or ship indicated.

AI Torpedo is making erratic run starboard quarter this or ship indicated.

NOTE.—Signals AB to AI are orders for boats in the immediate vicinity of the torpedo to proceed to the spot and recover the torpedo when it stops running or buoy the spot in case it goes down.

AJ Torpedo (shot indicated by numeral below) passed ahead of target.

AK Torpedo (shot indicated by numeral below) passed astern of target.

AL Boat or group indicated follow and recover torpedo bearing from boat or group as indicated (distance in yards may be indicated).

BF Ahead.

CE Astern.

DQ Port bow.

EI Port beam.

FA Port quarter.

FL Starboard bow.

RQ Starboard beam.

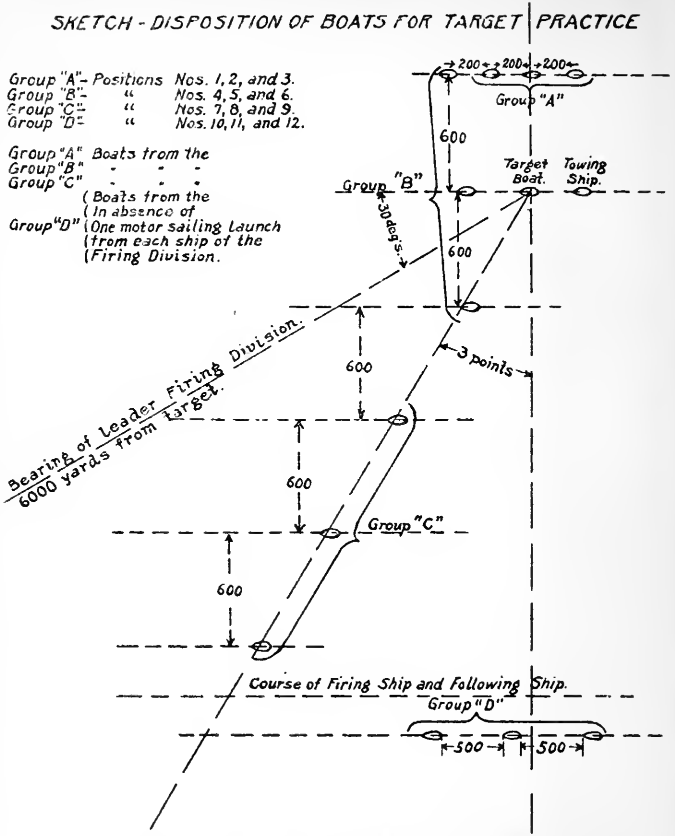
SU Starboard quarter.

UP --

VE --

YO --

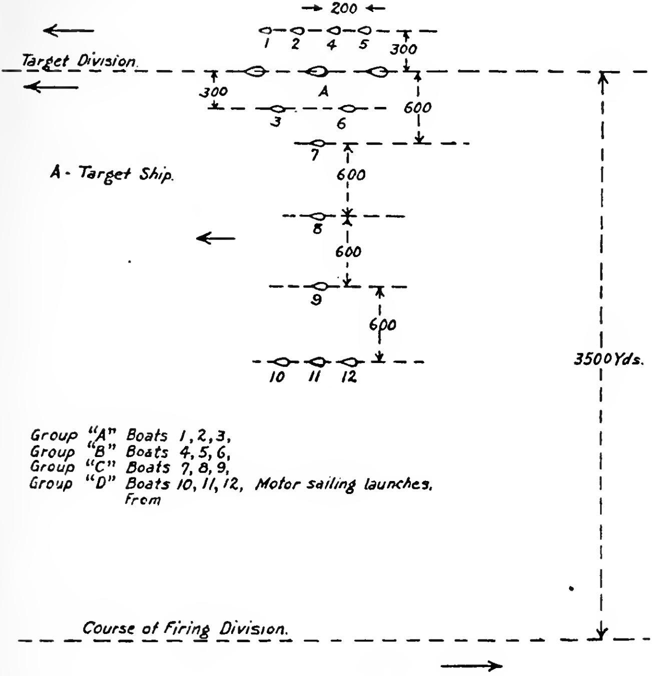
ZI --



Group "D," Leader 3,800 yards from target.

NOTE.—In addition to the arrangements of ships shown in sketch, one ship keeps position near the towing ship, either ahead or astern, during the entire practice.

205. Deterioration caused by salt water.—It is harmful to allow torpedoes to remain in the water, as water getting into the gyro pot, afterbody, immersion chamber, etc., causes de-



Disposition of boats for battle practice.

terioration. Gyros should be taken out, cleaned and oiled as soon as possible after a run to prevent deterioration of the bearings.

206. Possibilities of actual service.—In developing the personnel and material the possibilities of actual service should never be lost sight of. The ability to maintain gyros and other parts in adjustment, and to keep torpedoes loaded in the tubes and ready for firing for long periods must be acquired. The adjustment of the war nose and details used only in war, the quick, accurate use of the torpedo under all of the peculiar conditions and emergencies that may occur in actual service must be anticipated and prepared for. Ability to recognize and seize opportunity for torpedo firing is essential. Training should always be with the idea that the torpedoes may be employed while the guns are engaged. A full knowledge of the favorable positions for offense and defense is necessary. The training includes the tracking of the enemy (target) i. e., the correct estimation of his course, speed and range, and formation, as well as the ability to quickly place the correct setting on the gyro index and director, and to correctly direct and fire torpedoes when ordered.

207. Importance of weapon.—The importance of the weapon warrants every effort to make it effective when an opportunity for its use is afforded.

208. History.—It is no small part of the duty of all torpedo officers to systematically investigate the history of torpedo warfare before being satisfied with any conclusions as to the war method of using the material assigned to their charge.

209. Maneuvers and game board.—Torpedo officers should give their serious attention to maneuvers and game-board practice with a view of studying the part the torpedo can and should play in service. These furnish the nearest approach to war conditions possible in peace.

CHAPTER 9.

HINTS FOR TURRET OFFICERS.

[Attention is invited to Chapter 4.]

210. Ordnance pamphlets and description of mechanism.—Ordinance pamphlets are issued by the Bureau of Ordnance and are, with drawings and descriptions, kept on board ship in the custody of the gunnery officer. Consult these for details of the mechanism of the battery at which you are stationed, and thoroughly familiarize yourself with all features.

211. Importance of duties.—An officer given the charge of a turret must appreciate the importance of his duties and of the necessity for developing to a maximum the efficiency of the organization and material intrusted to his care. He may work hard and not have the most efficient turret in the Navy, but he will never have an efficient turret without hard work. If, during peace, his guns fail to make a creditable showing at target practice, he is responsible. An energetic turret officer will find ample work to keep him busy at all times with the installation and crew under his charge.

212. Responsibility.—In battle, intelligence, zeal, and courage are pitted against those of the enemy. If the enemy is of equal ability, but has worked and thought to a better purpose, then he will be the victor, other conditions being equal.

213. Methods to be followed.—The systems of training and the experience of past years are all available for information. The development of an expert turret crew is not a mystery. It requires common sense, an ability to judge and to handle men, attention to details, study and investigation, and finally *hard work*. The ability to take advantage of opportunities that are presented for training, the formulation of proper plans for training; and the intelligent carrying on of this training are the reasons for success in gunnery.

214. Battery log.—If the turret log has been kept up, read it carefully; if not, start one at once. It will be valuable to your successor as well as yourself. It should contain a record of methods used and the results obtained, summaries of target practices and conclusions reached, modifications to drills, and whether or not such modifications are improvements, records of machinery and how repaired, record of tests of machinery explained in detail, data relative to the crew, what positions other than their regular ones they are capable of filling, and any other data which may be of interest or value. Any records made, to be of value, should be in sufficient detail to be clearly understood by those not familiar with the turret or its crew. Do not detract from the value of the turret log by entering unimportant remarks, such as "held loading drill," etc. Keep a record of all measurements taken, and of all accessories and spare parts provided, with their respective places of stowage. Do not condemn a piece of mechanism until you are sure that you understand it, that it has been used as designed, and has been given a thorough trial.

215. Inspections.—Frequent inspections of the entire installation should be made by the turret officer. These inspections must be detailed and are a constant check in the routine upkeep of the gear.

216. Care in moving turret machinery.—Great care must be exercised in moving any of the mechanism of the turret. It is not uncommon for great and sometimes permanent damage to be done because of a lack of familiarity on the part of members of new crews. Caution in operation, when breaking in new men, will generally obviate damage which should have been prevented and which will be inconvenient if not irreparable.

217. Material.—The first work to be done upon assignment to a turret is to clean and to overhaul the mount and all parts of the gear and to check up the stowage of spare parts, tools, etc. The division officer, junior officer, and turret captain should familiarize themselves with everything in the turret, consulting blue prints, descriptions, etc., freely and frequently. Every detail of every part must be understood. Never attempt to dismount or disassemble a part of any mechanism without first studying and learning the details thereof from the drawings and descriptions that are at hand. Be extremely careful in overhauling and in assembling mechanisms. The employment of force at these times, which is a natural tendency on the part of one who is not a skilled mechanic, generally does more harm than good, and an ignorant man with a long-handled wrench, a sledge, or bar in a few moments may cause damage that will take days to repair, if it is not irreparable. It is very necessary that all gear be thoroughly overhauled and cleaned before running, as chippings are apt to be present in bearings, which, if not removed, will cause cutting and permanent injury.

218. Use of emery.—The use of emery or other gritty substances must be closely watched. Never allow them on any working surfaces, such as threads of the plug, screw box, plug tray, gearing, or where they may fall on bearings. Be particularly careful that such substances are never used on the primer seat, for if this is enlarged fuzed and burst primers will result.

219. Lubrication.—Insufficient lubrication is a general cause of trouble. Special attention should be given inaccessible gearing. Keep oil holes plugged with leather. Graphite hoist cables thoroughly. Keep oil always from contacts of firing mechanism and primer seats. The kind of lubricant that is used may cause trouble, as the amount of lubrication required will sometimes depend on whether a light or heavy oil is used. Heavy oil should be used on bearings of slow moving, heavy duty shafts. Such bearings should be flushed out occasionally with kerosene to prevent the grease hardening in the bearing and stopping the flow of the lubricant over the entire bearing surface. All gears require heavy grease, such as vaseline. If uncased, they should not be left too long unattended, as particles of dust or metal from the gears frequently remain suspended in the grease instead of settling. Much used gears will frequently heat up and soften the lubricant to such an extent that it will ooze out of the gear box. In such cases heavy grease mixed with powdered graphite will usually diminish the trouble. Ball and roller bearings are usually packed with vaseline, but where not sufficiently inclosed to prevent the collection of dirt should be carefully watched. Variable speed gears require a light grade of pure mineral oil. Poor oil containing animal fats soon separates and leaves a deposit of paraffine, which is liable to clog cylinders or parts and reduce considerably the efficiency of the gear. Gun slide bearings have frequently been found very badly corroded upon dismounting of the gun. Grease should be forced in freely before each target practice, in order that it may be dragged into the slide as much as possible upon recoil of gun. Trunnions, being difficult to examine, are also frequently found in bad shape. As there is no method of forcing grease into them except in some cases at the top of the bearing, the safest method is to flush frequently with kerosene, followed up immediately with light oil, which will more surely flow to all parts of the bearing. Guard against leaving kerosene in a bearing or on a metal surface. It sometimes occurs that an oil hole gets stopped up with hardening grease. The remedy is obvious. Turret captains frequently establish an oiling routine, and at certain regular times go over the entire turret. This is a dangerous habit, as the amount of oil required depends upon the extent to which the machinery is used. A weekly oiling routine, plus additional oiling for each day's drill, is much safer. High-speed shafts require and should receive more attention than low-speed shafts. A list of such bearings should be made and their inspection made more frequently than the others.

220. Roller path.—Before training the turret inspect the roller path and see that it is clear and well slushed, that the holding-down clips are secure, and check up all clearances. Roller paths, being difficult of access, are often neglected and the lubricant used in them frequently becomes heavy with dust and dirt. Light oil is more efficient than heavy grease, as the dirt more easily washes away, and there is less drag to the rollers. Do not let the oil get so thin that the upper roller path becomes dry. Roller paths and rollers should be carefully cleaned after a visit to a navy yard for repairs and alterations. Roller pins should be inspected and lubricated occasionally to see that they do not become frozen to the roller path becomes dry. Roller paths and rollers should be to the floating ring. The rollers tend to creep away from the center of the turret, bringing considerable pressure between the inside flanges of the rollers and the inside edges of the roller paths. These bearing surfaces will wear smooth and become polished, and should be inspected to see that no burrs are formed on them. In some of the older ships depressions have been found in roller paths worn by the rollers, due to the fact that the turret is always secured for sea in one position, bringing rollers on the same spots on roller paths. To avoid this danger the turret should not be trained always in the same position when not in use except when it is necessary to secure it for heavy weather with the locking pin or wedge. If it is found that the rollers creep around and do not come at the same point on the roller path when the turret is centered fore and aft, then the above precaution is not necessary.

221. Electric leads.—The electric leads, terminals, switches, contacts, circuit breakers, etc., should be carefully examined.

See that the lighting circuits are in order and that the lights in turrets and handling rooms are properly placed. Have all circuits tested weekly for grounds. An occasional record of voltage and current used by the various motors will be of value in ascertaining whether the machinery is working hard or easy. If the elevating motor of one of the guns is using three horsepower on a certain speed when a similar motor in another turret is using only two horsepower, then a search should at once be made to determine the cause of such a discrepancy. An electrical connection may have loosened, brushes may not be properly adjusted, or the commutator may be scarred. In case of motors operated by controllers the controller fingers, if blistered or not properly adjusted, will cause considerable trouble. Even if fingers are smooth they will need to be gone over frequently. Any electrician's handbook will give all necessary instructions relative to their care and adjustment.

222. Elevating gear.—The elevating gear should operate very easily. If such is not the case it will probably be found that some of the levers or shafting are out of line or bearings are badly adjusted. Occasionally the rack controlling the "tilting box" (Waterbury gear) bears too heavily against the pinion. Sometimes one of the levers or rods leading to the pointer's position are sprung or bear against something. All shafting and motors must be adjusted until the mechanism will run without any heating, and a light touch on the lever will elevate or depress the gun. If the Waterbury gear does not function exactly it should be overhauled. Investigate when, how, and by whom it was installed, and its condition at that time. See that guns are properly balanced.

223. Firing panel in turret booth.—A switchboard should be located in the turret booth through which the firing circuit should be led. By means of switches the turret officer can accomplish the following on either the battery or motor-generator circuits: (*a*) Right gunfire; (*b*) left gunfire; (*c*) both guns in salvo, right pointer firing; (*d*) same as (*c*), but left pointer firing; (*e*) off position, neither gun able to fire by electricity.

224. Signals.—The system of communications and of signals should be thoroughly investigated and understood. There should be a system of signals to the pointers and trainer controlled from the turret officer's booth; also a system of lights and signals from the booth to each plugman or gun captain, and from these men to the turret officer, will be found advantageous.

225. Safety of crew.—Make sure that arrangements are such that handling-room crews may load the hoists in perfect safety. Dangerous traps cause unsteadiness on the part of the crew and must be eliminated. The turret officer is responsible for his crew and every precaution should be taken to avoid accidents to the members thereof. The plugman should be carefully trained to watch for the recoil of his gun when it is fired. When firing he must not open the plug of a loaded gun until the gun is discharged, unless specially ordered to do so. In cases where guns are fitted with salvo attachments this may not be necessary.

226. Installation of dotter.—The first installation of the dotter is usually made by the yard force. The division officer should understand the fundamental principles of the particular dotter. If these are understood and careful attention is given to the points vital to its accuracy at this time a great deal of trouble with the device in the future will be avoided. The first adjustment often takes several days and requires patience. After it is once made to work and the particular features of the mechanism are understood but little trouble should be experienced with it. The dotter is a delicate mechanism and at all times requires care in handling. Bearings and exposed parts should be kept oiled and properly covered.

227. Running mechanisms.—All mechanisms should be run daily by the men who regularly operate them.

228. List of division.—It will be found very useful to make an alphabetical list of the division showing opposite each name the man's general characteristics and previous experience; for example:

Brown, J..........	O. S......	Age 20, strong, clean, small, good worker, intelligent; previous trade, farmer; experience, rammer man 6-inch, U. S. S. ....

229. Selection of turret force.—To each turret there is assigned a turret captain, electrician, and one or more gunners' mates. It is desirable to supplement this force by two or more turret strikers who should be carefully selected for their intelligence and industry.

230. Turret captain.—The turret captain is the leading petty officer of the turret crew and should be freely consulted. Give all orders and directions through him and make him thoroughly understand his responsibility.

231. Duties of turret force.—The turret force cleans and cares for all parts of the turret, mount, guns, handling and ammunition rooms, and forms a part of the turret crew.

232. Cleaning bill.—A cleaning bill should be drawn up and posted showing each man's station and for what he is responsible, together with the time for overhauling and cleaning. The station bill of the gun and magazine crews and the safety regulations should be hung in the turret and handling rooms.

233. Living quarters for turret force.—It is desirable to have the turret force live in the turret and handling rooms. If they can be arranged, metal lockers for the members of the force, and a desk for the turret captain, placed on the electrical deck or elsewhere in the turret space, will contribute greatly to the comfort and satisfaction of these men, who should be encouraged in every way to take pride in the appearance and condition of all parts of the turret installation.

234. Selection of gun crews.—A man should be stationed in the position that he is best qualified to fill. Each man should be trained for as many stations as practicable, though specially trained for his own particular station. Generally the greater the number of stations a man is capable of filling the better he is able to perform the duties of his own, and the better the duties of those who may be disabled will be absorbed by the remaining members of the crew. The gun captain will be responsible for the service of the gun in action. Gun captains should not be finally selected until the division officer knows his men thoroughly. A gun captain should not be recommended for examination until he has been through at least one target practice while acting in that capacity. Plugmen should be strong, quick, and steady. Men who are mentally quick should be selected to run electrical gear, rammers, hoists, etc. Turret strikers are frequently desirable men to assign those stations, as they are generally familiar with them. As a rule two men should be trained for each station.

235. Stationing of remainder of division.—When the guns' crews have been selected others of the division should be stationed as powder passers, magazine powder men, shellmen, etc. There are always men in a division who are difficult to get hold of at drill because of their other duties. It will be found a convenience to give them stations where but little drill is necessary.

236. Pointers.—If there are any qualified pointers in the division they should be stationed at once in order to permit them to draw their extra pay. They should be given to understand, however, that they will hold the position only as long as they show ability. In trying out pointers remember that appearances are deceptive; do not formulate an opinion of a man's ability to point a gun from his general carriage and appearance.

237. Preliminary.—The candidate should be sent to the sick bay (or to the hospital ship if she is near by) for eye examination. The next step should be instruction in the elementary principles and operation of the training and elevating mechanisms and the most probable causes of failure to function properly. The location and the operation of the clutches for disconnecting power and connecting up for hand operation should be explained. It is a very common mistake to expect new men to be familiar with mechanical devices, which, however simple, may appear quite obscure to them.

238. Development of pointers.—Having become familiar with the gun and its appurtenances, the candidate should be taught the significance of the "stand-by" and the firing signals, the time interval to be used, etc., the necessity of being "on" when he fires, to "hold fire" if he is not "on," and in general given a thorough knowledge of the system of spotting and fire control. It is not sufficient to tell a pointer that "the better the pointing the poorer the results if the sights are incorrectly set." He must be told *why*. He should understand enough of the principles of fire control to know *why* implicit obedience to the orders of the spotter is necessary, and why an attempted betterment of the spotter's corrections will certainly result in disaster. He should understand the firing connections, the methods of firing, and the safety precautions. After instruction has been given the would-be pointer he should be put through exhaustive tests. The time to be spent on each man will vary considerably, but sufficient time must be allowed to give each candidate a thorough and impartial examination. Too little attention is sometimes paid to the *consistent* drilling of pointers. The turret should be in a state of preparedness at all times, and should have an adequate supply of expert gun pointers.

239. Selection of those to continue training.—Some men will soon begin to do better than others, the groups of candidates should be rearranged, putting the best men together. The best and steadiest should be tried at training as this is the more difficult position. After a few drills and trials of different arrangements of groups the poorer ones can be dropped. During drills all mistakes should be criticized and errors pointed out.

240. Method of scoring.—A system of scoring should be established. For example, with everything stationary and the sights "on," pull the trigger. With the mark thus made as a center, describe two circles of different radii. All hits in the inner circle can be counted 4, all those in the next 2, and any other 0. The larger of these circles should be small enough to exclude any shots that were fired when the sights were not very nearly "on." This system of scoring will arouse the interest of the men and will give a basis of comparison.

241. Officers to train as pointers.—Turret officers should train and acquire skill in gun pointing. Only by working the gear themselves can officers learn the difficulties that the pointers experience.

242. Beginning drills.—When the turret gear is in good working order drills may be begun. Remember the cautions already given regarding the particular care to be exercised in running the gear when breaking in a crew. Always inform the turret captain sufficiently in advance of what the drills are to be to permit him to prepare the gear.

243. The first drills.—Having tentatively stationed the guns' crews the first drill periods should be devoted to explaining and demonstrating the gear. The men should be taught at this time the general scheme of loading, the necessity for precision, safety regulations, nomenclature of parts. After these are understood the individuals should be drilled in their particular tasks. Each movement of each man should be studied until the best, surest, and quickest method of accomplishing each task is discovered. Insist upon precision rather than speed. The candidate for each position should carefully practice his part until fairly proficient, and then the crew can be given exercise in loading.

244. Loading exercises.—In the complicated power-loading turrets save the gear as much as possible. After a load criticize in detail each mistake. Then load once more and repeat the lecture. It is a frequent and bad practice to slam through seven or eight loads, all imperfect in some detail. With a power-loading turret, it is a question of weeks or months until parts of the mechanism begin to become balky because of wear and tear on the installation. With hand-loading turrets it is safe and proper to load as often as the crews need it, for no harm can come to the gear except to the breech mechanism.

245. Timing loads.—As soon as the crews can load with precision, begin to pit them against one another. Speed in loading is the natural result of precision and team work. In the event of mishaps always have the fault remedied as would be the case in service, and always complete every load that is attempted. The time should be taken from shot to shot as seconds saved in loading may be readily lost by the pointer.

246. Priming.—The plugman should practice priming many times a day until proficient.

247. Powder passing.—If the powder is passed by hand, the passers should be required to pass at least 50 bags a day. This can be accomplished by sending the bags up on one side of the turret and down on the other. Care must be exercised to always have the strap end of the bag uppermost, and that this strap is not used in passing the bags. The powder passers should be drilled daily until they are developed, and can continue their duties without becoming fatigued. Every individual who handles the powder must understand that the ignition end of all bags when loaded must be toward the breech. Instruction must be given regarding the care to be taken in handling bags—the breaking of a single powder bag may interrupt or delay the firing and should not occur.

248. Requirements at drill.—Some of these are thorough seating of the shell, the loading of powder bags with ignition ends toward the breech, complete closure of breech, insuring closing of contract in firing circuits, no skylarking or unnecessary noise, the completion of every load commenced, the simulation of actual firing conditions, use of regular signals and methods of communication, the closing of the turret hatches and doors as would be the case in service. Give "silence" frequently; develop spirit of responsibility on part of gun captains and members of the crew. Exercise at casualties.

249. Casualties.—The best way to avoid casualties is to make a list of such as you can learn of having occurred in other turrets, and of any others that can be conceived. Note the remedy and drill accordingly. The following are some of the casualties that may occur with remedies:

(*a*) **Misfires.**—Train the firing pointer to be sure he tries both motor-generator and battery-firing circuits before he calls "Misfire." If both circuits fail, fire by percussion. If the primer does not fire, shift primers and try again by electricity. One member of the crew should be drilled to watch the lock and observe whether the primers fire.

Recent records show that where misfires have occurred they have generally taken place for the reasons stated below:

Failure of pointer to make contact (70 per cent).	Failure of circuit (20 per cent).	Failure of charge (8 per cent).	Failure of primer (2 per cent).
1. Squeezed grip instead of trigger. 2. Pushed button sideways instead of straight down. 3. Made contact before order "Ready" was given; i. e., before breech was fully closed.	1. Circuit broken. (*a*) Before firing, not carefully gone over and tested. (*b*) During firing, jarred out of place, jammed between moving surfaces. (*c*) Allowance for recoil insufficient. (*d*) Too much tape on terminals—hides an evident flaw. (*e*) Terminal on plug held back when plug is closed by short leg wedging down on face of breech next to binding post. 2. Insufficient current. (*a*) Battery charged and allowed to run down. (*b*) Motor generator grounded. 3. Dirt, grit, or oil on contact pieces.	1. Last section shoved too far from mushroom. 2. Last section inserted ignition end forward. 3. Charge wet.	1. Primer not seated. 2. Imperfect manufacture. 3. Using percussion for electric, by mistake.

(*b*) **All lights in turret and handling room out.**—Use small battery hand lamps that are provided. The crews should be drilled to be able to load in absolute darkness, slowly but completely. This particular casualty has happened a number of times and has usually been unprovided for.

(*c*) **Gas ejecting system carries away or air valve fails.**—Use auxiliary air line. Be very careful about giving "bore clear."

(*d*) **Fire in any part of turret or handling room.**—Get all powder away from scene of fire and into barrels of water or shell rooms behind closed doors. Keep all magazine doors closed. Man the fire hose.

(*e*) **Broken powder bag.**—Stop all gear on that side. If badly broken, gather up powder and throw it into bucket of water; if only a small break, gather up powder and throw into gun.

(*f*) **Broken rammer.**—Use hand rammer.

(*g*) **Plug won't close.**—Open plug to see if powder bags are shoved in far enough and try again. If this is not the trouble try to locate the cause and remedy it. Look for burrs, bent hinge pin or plug tray, or jammed operating shaft.

(*h*) **Plug sticks.**—Nut on mushroom stem may be set up too hard, causing split rings to expand and bind on gas check seat. It is possible that the inner bearing of the shaft carrying the worm is bound by particles of metal worked into the lower part of the bearing, making it impossible to open the plug without disassembling the operating mechanism, which should be done at once.

(*i*) **Powder bags come up wrong end first.**—Reverse and load as usual.

(*j*) **Shell hoist cable carries away.**—Provide shell from other side until new cable is rove off.

(*k*) **Circuit breaker blows.**—Put controller on "off" position and throw in circuit breaker.

(*l*) **Signal bells and buzzers gone.**—Use voice tubes from turret officer's booth in connection with telephone.

(*m*) **Burning fragments of powder bag on mushroom head.**—Sponge off carefully with wet sponge. Be careful that "bore clear" is not given before it is removed.

The above are but a few of the many contingencies that must be prepared for.

250. Difficulty in seating shell.—If the gun is elevated or has a steep compression slope there may be trouble in making a shell stick when seating it. With such the case, a grommet of small twine around the shell, just forward of the band, will insure it sticking.

251. Powder charge left in gun.—If it is apparent that the gun is not to be fired promptly the charge should be removed and kept at the temperature of the magazines. Otherwise the charge will take up the temperature of the chamber, resulting in an I. V. above or below the normal.

252. Excessive oil in screw box.—Do not fire a gun with the screw box and breech plug threads covered with grease or oil. When fired in this condition the set back will tend to unlock the plug and carry away worm, the pinion, and other parts of the mechanism.

253. Unburned fragments in chamber.—Unburned tape is frequently found in the chamber and bore of guns that use bags bound with woolen tape. This tape sometimes smoulders after the breech is open, and constitutes a grave source of danger.

254. Clearing vent.—It is seldom necessary to clear the vent. If it becomes necessary, use the priming wire from the forward end. Carefully avoid scoring, and thoroughly clean the primer seat.

255. Ray filters.—Attention is invited to the ray filters for use in sight telescopes. These should be kept at hand near the guns and used when pointing into the glare of sunlight or at a searchlight.

256. Removal of tompion.—Be sure to remove tompion before a primer is fired, otherwise, it may be lost overboard. If left in gun when the latter is fired the muzzle may be blown off.

257. Refilling shell racks.—During an engagement take advantage of every cessation of fire to fill turret shell racks.

258. Talks.—Drills should be interspersed with talks on target practice, and the end in view, which is preparedness for battle. The men should be questioned regarding safety precautions and casualties. They should be given general information regarding the ordnance gear, the action of the gun when fired, the method of taking up the recoil, weight of shell and charge. The theory of fire control and spotting should be explained, and the effects of inaccuracy of pointing demonstrated.

JUNIOR DIVISION OFFICERS.

259. **Suggestions for.**—Given a well-organized turret division, a lieutenant in command, you are ordered to this division as junior officer. Upon joining ship, division officer orders you to familiarize yourself with the turret and crew as soon as possible. The turret officer may make, with you, a thorough inspection of the turret, pointing out the general scheme of loading, the stowage of ammunition, the parts or places he has found needing particular care, and the assignment of various parts to the gunner's mates and their helpers. Lay out a plan of study for yourself and stick to it so far as your other duties permit.

The following is an example of such a plan. Any one which completely covers the entire installation will be satisfactory.

First day.—Go over the general arrangement of the turret, (1) note method of supply of ammunition and (2) access to handling room, (3) draw a plan of magazines and shell rooms with positions of flooding and sprinkling valves on decks above, (4) examine barbette inside, noting which parts revolve with turret and which are stationary, (5) note methods of securing turret for sea in order to tell at a glance whether turret is ready for training or not. (Wedges, center pins, etc.)

Second day.—Examine turret turning mechanism: where placed, how many sets of motors, where controlled, how shift from power to hand, how set up on friction gear (read pamphlets describing the gear).

Gun-elevating mechanism, where placed, where controlled and method of transmission of control, how shift from power to hand elevating, what the friction gear is, and how set up, how balance a gun, i.e., whether when loaded with shell and drill charge, the gun is balanced and if not, why not (sub-caliber attachments may be in place). Examine trunnions and wedges, note whether guns are on knife edges.

Third day.—Sights and mechanism, routine of oiling and cleaning the working parts. Mark of telescope, method of protection from dampness, how focus for dotter work, how shift sights when bore sighting.

Fourth day.—Recoil mechanism; how many cylinders, how many springs in each, principle of action, position of cylinders, how liquid is supplied. Amount of recoil, and how firing circuit and gas ejecting hose are fitted to allow for recoil.

Fifth day.—Firing circuit. How many methods of firing, how connected, what breaks in circuit and where, whether each pointer can fire his own or both guns and how this is accomplished. Where motor generator is placed, where storage battery is secured, kind of battery and characteristics. How fire by percussion, what kind of primers are used, trace each lead of circuit, and note its use.

Sixth day.—Breech mechanism. Dismount and examine parts of mechanism, function of each, method of operation, safety devices, mushroom pad and rings, their object and method of adjustment. Note particularly the wedge of the lock and extractor and test a primer in the lock to see if it is possible to insert primer beyond extractor, and how avoid this.

Seventh day.—Miscellaneous subjects:

(*a*) Roller paths, condition of rollers; they must be free to revolve on pins. See nuts on holding down clips free of rust, path well greased.

(*b*) Ventilating system. Where supply is obtained, and path of air circuits in handling room and turret.

(c) Where drains lead from barbette and handling room.

(d) Adjustment and operation of dotter gear. This can be studied best at drill.

(e) Source of supply of compressed air for gas-ejecting system, and location of accumulator and lead from it to guns.

(f) As opportunity offers, read over the battery log, noting the number and kind of drills you can expect to have, the records of last firing, scores made, any interruptions or accidents that ought to be avoided in future, any remarks on the practice made by the battery officer.

(g) Make an inspection of the subcentral (get the electrician in charge of the plant to accompany you). Find out how battle orders are communicated to the turret. General arrangement of central, subcentral, and subs.

CHAPTER 10.

HINTS FOR OFFICERS OF A BROADSIDE BATTERY.

260. General.—Many of the remarks in the chapter "Hints for turret officers" are pertinent for an officer assigned to a broadside battery. This battery constitutes an important part of the armament of the ship.

261. Organization and drill.—The organization and successful administration and drill of a broadside battery, composed of guns frequently widely scattered, require the closest attention, and many officers consider that it is a more difficult task than the development of a turret unit, where the crew and material are all closely assembled.

262. Material.—The details of the material assigned the division must be thoroughly learned and every accessible part examined and put in order.

263. Lining up.—It is presupposed that the guns have been properly lined up and balanced when installed. The lining up may be checked when the ship is in dry dock. Too much clearance between trunnions and trunnion seats or cap squares may be taken up by screwing in on the wedges fitted for the purpose. Excess of clearance may be detected when the gun is being trained in either direction by suddenly reversing the direction of train.

264. Running in.—The guns should be run in and the roller paths carefully examined for flaws, cracked rollers, etc. The recoil cylinders should be opened and cleaned and springs closely examined.

265. Firing circuits.—In preparing gun for firing, the electric firing circuits should be thoroughly overhauled. Wipe off all connections with alcohol or gasoline to free them from dirt and grease, connect up leads, and ring through with a magneto. If circuit is found continuous, then connect a voltmeter in series, close first one firing key then the other and note voltage given by both motor generator and battery; should be about 20 and 10 respectively. As a final test fire a drill primer with each circuit, first seeing primer seat wiped clear of grease and oil. Tape all connections around breech to prevent possibility of grounds.

266. Friction disks.—Dismount elevating-friction disks, wash with lye water, and clean with silicon to remove all grease. Reassemble and set up as taut as can be done by one man with a 24-inch wrench. If this is not done the tendency of the muzzle to jump on firing will throw the breech down. During firing leave the cover off the gear case and split pin out of the nut so that if friction disks slip they may be set up again without loss of time.

The training disks should be set up to grip the arc tight enough to prevent slipping when the direction of train is reversed suddenly. The main precaution, however, should be to keep the arc at all times free of oil or water.

267. Breech mechanisms.—Dismount and examine breech mechanism carefully. Examine gas check pad for cracks, smear well with tallow, and set up hand taut. Have a can of tallow at hand for this purpose during firing. See split rings turned with splits at opposite ends of diameter. See primer vent clear in wedge of firing lock. See that firing pins are straight, unbroken, and clear of seat in wedge.

268. Gas-ejector system.—Turn air on gas ejector and examine line for leaks. Inspect nozzles. Do not forget to remove tompion before doing so.

269. Fire control.—The fire-control leads and devices must be understood by the entire division.

270. Ammunition supply.—The ammunition supply for guns is an important matter that should receive careful consideration. There is a great deal of detail connected with the supply of ammunition, the opening of cases, the disposal of boxes, wiping off of cartridges, etc., which will require preparation and good organization.

271. Selection of crew.—For 7-inch guns the rammer men should be tall men, long armed, and of average strength. First and second tray men should be good strong men, the strongest of the division, as the speed of the loading depends on them. Small men are best for primer men.

272. Routine of drills.—To drill a large broadside battery the work must be mapped out ahead. One officer can not run the whole drill, each gun captain must do his part. The dotter and the drill gun should be made ready before quarters. When drill call sounds send the gun crews to the loading machine and the pointers to the dotter. One officer takes the loading crews while another takes the pointers.

273. Detail of pointer drills—Mechanical target.—In the early stages all drill will be with the mechanical targets. Determine on the dotter cards the area which indicates a hit and mark all cards accordingly. It is not well to have the pointer fire too many shots at a time. A string of the number of shots he will fire at practice is best. High-power glasses are trying to the eyes. Forty shots for a pointer's morning work is enough, which means double that number when the time at the trainer's sight is considered. If a bull's-eye is available make the pointers get well in the black. The target is only of such size that it will catch all shots aimed at the bull's-eye. In case of doubt count a miss. Use a buzzer attached to the firing key and also have the pointer sing out "fire" to stimulate percussion firing. Figure out all scores with mechanical targets or check sights and post the results on the bulletin board daily. Keep record in a book and average by week and month. Do not make the firing signal too short at first. Drill the battery in broadside firing by sending a man to the substation. Let him wear a phone and be in communication with a man on the gun deck who will give the stand-by and firing signal.

274. Cards for recording performances of gun pointers.—The following types of cards have been used with success, and are recommended by a gunnery officer for keeping a record of the work of pointers with the dotter:

(Obverse.)

Name..

SCORES MADE ON RECORD STRINGS.

Date.	Score.	Date.	Score.	Date.	Score.

[This side may be filled in with pencil.]

(Reverse.)

GUNNERY RECORD CARD.

Name, ...

Rate, ..., Division, ...

Gun, ...

Station, ...

Date of detail, ...

Qualified as.......................................

Date of expiration,................................

Small arms qualification, ...

Notes, ...

....

....

[Fill in this side with ink. See instructions for keeping these cards. Turn in to gunnery officer at end of week, and when completed.]

TURRET DOTTER TARGET.

Name......................................

Rate......................................

Date......................................

Score....................

Full size of target, 30 by 60 feet at 7,000 yards.

3 AND 6 INCH DOTTER TARGET.

Name......................................

Rate......................................

Date......................................

Score....................

White bull's-eye counts 5; black border 3; outside 0.

Full size of target 15 by 15 feet at 2,000 yards. Elementary Practice, 1913. Obtain targets from armory. Enter score on Gunnery Record card and give target to pointer. Record strings must be fired under the exact standard conditions prescribed by the Gunnery Officer.

3 AND 6 INCH DOTTER TARGET.

Full size of target, 21 by 15 by 25 at 4,000 yards.

275. Misfires, hangfires, safety precautions.—Train the firing pointer to be sure he presses both the motor generator and the battery firing key before he calls "misfire." Train the gun captain to fire by percussion at the order of the pointer. Train him to shift primers when all three methods have failed to fire the gun. Train the rest of crew to stand clear while primer is being shifted.

Train the crew never to open the breech of a loaded gun after an attempt has been made to fire it, without orders from the battery officer. (See Naval Instructions 1913, art. 2858.)

276. Loading drill.—The drill gun must be used daily. From 10 to 20 loads are enough. Reward the best crews by shortening the number of loads. Time each load from the order "load" until the plug is primed and closed. Average the times and post on the bulletin board. After the loading drill, work the primer men with their plugmen at the drill gun. Let each primer man place 25 to 50 primers daily. Impress the crew that there is no danger and that they are as safe just beyond the limits of the gun's recoil as anywhere in the compartment. Particular attention must be given to the plugman. He must invariably completely close the plug to avoid a misfire, and must stand and move in a way that will obviate interference with the loaders and at the same time clear the recoil of the gun.

277. Sight setting.—Send out ranges through the visuals and telephones. Have each sight setter at his own gun, and have the gun captain record each range and deflection as set. From 15 to 20 ranges are enough. This is in addition to individual instruction and drill. It is important that the officer of the division should check the ranges as received from the substation. In training for long-range firing it is a good idea to have the sights set at the probable firing range to accustom the pointers to working with the gun constantly in elevation.

278. Afternoon work.—The afternoon period is best devoted to light work. For instance, have pointers fire a string or two apiece and drill the loading crews again that were a bit off in the morning. Stop drill in time to let the men rest. There is plenty of time during drill periods to get in the work if it is done properly. Demand as military and clean appearance during target practice as at any other time. If there is going to be a loading drill after quarters, allow the men five minutes to shift. Shells are usually greasy, and it does no good to have the men ruin their uniforms.

279. Night drills.—As this battery is an important part of the torpedo-defense armament, the pointers and crew must be exercised after dark. A station bill for lookouts, gun crews, and fire control when in the presence of an enemy must be prepared.

280. Difficulties in assembling men.—A battery officer will find it hard to get every man of the division at the same time. Make petty officers and the gun captains responsible for getting the crews up promptly. Arrange the details for the day calls, working parties, etc., by gun crews. If details miss drill in the forenoon they can be drilled in the afternoon. Watch the division list closely. The gun captain or the pointers should not be detailed as coxswains of boats. Assign men of unimportant stations as boat keepers, etc.

281. During practice.—The crews should be at their stations well ahead of the time and all precautions and regulations required for general quarters carried out. See that the primer men have a supply of tested primers. Fire a primer in each gun. The primer men should have been instructed never to pick up a primer. Remind the pointers of the target at which they are to fire. Note the reading of the sights at the finish. Check the timekeeper. Explain to the umpire before you start in what order you wish to fire the guns.

282. Procedure before and during battle practice.—This will follow the same general scheme as elementary practice, and most of the preparation for battle practice will have already been covered. All firing is by signal. Subcaliber by single guns and in salvo is used in preparation, together with check sights. All orders should be given through the fire-control phones. This can be arranged by having one of the division officers run the substation. Loading is equally as important as in other forms of practice, and the crews should become accustomed to loading with guns in elevation.

CHAPTER 11.

TORPEDO VESSELS AND SUBMARINES.

283. Essentials of training.—The general system of training outlined in previous chapters obtains for these vessels. Essential modifications must, however, be introduced in details.

284. Artificiality of peace exercises.—The peace exercises given to vessels of these classes partake, to a very considerable degree, of artificiality because of the absence, to some degree, in them of the high tension and nervous strain, which will be the most potent factor in the operation of these craft and of their armaments in war. The ranges in practice for both gun and torpedoes are long, imposing some difficulties. It is not intended that this training should teach that such are necessarily to be the ranges for battle.

285. Lessons of Russian-Japanese War.—A lesson of the recent struggle in the Far East is that generally an attack with torpedoes by these classes of vessels at night must be driven home, and the torpedo range must be one *where hits are assured*. The development of the long-range torpedo will probably give these vessels a new and wider rôle in future-day action.

286. Gun on destroyer.—While the torpedo is the major weapon of the torpedo vessel the gun on the destroyer must not be neglected. We have numerous instances in war of the use of the destroyer for other purposes than that of defeating torpedo boats and of delivering torpedo attacks. Many occasions may be expected to arise when quick and accurate shooting will become necessary.

287. Destroyer actions.—The following are examples of recent destroyer actions:

On the night of March 9, 1904, four Russian and four Japanese destroyers engaged in an indecisive battle at short range. One Japanese destroyer was not engaged. One reported 1 killed and 3 wounded, not seriously hit. Another reported 1 killed and 3 wounded, 2 guns disabled and speed reduced. Another reported 5 killed and 2 wounded, 1 gun disabled and speed reduced.

On March 10, during daylight, 4 Japanese destroyers encountered 2 Russian craft, 1 of which was sunk. After this action 1 Japanese destroyer reported 27 hits, 1 killed, and 3 wounded. Another 6 hits, 1 killed, and 1 wounded. Another 7 or 8 hits, 1 killed, and 1 wounded. The fourth nil.

288. Independent control of guns.—Because of the excessive motion of the destroyer the centralized control of fire, practiced in larger vessels, and which is desirable, may not always be possible. Training should permit the independent control of guns under the difficulties imposed by the poor gun platform, and the wide separation of the pieces.

289. Training for individual control of guns.—Particular attention should be given to the training of gun captains and pointers in these vessels. Spotters must be trained who will be competent to independently control the fire of each gun (as is the case in larger vessels, should such become necessary), at the short distances which will probably become the battle ranges with guns.

290. Proficiency of pointers trained in larger vessels.—It may be that pointers of secondary guns who have received training in larger vessels will not be well qualified to direct the pieces in smaller craft having an excessive and irregular motion. There should be no hesitancy in replacing such qualified pointers at any time by other men whose fitness has been demonstrated.

SUBMARINES.

Hints and Suggestions for a Torpedo Officer of a Submarine.

291. Organization.—The complement of the present-day submarine is 18 to 20 men, of whom 6 are gunner's mates. Submaries carry from 2 to 4 torpedoes and should have 1 torpedo man for each tube. These torpedo men form the torpedo crew.

292. Torpedo firing.—Suppose a torpedo has just been fired: Close the torpedo-tube cap, blow or pump the tube dry. On deck rig the skids; in the torpedo compartment, rig the cradle to the torpedo hatch. For holding and manipulating the latter, small double tackles hooked to pad eyes are used. Six tackles, four to hold the cradle up and two to move it fore-and-aft, are generally employed. In some vessels the forward end of the cradle is held by an iron becket into which a 1-ton differential chain purchase is hooked.

293. Recovering torpedoes.—Special care should be given to the equipment and instruction of crews of boats employed in recovering torpedoes. The equipment should include sufficient buoys with anchors, nose and tail lines, signal flags, propeller locks, etc. The instructions should include method of going alongside torpedo, necessity for getting nose and tail lines on quickly, necessity for keeping boat's propeller clear of torpedo, point and manner of delivery alongside, and signals to be employed. The men of the firing vessel should be thoroughly instructed in the details of hoisting out the torpedo and striking it below.

294. To load and fire a torpedo submerged.—In order to put the torch pot into the exercise head, the torpedo must be pulled nearly clear of the tube. After the torch pot has been inserted and cutter screwed on, the torpedo may be pushed back into the tube until only the immersion chamber and afterbody are out. In this position the torpedo is charged and the adjustments made; the cap is, of course, closed at this time. When ready, ram the torpedo home, one man holding the tube-tripping latch up so that it will not catch on the guide stud. When the latter brings up against the stop the torpedo is home and seated. In order to be assured that the stop will lift readily when the torpedo is fired, the whole torpedo should be pulled to the rear about one-eighth of an inch. Next try out the impulse valve to see that it lifts. Then take off propeller lock and close the tube door. There are several schemes for flooding the tubes. Some officers obtain the trim of the vessel, then pump the tubes full from the water in the forward trimming tank. This is considered the best way where there is time and water enough in the forward trimming tank to fill the tubes, as it causes very little change in the weight and trim of the vessel. Other officers prefer to flood the tubes which are not to fire, trim down, leaving a deficiency of about 500 pounds in the forward trimming tank. When the run toward the target is nearly completed, open to cap and flood the tube to be fired. If accurately done this is a very good method, but there is always a chance of an error being made in the proper estimate of the trim, and when this occurs there is difficulty in handling the vessel. Some other officers flood all tubes at the beginning of the run and obtain a perfect trim at the start. If the torpedo is absolutely tight this method is excellent, but the torpedo being in the water for perhaps as much as half an hour, there is always a chance that it will leak. Just before time to fire put a pressure of from 75 to 90 pounds per square inch in impulse tank and see that the hundred-pound tank to which the firing line connects has 100 pounds pressure in it. In the D and later classes the stop bar lifts automatically from the guide stud, but in the C class and earlier vessels the stop bar has to be lifted by either a pedal or a hand lever just before firing.

295. Care of torpedoes.—Owing to the very limited space for handling torpedoes in a submarine, they are necessarily subjected to much more severe usage than in other vessels and therefore need more care in order to obtain the best results. In times of peace only half the full complement of torpedoes is carried and these are stowed in the tubes. The tubes are always more or less damp and torpedoes must be hauled out, wiped off, and oiled once a week, and before firing must be completely broken down and reassembled in perfect condition. After this final overhaul a torpedo should not be put in water until ready to fire. As it is necessary to flood all tubes in order to open the cap and fire any one tube, tubes that are not to be fired should be empty. A submarine making an attack on a battleship or fleet of battleships would have all her tubes loaded with torpedoes ready to fire and would have the remainder of her torpedoes ready to load into the tubes when the first were fired. This operation should not take long and would be accomplished as follows: Close the cap, blow the water out of the tubes fired, open the doors of these tubes, and load the torpedoes.

When in a navy yard for a considerable stay, the torpedoes should be stored in a building and, before leaving the yard, given a thorough overhauling and test.

296. Care of gyros.—The interior of a submarine is more or less damp at all times, due to sweat, and special care must be taken of the gyros to prevent rusting of bearings. The following methods have been used with good results:

(*a*) Fit either a locker or a tight box with felt-covered pedestals for the gyros and a socket for a 5-candlepower lamp. When the gyros are in place, turn on the light and leave the door or cover open slightly for an hour or two, until the air in the locker or box is dried, then close the cover and the gyros will be kept dry.

(*b*) A copper tank is made and fitted with pedestals for gyros and then filled with sperm oil, in which the gyros are kept completely immersed. Before using, the oil must be blown off the gyros with dry compressed air. Twice a year the gyros should be completely disassembled and all bearings cleaned, those in poor condition renewed, and all given a light oiling of watch oil. Before beginning torpedo work the gyros should be adjusted in the stand. If opportunity offers, it is desirable to check the adjustment by running the torpedoes over a range. A steady platform for adjusting in the stand may be obtained quickly by submerging to the bottom.

297. Tests.—The firing valves and tube mechanism should be tested frequently, and always before firing, and should be thoroughly overhauled while at a navy yard.

CHAPTER 12.

NOTES ON TARGET PRACTICE.

298. Preparations for target practice.—Target practice is a test of previous training and preparation for battle, and when the time for practice arrives it is too late to correct neglected features. If the training and preparations have been thorough, everything should run smoothly and all casualties that occur will be handled without confusion.

299. Suggestions for target practice.—Following are certain suggestions for target practice—some apply to elementary and others to battle practices, some to turret and others to broadside guns.

(a) MISCELLANEOUS.

1. A smart performance is generally a good performance. Loss of time and a carelessness with details incidental to the practice militate against interest in the exercise and a satisfactory result thereof.

2. Arrange and publish a complete sequence of the practice. See that safety precautions, rules, and the orders for the practice are understood by all concerned.

3. Be sure that pointers understand the theory of and practical necessity for laying pieces accurately.

4. Take precautions to prevent noise and crowding in neighborhood of guns; rope off space if necessary.

5. Sweep up decks about breech of guns.

6. Paint a circle around broadside guns at a distance from breech about 6 inches greater than the recoil as a guide to the crew.

7. Be prepared for any casualties that may occur.

8. Designate and man substitute guns for each run.

9. Arrange to care for observers and umpires that visit ship.

(b) RANGE, TARGETS, ETC.

1. Measure and check size of target screens.

2. Give full instructions to repair party.

3. Arrange system of signals with repair boat.

4. Provide ample spare target gear.

5. See target screens correctly set.

6. Check speed and course of target.

7. In coming on range be sure that ship has attained standard speed and is steady on course before the firing point is reached.

(c) FIRING CONNECTIONS.

1. Thoroughly test all connections. See that every connection in the circuit is clean and secure and thoroughly tape them all. Use ether or alcohol in cleaning connections.

2. Overhaul firing keys. (Instead of using a transfer switch many officers prefer to use the pistol grip on the motor generator circuit and a push button secured to the side of the pistol grip in the battery circuit.)

3. Overhaul, clean, and oil the lock. Use oil sparingly around firing pin and on face of wedge.

4. Clean and examine firing pin, and vulcanite bushings in electric firing locks.

5. Examine all wiring and insulation in firing circuits.

6. See that circuit will not be fouled or damaged by the recoil of the gun. If necessary trice up bight of wire by moderately strong spring to some point above gun.

7. Test firing circuits with volt and ammeter and finally with primers.

8. A missfire should not occur, but anticipate and be prepared for such a contingency.

(d) AMMUNITION.

1. Clean, brighten, and test all primers.

2. Clean all shell and cartridge cases.

3. Examine powder bags and repair any that may be damaged. (Place paper in chamber of gun and then try a powder charge to be sure that the index to be used is in all respects satisfactory. See lacing is tight. **Be sure that this charge is fired on the practice.)**

4. Weigh shell and paint noses as directed; wet paint is slippery and may give trouble to and worry shellmen and rammermen.

5. Watch magazine temperatures carefully and have all powder temperatures the same when firing takes place. Have regard for powder temperatures if ammunltion is to be left long on deck.

6. Test fixed ammunition by trying each cartridge in gun, first removing firing pin.

7. Examine carefully for sunken primers (fixed ammunition).

8. Be sure that charges will be loaded with ignition ends to the rear.

9. See shell well seated and secure in cases (fixed ammunition).

10. See that shell bands are not burned and arrange to have shell uniformly and well seated in gun (separate ammunition).

11. Lay out shell and charges in a way most convenient for loaders.

(e) MOUNT AND GUN.

1. Eliminate lost motion and see mount in perfect working condition.

2. See screw box free of burrs.

3. Overhaul and adjust gas check pad.

4. Overhaul, clean, and oil the plug, and all features of the plug operating mechanism.

5. See primer vent clean and primer seat clean and free of grit or dirt.

6. Set up friction cones in training gear.

7. See electric-controller fingers smooth, and give same a light coating of vaseline.

8. Examine gas-expelling devices, blow through to get water and any possible dirt out of system, and see nozzles clear.

9. Examine and be sure that every nut, bolt, gland, etc., about the mount is in place and properly adjusted.

10. Fill the recoil cylinders and see filling plugs in and well set down.

(f) SIGHTS.

1. Be sure that guns are correctly boresighted and that there is no parallax in telescopes, or parallax in the boresighting telescopes when the sight adjustment is made.

2. Be sure that sight scales are properly illuminated.

3. Be sure that sight setting will be accurately and expeditiously accomplished.

4. See strips properly secure and be sure that proper strip is in place for the charge and type of shell that are employed. Be prepared to wipe off sight lenses.

5. See that all clamps, etc., are secure. Set up taut before boresighting, and don't touch again before firing.

6. Have ray filters provided and ready for use.

7. When at navy yard test sights for parallelism, drift, deflection, and adjustment with the guns, using battens, and eliminate lost motion.

(g) FIRE CONTROL.

1. Arrange a definite plan for fire control, including firing of ranging shots, and salvos, and for individual turret control.

2. Prepare and check the necessary range data, ballistic and spotting corrections, carefully.

3. Test all fire-control circuits, telephones, etc.

4. Be sure that there will be no possibility of a correction failing to reach or to appear on the sight of a firing gun before the firing takes place.

5. Adjust range finders.

6. If trial shots are allowed, get all data possible, including record of ability of turret officers to spot through periscopes.

7. See that suitable arrangements are made for spotter, searchlight-control men, those stationed to give salvo signals, etc.

8. Be assured that point of aim is understood by all pointers.

300. Frequent causes of poor scores.—Reports show that scores are most frequently reduced by the following causes:

(*a*) Slow and inaccurate sight setting.

(*b*) Slow and uncertain communication of the spotter's observations to the firing gun.

(*c*) Too much spotting. With a correct rate of change of range after the spotter has brought the shots on the target they should automatically stay there. There should be no necessity for spotting other than the first shot of a string.

(*d*) Poor spotting.

Immediately after practice check up sights, and search out the reason for any failure of material or unsatisfactory performance.

CHAPTER 13.

ALIGNMENT OF SIGHTS AND BORE SIGHTING.

301. Alignment of sights—Necessity for correct alignment.—Sights should always be in perfect alignment with the gun; that is, the axis of collimation of the telescope should, when set at O and bore sighted at infinity, be parallel to the longitudinal axis of the gun at all positions of elevation and depression. In order to obtain such perfect alignment a high degree of excellence of sight installation is necessary and this alignment must be checked from time to time and adjustments must be made as required. The installation and alignment of sights requires expert mechanical workmanship and a thorough knowledge of the sight installation and it is not considered advisable to attempt to realign sights, which are out of adjustment, except in case of absolute necessity, with the means available aboard ship. However, battery officers should know how to check the sight adjustments so as to be able to locate the source of any improper alignment and the resulting effects. Apparently inaccurate shooting, inconsistent dispersion, and other faults, sometimes attributed to poor gun pointing, may be caused by improper alignment of sights and by inaccurate bore sighting. If the sights are out of line, bore sighting will not correct the difficulty and with such the case, it is impossible to bore sight with accuracy.

302. Causes of error.—Any of the following causes may affect sight alignment:

(*a*) Roller path not level.

(*b*) Guns not properly adjusted on the knife edges, so that the trunnion axis is not parallel to the plane of the roller path.

(*c*) Rigid parts of sight mount may be improperly installed.

(*d*) Working parts of sight may be badly worn causing lost motion in some places and binding in others.

The battery officer is not concerned with (*a*) for that is a defect which can not be readily ascertained, nor can it be easily corrected. Naturally, the amount of error depends upon the angle of inclination of the roller path, but whatever this angle may be, the sight alignment will be affected but little, if the trunnion axis is parallel to the roller path plane at any point in train. With guns independently pointed the error due to (*a*) can be neglected.

303. Checking broadside sights.—For checking broadside sights the ship must be placed in dry-dock. If yoke sights are once properly installed, and are cared for, improper alignment will result from only the natural wear of working parts, and this cause of error will be very slight.

304. Checking turret sights.—The following procedures are recommended for checking the alignment of turret sights. (See Ordnance Pamphlet No. 18 of September, 1907—Notes on installation and tests of turrets, guns, and sights.)

305. Distant object method.—This method can be conveniently accomplished in dry dock as follows: Adjust both gun-sight telescope and bore sight on a distant object. Elevate the sight to extreme range (without touching deflection) and then elevate the gun until the horizontal wire of the sight is again on the object observed. If the sight is in correct adjustment the vertical wire will also be on the object. If this is not the case, move in deflection until it is on and note the amount of knots error. By referring to the range tables the angular error can be obtained. If the error is one-half a knot or less it may be considered as satisfactory.

306. Batten method—(*a*) Train and secure turret.—The turret should be trained to its securing position either forward or aft where it can be secured for several days while the sights are being checked.

(*b*) **Erect battens.**—Procure five good pine boards 1 inch or 1¼ inches thick and 14 to 16 feet long, planed on one side. Erect these boards as far away from the sights as necessary for clear focus, with the smooth side of the boards facing the turret. The five boards must be parallel and in the same plane so that the axis of each telescope and gun prolonged will intersect the center of the board facing it. The boards must be well braced so that the completed structure will be absolutely rigid. Extreme care must be taken to insure that the face of the batten boards is parallel to the muzzles of the guns when they are level—in other words, parallel to a vertical plane passed through the axis of the trunnions. A step-ladder must be made so that work can be done on the structure without mounting the battens, for to do so will cause the structure to change its shape and cause error.

(*c*) **Adjustment of knife edges.**—Drawings in the possession of the gunnery officer show the amount of necessary clearance around the trunnions when the guns are on their knife edges, and the knife edges must be adjusted to this clearance. The trunnion should be just lifted off its seat and most of the clearance should be left on the upper side of the trunnion. Some mounts are fitted with micrometer gauges to measure this clearance, but with others it will be necessary to use feelers. Before adjusting trunnion bearings the guns should be approximately level.

(*d*) **Level guns.**—The guns must be laid accurately level. To do this, place the quadrant level on the gun or on the yoke in rear of the slide. Use hand elevating gear.

(*e*) **Set range strips.**—See that all range strips and deflection drums are tightly secured and set all sights accurately at zero range and deflection.

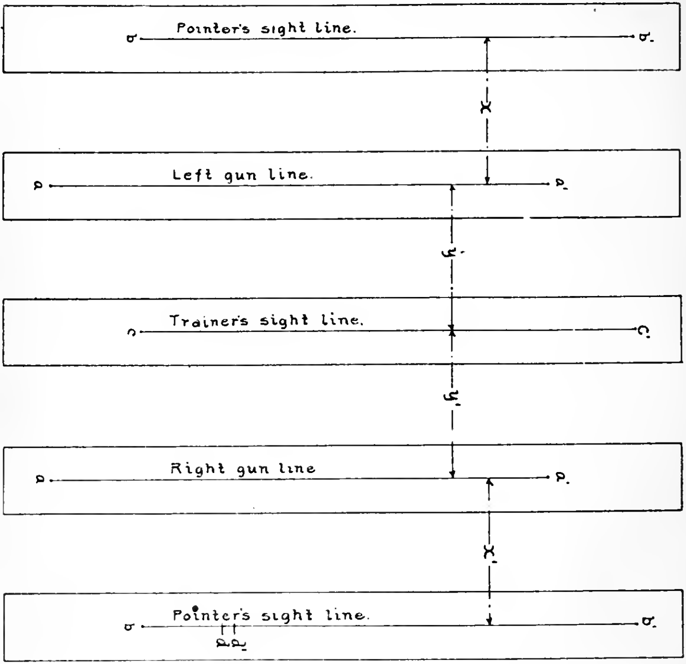
(*f*) **Adjust telescope.**—Telescopes must be clean, free from parallax, and well secured in their holders and focussed.

Cross wires must be exactly in place so that the vertical wire is actually vertical.

(*g*) **Adjust bore sights.**—Put in the bore-sight telescopes and have them well secured. As the bore sights will be in place for some time, it is advisable to entirely remove the breech plug, rather than to lash it back on account of the sustained weight of the plug on the hinge pin, which may affect the alignment of the rotating and swinging mechanism. Focus the bore-sight telescope on the batten boards after removing parallax. Put muzzle disks in place and adjust cross wires of bore-sight telescopes so as to split the central hole of the disk. Remove muzzle disks.

(*h*) **Spot points on battens.**—With guns level and using the bore-sight telescopes, spot points on batten boards and through these points stretch a small strong waxed line horizontally as shown on Figure I. Likewise with pointer's and trainer's telescopes spot points *a*, *b*, and *c*, respectively, Figure I. Through these points *a*, *b*, and *c* erect perpendiculars, using using strong waxed cord. These lines should be parallel and the distance x should be equal to x', and y should be equal to y'. Now if there be no turret structural defect and the guns are properly adjusted on the knife edges, they should elevate in the vertical plane and the vertical wire of the bore-sight telescopes should split the lines $a\ a'$. Likewise if the sights are in perfect alignment with the guns, the vertical wire of the telescopes should split the lines $b\ b'$ and $c\ c'$ at all degrees of elevation.

(*i*) **Settling of deck lugs.**—With a ship that has been in commission for some time and has been through numerous target practices, there is a certain inevitable settling of the deck lugs and turret structure. Though the guns may be properly adjusted on their knife edges, they may not elevate exactly in the vertical plane. After erecting the lines as mentioned above, elevate the guns, having an observer stationed at the bore sight; the displacement will at once be seen. After ascertaining that this condition exists, lay the guns level and again spot the points a, b, and c. Elevate the guns to a point near the top of the batten boards and spot



the points a', b', and c'; through $a\ a'$, $b\ b'$, and $c\ c'$ stretch tight lines and proceed with the checking of the alignment of the sights.

(j) **Check results.**—The guns should be elevated and depressed several times while the bore sight and sight telescope are checked over the lines to insure that they are correctly drawn. Measure the distance between each gun's gun line and sight lines. On the battens this should be the same at top and bottom; if not, sights are not aligned with guns.

307. Lag in range.—To test for lag in range, due to binding and springing of parts and to lost motion, set the sights accurately at any range, say 5,000 yards, and spot a mark on the batten board as shown at *d*. Run the sight up to extreme range and back to 5,000 yards and see if the cross wires split the mark *d*; if there is lag, a new point *d'* will be found. Run the sights down to zero and back to 5,000 yards as a further test. (See art. 305.)

308. Tabulation of results.—The following information is thus ascertained when checking sight alignment and should be carefully tabulated and recorded:

(*a*) Convergence or divergence of guns.

(*b*) Perpendicularity of plane of elevation of guns.

(*c*) Sight alignment.

(*d*) Lag of sights in range.

309. Parallelism.—Tram breech and muzzle at level and at elevation of 5° to ascertain the parallelism of the guns. It may be noted that exact parallelism is not essential, though desirable. A convergence or slight divergence at high ranges will not produce inaccurate results. It may not be possible to bring the guns exactly parallel or to any required degree of convergence, by trunnion bearing adjustment. This can be accomplished to a small extent, however, and once accomplished the adjustment should never be changed without immediately realigning the sights.

310. Adjustment to be made by yard force.—Sight alignment should not be attempted by the ship's force. The results of checking should be carefully recorded and forwarded to the Bureau of Ordnance for action, with a request that proper adjustments be made, if such appear necessary.

NOTES ON BORE SIGHTING.

311. Definition.—Bore sighting is the adjusting of gun sights, when the sight bar is set for zero range and the azimuth head for zero deflection, so that the lines of sight of the pointing telescopes will intersect the geometrical axis of the bore produced at the mean range at which it is expected to fire. Guns that are correctly bore sighted for ranges of 10,000 yards are, for the purposes of battle, bore sighted for battle ranges.

312. Why necessary.—It is necessary because the line of sight does not coincide with the axis of the bore of a gun.

313. Errors due to sights not being in horizontal plane with axis of bore.—First, consider the error due to the sights being elevated above the axis of the bore, Figures II(*a*) and III(*a*). It will be noticed that when the bore is centered upon a point Y at the target the lines of sight of the pointing telescopes will intersect the target in a horizontal plane through the point X, a distance X-Y above Y, equal to the amount that the center line of the telescopes are above the center line of the bore.

If the distance from the gun to the target is, for example 2,500 yards, the sight bar is set for 2,500 yards, and the gun

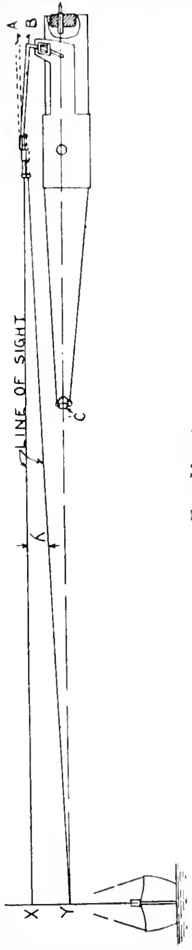


Fig. II (*a*).

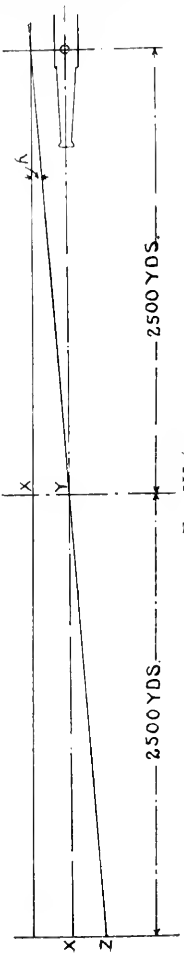


Fig. III (*a*).

elevated so that the horizontal wires of the pointing telescopes are on the horizontal line through X, a shot would hit the target at Y, not X.

However, if the gun is centered on the point Y and the sight bar raised or lowered until the wires of the telescopes are on the horizontal line through Y, the lines of sight will have been depressed through an angle λ, and the sight bar raised through an arc A–B. If the sight strip is now loosened and slid down until the zero graduation is in line with the pointer on the sight-bar bracket, without moving the sight bar itself, a shot fired under the same conditions as above would pierce the target at the same point at which the wires of the pointing telescope rested.

Without altering any of the above adjustments or conditions, except lowering the sight bar to read zero and moving the target out on its same bearing until 5,000 yards from the gun, center the bore of the gun upon the horizontal line through Y, and it will be found that the horizontal wires of the telescopes will lay upon a horizontal line through Z, a distance X–Y below Y, showing that an exact coincidence of the horizontal wires and the center of the hole made by the shot can only be possible when the gun is fired at the exact range at which the sights have been adjusted.

This angular error in the vertical plane we find to be greatest with turret parallel motion sights and least with the broadside periscopic sight mounts and the periscopic sights for turrets which are attached to the trunnions of the guns.

314. Errors due to sights not being in vertical plane of axis of bore.—Sighting errors due to the lines of sight of the pointing and training telescopes not being in the same vertical plane as the axis of the bore is shown in Figures II (*b*) and III (*b*).

In sight mounts which contain both the elevating and training telescopes the sighting error is the same for both telescopes, assuming that the lines of sight are parallel to the

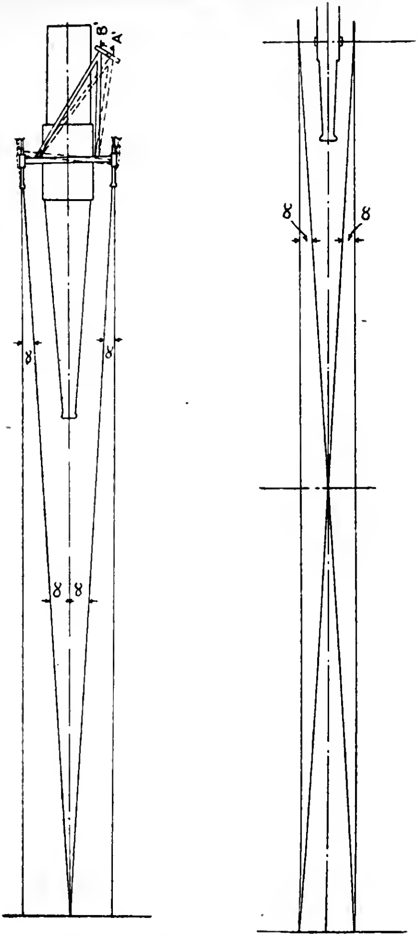


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FIG. II (b).

bore. Therefore, in order that the lines of sight be made to lay in the same vertical plane at the target as does the geometrical axis of the bore produced, it will be necessary to swing each telescope through a small horizontal angle *a*.

315. Uniform conditions when bore sighting.—Heat affects the droop of guns to some extent, and the atmospheric conditions vary at different times during the day. All guns of a battery should be bore sighted under similar conditions of temperature, light, etc., hence at as nearly as possible the same time of the day.

316. Turret trainer's sights.—In turret sight mounts where the training telescope is not connected with the elevating telescope, it is impossible to have the line of sight of the training telescope lie in the same vertical plane at the target as does the elevating telescopes, except where the target is at such a great distance that the axis of the bore and the lines of sight, if all parallel to one another, appear to meet and the horizontal angles through which the telescope should be swung are so small that the azimuth heads can not be moved a sufficiently small amount to correct them.

If the target is to be at a short range, say 2,500 yards, and the turret sights are to be adjusted in azimuth, the sights may be adjusted to suit conditions as follows:

Make each elevating pointer's telescopic line of sight intersect the geometrical axis of the bore of its gun at the target for zero setting of the range and deflection scales, as shown in Figures IV (*a*) and (*b*). Then have the line of sight of the training telescope intersect the plane of the target midway between C and D. It would be necessary for the training pointer to have a point of aim to the right of the bull's-eye for the left gun, and to the left of the bull's-eye for the right gun, if guns are fired independently and the target is not of sufficient length to allow for the distance between the guns.

317. Preparation of bore sights.—The ship being at anchor, where there is no motion, anchors a raft or boat parallel to its own heading, and in it erects a screen, preferably white with black horizontal and vertical lines. This screen should be spread as taut as possible, so that the top and side edges will be as nearly horizontal and vertical, respectively, as can be.

If circumstances do not permit using a boat, then some prominent object, either ashore or afloat and at the required distance, may be utilized. Bore sighting at night may be accomplished by using a searchlight to illuminate the target if the range is not too great.

If the telescopes have been removed, before returning them carefully wipe the telescope holders to remove all grit from the bearing surfaces.

In setting up the securing nuts on the holders, set up gradually upon each one in succession. Never set one screw or bolt of a bearing up taut and all the way home independently of the others. In setting up, never use any wrench other than the one supplied with the sight for this purpose, as the jaws of this wrench will give before the threads on the nuts will strip.

After the telescope is in place the sight bar and the deflection drum are moved through a complete throw to insure there being no freezing of parts.

The breech plug is lashed back to prevent its accidently being closed against the telescope in the breech disk. (This is mandatory.)

The breech disk is fastened or screwed into the breech, and the bore-sight telescope secured in place, all parallax being removed. This telescope is focused after it has been screwed and clamped in place. When in focus the hole in the muzzle disk will appear blurred. The muzzle disk (*c'*) Figure II (*a*) has a hole about one-sixteenth of an inch in diameter in its center. Only the central hole should be used for centering the bore-sight telescope, the other four holes in the muzzle disk are for lighting purposes only. Before bore sighting, the

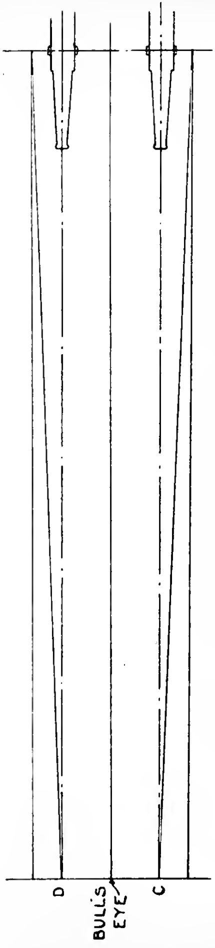


FIG. IV (*a*).—Lines of sight of elevating telescopes intersecting axis of bores at the target with line of sight of training telescope midway between.

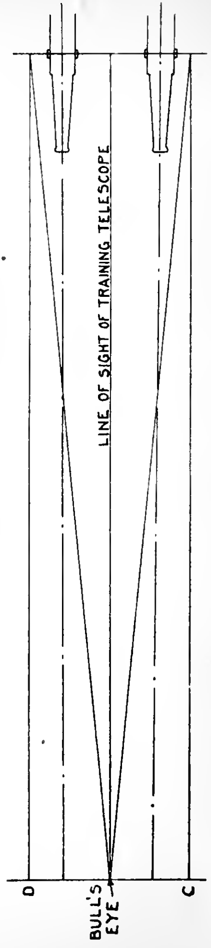


FIG. IV (*b*).—Lines of sight of both elevating telescopes and that of training telescope, all intersecting midway between intersections of axis of bores on plane of target.

horizontal wire of all telescopes should be adjusted on the horizon or any distant level object. In order to prevent injury or loss in centering it, a lanyard should be made fast to the disk and the end passed in on deck or properly secured.

To adjust the breech telescope, there are four adjusting screws on the holder for the telescope so that by coming up on one and setting up on the one diametrically opposite, the telescope may be moved about until the intersection of the cross wires appears in the small hole in the center of the muzzle disk.

These adjusting screws must not be set up so hard as to strain or distort the telescope, and only sufficiently to hold the telescope properly in place. In looking through the bore-sight telescope, care must be taken not to disturb the adjustment by touching it with the hand, cap visor, or forehead.

In case there is not sufficient light to see the cross wires of the breech telescope when the muzzle disk is in, a small portable may be held near the muzzle.

The muzzle disk is rotated through 180° as a check as to whether or not the intersection of the cross wires is centered. If it is found not to be, the fault is probably due to the muzzle disk not having been placed squarely in the muzzle.

318. Information in regard to the bore-sight telescope.— On pages 4 and 5 illustrated by plate 2 of Ordnance pamphlet No. 345 are a few words regarding the bore-sight telescope. On pages 7, 8, 9, 10, and 11 are some general notes on the care and handling and cleaning of telescopes which apply to a certain extent to the bore-sight telescopes. There are two sources of error in bore-sight telescopes which, it is believed, are very frequent, and are caused by disassembling the telescopes for cleaning. One of these errors is due to the fact that after cleaning the cross-line diaphragm and replacing it, it is not returned to its correct position, resulting in a parallax, which causes an increasing error depending upon the distance of the cross-line diaphragm from the focal or image plane of the objective. All telescopes, if disassembled for cleaning, upon reassembling should be tested for this error by accurately focusing the telescope upon a distant object and moving the cross lines back and forth until no parallax remains. This, of course, will have to be done before the breech piece socket (57) and the outside adjusting tube (69) are replaced on the telescope.

The second error is caused by the fact that in reassembling, the cross-line intersection is not accurately placed in the line of collimation of the telescope. To overcome this error, after the parallax has been eliminated as indicated above, the telescope should be placed in Y bearings and rotated. A turned surface is provided near the two ends of the telescope tube for this purpose. The telescope should be sighted upon a distant object, and it will be found that when the telescope is rotated in the Y's that the cross lines will shift upon the distant object. The cross lines should be accurately centered by means of the four cross-line adjusting screws (27) until the cross-line intersection does not shift upon the target when the telescope itself is rotated. In many cases it will be seen that the whole field of view moves up and down and from side to side as the telescope is rotated, but this is immaterial; the whole point to be gained is so to adjust the cross lines that the intersection itself remains steadily upon the same distant spot through a rotation of the telescope of 360°.

When bore sighting on battens or at short distances there will be parallax in all bore sights. This can be best minimized by placing over the eye lens of the telescope a paper disk with a very small hole in the exact center. This centers the eye at one spot and eliminates the greater part of the error which would be caused by the parallax.

All telescopes when received aboard ship are supposed to have been accurately adjusted and the two sources of error pointed out above are eliminated. Their adjustments should, however, be checked. It has been found that, owing to disassembling for cleaning purposes or other causes aboard ship, all telescopes returned to the gun factory for overhaul and repair or sent to the fleet repair ship for repairs have been out of adjustment, due to one or both of the above-described causes. The obvious remedy is that these telescopes should not be disassembled for cleaning purposes aboard ship. If necessary to have them overhauled, they should be sent to the repair ship for cleaning and adjustment.

A new bore-sight telescope now in contemplation is so designed that the bad features of the present bore-sight telescope will be eliminated. It is expected that this new bore-sight telescope will be furnished to all ships now under construction, and that it will, in time, replace the bore-sight telescopes now in use aboard ships in commission.

319. Inverting bore-sight telescope.—With the present design of bore-sight telescope, it is not practicable to invert the cross wires (turn them through 180°) in order to check for error, as it necessitates a loosening of the parts of the telescope, thus destroying adjustments already made. A new bore-sight telescope has been designed, but not yet adopted, which provides for inverting the cross wires in order to check the setting. At present it is necessary to invert the muzzle disk as a check on the centering of the bore-sight telescope as described in article 317.

320. Method of bore sighting.—Three persons, generally the division officer and two junior officers, do the work, at the same time utilizing the pointers to verify the results. (It is always well to have the pointers check the bore sighting of their gun, for then they can not attribute erratic shooting to poor bore sighting.)

Frequently ships have a regular "bore-sighting board" composed of the gunnery officer and two division officers. This board makes a final check of all guns that have been bore sighted. The value of this scheme is readily seen.

In making the adjustments, one officer is stationed at the breech telescope, one at the elevating telescope, and the other at the training telescope.

It must be remembered that with yoke sights, a movement of the pivot bar moves both telescopes so that it is necessary to have an independent means of adjusting one of them. This adjustment is accomplished by two tangent screws with clamp bolts, placed under the holder of the training telescope. The pointing (elevating) telescope is adjusted by the sight bar and azimuth head.

It is necessary to make the first adjustment on the elevating telescope and then the training telescopic adjustment. Either the horizontal or the vertical wires of telescopes may be adjusted first.

For example, the officer at the breech coaches in elevation and train until his horizontal wire rests upon, say, the top edge of the target when he calls out "Mark! Mark! ----" so long as the horizontal wire of the breech telescope remains in that position. The man at the elevating telescope notes how much his horizontal wire is off, and by moving the sight bar brings this wire "on" to coincide with that of the breech telescope. In the meantime the observer at the training telescope notes how much his horizontal wire is off and after the elevating pointer has made his adjustment the trainer brings his "on" by means of the tangent screw under the telescope holder, so that when it is adjusted all three horizontal wires will be "on" at the same time.

The three observers change places and check.

The same procedure is carried out for the adjustment of the vertical wires. The man at the breech coaches the trainer, calling out "Mark! Mark!" so long as the vertical wire of the bore-sight telescope remains "on." The elevating pointer notes how much the vertical wire of the elevating pointer's telescope is "off" when that of the breech telescope is "on" and by moving the azimuth head brings it "on." In so doing he necessarily moves the vertical wire of the training telescope through the same angle, so that the man at the training telescope will have to wait to make his adjustment until after the elevating telescope is adjusted.

The trainer makes this adjustment by using the tangent screw at the side of the training telescope holder and secures the holder with the clamp bolt. All observers change places and check results.

In bore sighting broadside guns that are equipped with heavy periscopic telescopes that are seldom removed from the holders there are no tangent screws on the holders for separate adjustment of the trainer's sight, and in lieu thereof the cross wires of the telescopes can be independently adjusted by moving them in their vertical plane. The cross wires may also be rotated around their intersection as a center so as to make them absolutely vertical and horizontal. Each wire may also independently be moved at right angles to the line of sight without moving the other.

In guns equipped with this type of telescope the elevating pointer's wires are brought "on" as with other types (although this can be done by moving the cross wires), but the training pointer must be brought "on" by moving the cross wires of the training telescope.

321. Adjustment of the sight scales.—Without moving the sight bar or azimuth head, the clamp screw, securing the range strip to the sight bar, is loosened and the range strip moved up or down until its zero graduation is opposite the reference mark on the sight-bar bracket. The clamp screw is then set up and the range strip secured.

The dial of the multiplying range scale is then removed, cleansed of all oil, and the holder and back of strip washed off with lye water. This is to prevent the dial from turning in the holder when the gun is fired. As an extra precaution against turning, a piece of emery paper may be cut to shape and placed between the dial and the holder. Some sights are so constructed that instead of moving the dial the zero mark on the holder may be adjusted.

The friction clutch on the azimuth drum is loosened, and the drum rotated until the "50" mark is under the pointer on the azimuth head when it is then secured. In some sights the pointer may be moved by tangent screws to its position over the zero mark on the drum.

The muzzle disk is now again placed in the muzzle so as to check up and make certain that the telescope in the breech disk has not been accidentally deranged during the bore sighting.

Very often the square marks on the reference pointers for both range and deflection scales are very dim. This may be remedied by rubbing a small quantity of white paint over the mark engraved upon the pointers, and then wiping off all except that which has settled into the engraving.

Before removing the bore-sight telescope, move the sight bar and azimuth head away from zero, then return to the zero readings again. Now observe whether or not the cross wires of all three telescopes intersect at the target. If they do not it is an indication of lost motion in the scales or binding of parts. This error should not be greater than 4 inches on a target 1,450 yards distant, in sights that have micrometer attachments, but it should be inappreciable in direct reading sights.

322. After bore sighting.—Remove breech telescope and breech disk and return them to proper custodian. Cover the pointing telescopes with flannel covers. (If circular pieces of blotting paper are inserted inside the dust caps it will be found that they aid greatly in preventing moisture collecting upon the object lenses.)

A sign, such as "*hands off*," or "*this gun has been bore sighted*," will prevent thoughtless men from tampering with the sights.

The peep sights carried alongside the telescope in holders should be bore sighted after adjusting the telescopes. This is accomplished in the same manner as for the telescopes, except that both the elevating and training sights are brought "on" by moving the cross wires in their respective holders.

323. Turret bore sighting.—The bore sighting of turret guns follows the general plan previously described for broadside guns. Before adjusting, the parallelogram of parallel-motion sights should always be carefully tested. This is done. first, by raising and lowering the sight bar and being assured that the sight mechanism is in proper working order, by placing the bore-sight telescope in the breech diaphragm, and then centering the bore upon a distant object. The sight of the elevating pointer is then brought on the same object by moving the pivot bar. The gun is then elevated to extreme elevation and again depressed, the observer at the breech telescope calling out "Mark! Mark!____" when the cross wires of the breech telescope are again "on," and the observer at the elevating telescope again notes the position of his wires. The gun is then run down to extreme depression and elevated until the cross wires of the breech telescope are again on the object. The position of the cross wires of the sight telescope is noted again when the observer at the breech calls "Mark! Mark!____." Each time that the observer at the breech is "on," the observer at the elevating telescope should be on. Errors will appear as follows:

When the gun is depressed from extreme elevation, the line of sight of the elevating telescope may be above that of the breech telescope, or when the gun is elevated from extreme depression the line of sight of the elevating telescope may be below that of the breech telescope. This may be due to the following:

Looseness in the bearings of the parallel motion.

Springing of either the pivot bar, connecting arm, or connecting bar, caused by tight bearings. (Be extremely careful to keep all oil holes clear and well supplied with oil.)

Shifting of the trunnions due to too great clearance.

Knowing the distance to the object sighted on, by measuring the discrepancies in the vertical plane, the angular amount of these discrepancies may be ascertained.

324. Importance of keeping clear of sight.—It is very important at all times, especially when bore sighting or shooting, that no one should lean against or exert any pressure on any part of the sight mechanism.

325. Checking sights after firing.—As soon as practicable after firing, the sights should be examined and any derangement, such as slipping of the range strips and dials, etc., together with causes, should be noted, and the fact, together with appropriate remarks, should be entered in the battery journal.

326. Droop as affecting bore sighting.—(See arts. 315, 459.) There is a diversity of opinion as to whether droop should be taken into consideration when bore sighting. If not, then our present method of bore sighting is correct. If it is considered as having an effect, then our method of bore sighting must be changed. Instead of placing a disk in the muzzle to bore sight it would have to be placed at or near the center of gravity, which would be little forward of the trunnions. This would insure a straight line through the gun, coincident with the longitudinal axis, through the rigid part; that is, from breech to center of gravity, but divergent from the c. g. to the muzzle by an amount equal to the droop. A new source of error would be introduced. In order to have a steady center disk, a long bearing surface is necessary, and since the disk must be inserted from the muzzle end, a slight clearance must be allowed. Erosion and wearing away of the rifling is greatest at the origin and decreases toward the muzzle. This would make a greater clearance when the disk reaches its position over the c. g. than at the muzzle, throwing the peep-hole off the center, by an amount which in many cases may exceed the amount of the droop. So far as known at present, droop should not be considered in bore sighting.

CHAPTER 14.

FIRE-CONTROL TELEPHONES.

327. Comparison between fire-control telephones and commercial or ship's service telephones.—The design of the fire-control telephone is necessarily special, due to the fact that it must be designed to meet practically the same conditions as the commercial telephone; and also, it must be capable of working in multiple with a number of other telephones. Precautions must therefore be taken to build a telephone which is capable of withstanding considerably larger currents than the commercial telephone, and which possesses such physical characteristics that rough usage and even exposure to the worst atmospheric conditions will not make the service bad or the telephone inoperative. With these conditions, it is manifestly impossible to attempt to develop an efficient fire-control telephone which will compare favorably in cost with the commercial telephone.

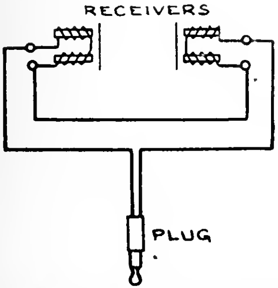
328. Types of fire-control telephones.—In order to meet all conditions, the department has approved several types of fire-control telephones, the type depending upon the use to which it may be put.

The Bureau of Steam Engineering, recognizing the weakness of a system in which a number of types are involved, has devoted a great deal of time to the development of a fire-control telephone which will eliminate the use of or the necessity for so many types. As a result of this work and exhaustive experiments, two new types have been decided upon in lieu of the numerous types previously used. It is the department's intention to supply all vessels in commission with the new type of telephone at an early date.

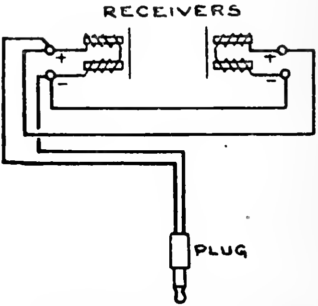
329. Types in use.—The principal types now in use are as follows:

(*a*) *Type C telephone* consists of the microphone receivers, connected in parallel. This telephone is used for sight setters at stations where receivers are not required.

(*b*) *Type CP telephone* consists of the microphone receivers, as used in the type C telephone, and a transmitter which is *in parallel* with the receivers. This telephone is used in a few places where one transmitter must communicate with a large number of receivers, such as substation transmitters to turret sight setters and chief fire-control officer's transmitter



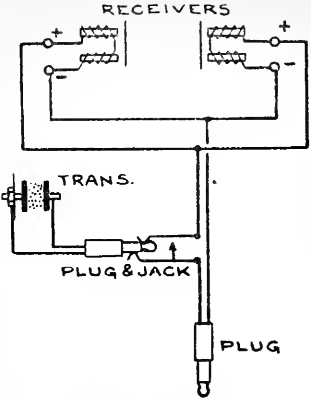
Latest type C telephone receivers series connected.



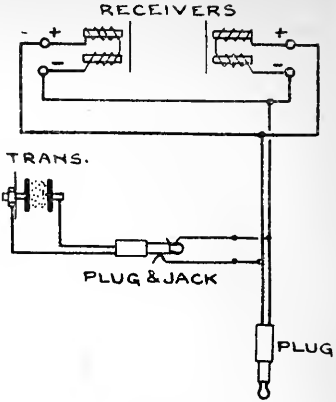
Original type C telephone receivers multiple connected.

to all turret officers' telephones. There are, therefore, fewer type CP telephones supplied than any other.

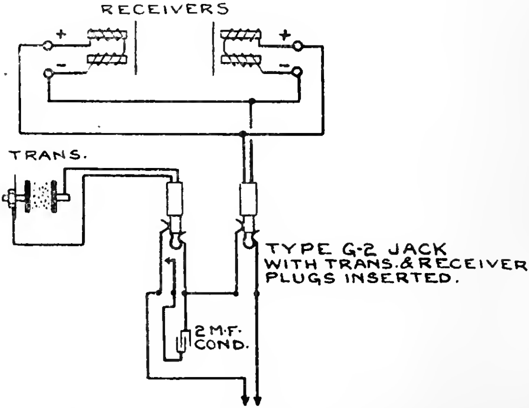
(*c*) *Type CS telephone* consists of the microphone receivers of the type C telephone, with the addition of a transmitter which is *in series* with the receivers. This telephone is used by sight setters, by the fire-control party, and generally in all receiving locations where the type CP telephone is not employed.



Type CP telephone.



Type CS telephone.



Type CT telephone.

(*d*) *Type CT* has the same characteristics as the type CS telephone, except that the transmitter and receiver plug separately into a type G-2 jack, which is of special construction, containing a 2-m. f. condenser. On account of the cost of the special jacks few of these telephones are in use.

Since two separate lines are necessary from the jack, the type is not considered entirely practical.

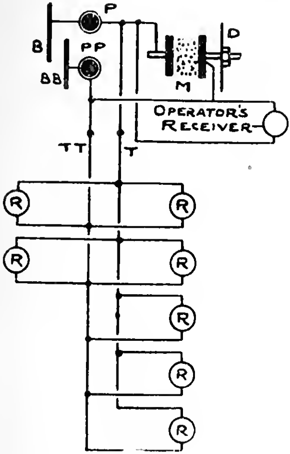


FIG A.

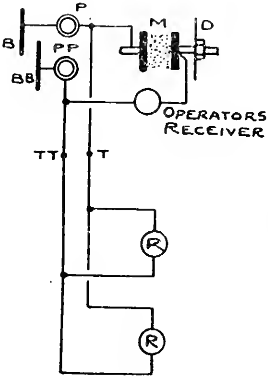


FIG. B.

330. Conditions governing use of different types of transmitters.—(*a*) From figure A, note that on a given line all receiving sets, since they are plugged *across* the lines, are in parallel. Therefore, the current which goes through lines T and TT at the point indicated is the sum of all the current required for each set of receivers, or the current of one set *times* the number of sets in use.

The source of *direct* current for this line is B and BB and through impedance coils P and PP. Similarly, the source of

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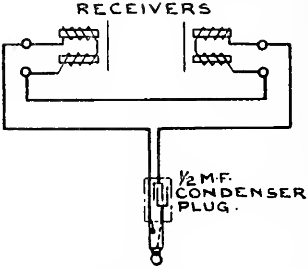
alternating or *talking* current for all the receivers is the transmitter M, which receives its impulses when sound waves strike the diaphragm D and cause it and the upper electrode (to which it is secured) to vibrate, thus varying rapidly the resistance in the small carbon particles and sending forth the impulses to the receivers. But if this transmitter were in series with its receiver (instead of in parallel), its total out-



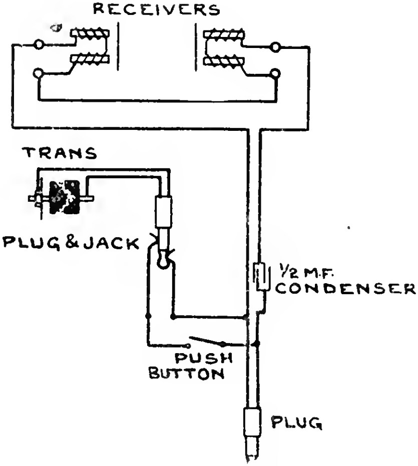
Type CC telephone.

put would be limited by the resistance of the receiving set; or the *talking energy* supplied for the whole line would really be only what is necessary for a small portion of it. Since a comparatively large amount of energy must be emitted from the receiver in this case, it is obvious that the parallel connection is the only practicable one.

(*b*) For the same reason, on lines having a few receivers, a series connection is used (fig. B). It would be satisfactory to use a parallel connection on these lines, except that larger currents than necessary would flow through the transmitter, and in this case there would be danger of heating. It is considered more satisfactory always to keep the current (direct) as small as possible. In a CS telephone, as shown on sketch, it is obvious that the amount of current flowing through the transmitter is limited by the higher resistance of the receiver coils.

331. New types.—All of the above-mentioned types are to be abandoned, and new types, as follows, furnished to all ships:

(*a*) *Type CC:* The type CC telephone is modeled after the present type C telephone, except that the plug is so designed as to have a ½-m. f. condenser installed as a part of it, and the



Type CN telephone.

receivers are *in series*. This will enable all type C telephones to be fitted at small expense with condensers, and will necessitate no change in the present equipment other than the use of the new plug in place of the old, and a slight modification in wiring up the head set.

(*b*) *Type CN:* The type CN telephone consists of receivers similar to receivers of the type CC telephone, in conjunction with a new design transmitter having *conical electrodes*, and also incorporating as an integral part of the set a ½-m. f. condenser, and a cut-out push button, which must be closed when talking. New mechanical features of design have also been incorporated in this telephone.

332. Care and operation.—(*a*) Test fire-control telephones daily.

(*b*) Use spare telephones frequently, as a certain amount of usage, in addition to checking their condition, makes them more efficient. The worst thing that can be done for the efficiency of the fire-control system is to lay the telephones up where they will not be used for a considerable period of time.

(*c*) Never carry a telephone by the cord, and grasp the top of the plug when unplugging. Telephones now in use have practically all the strain taken on the terminals, and these precautions must be taken to avoid pulling loose a connection, and thus rendering the telephone inoperative.

(*d*) Avoid bending the cord sharply over the edge of the terminal tube. This gradually breaks through the braid and insulation, in addition to straining the copper conductors, and a short circuit or open circuit results.

(*e*) When talking, keep transmitter in an approximately vertical position. If the transmitter is placed horizontally, transmission becomes very bad, since the upper electrode presses on the carbon particles; and, consequently, the vibrating impulses are dampened. In case the transmitter is inadvertently held horizontally, bring same back nearly vertical, and tap sharply a couple of times with the hand; normal operation should then be obtained.

(*f*) Often, when transmitters have been used for a considerable period of time, heating is noticed. This is due, probably, to the large number of receivers to which the transmitter is connected, and the best thing to do is to put in a new transmitter, and allow the heated one to cool off gradually.

(*g*) Receiver diaphragms sometimes become hot; and, as a result, the paraffin melts, collects in a drop, and the receiver is practically deadened. It is a matter of only a few minutes to remove the cause of the trouble; but, ordinarily, it is better to use a spare head set, and allow the heated receivers to cool off. The receiver diaphragm can be put in condition again with little trouble.

(*h*) Cross talk is caused most frequently by insufficient impedance; however, if everything is going along normally and cross talk is noticed, the voltage of the system should be investigated at once; the chances are that it is high. Frequently, when impedance coils have been in use for a long time, it will be found necessary to reduce the working voltage several volts in order to lessen cross talk.

333. Impedance coils.—The impedance coil is an inductive resistance coil, whose function is to promote the supply of direct current to the telephone, and to confine the variations of current caused by talking, which are alternating in character, to its own circuit. Thus, in preventing the leakage of these alternating impulses to other circuits, the impedance coil performs its function of preventing cross talk. All telephones, in any circuit, are in parallel; therefore, the more telephones there are connected, the more current is needed in a circuit to give each telephone its proper share. For this reason, 3-ohm coils are used where a large number of telephones are employed, and 10-ohm coils where a small number are employed.

Experiment has shown that 10-ohm impedance coils give good talking results with from 2 to 10 telephones, and that 3-ohm impedance coils give similar results with from 6 to 20 telephones.

334. Condensers.—A condenser is an electrical appliance so constituted that electromotive force applied to it stores up energy in the form of electrostatic stress, which latter starts this energy back in the form of current when the constraining electromotive force is removed.

In the case of fire-control telephones, where the inductance (impedance) and capacity (condensers) are in series, the talking efficiency is improved. In such a case the only current which goes through the telephone receivers is alternating in character, and is generated when the diaphragm of the transmitter receives its impulses from talking, and hence is necessarily very small. Under normal conditions therefore, no heating or other deleterious effects due to the flow of current will be obtained in receivers when these small condensers are used.

One-half m. f. condensers are used in series with the new fire-control receiving sets (types CC and CN).

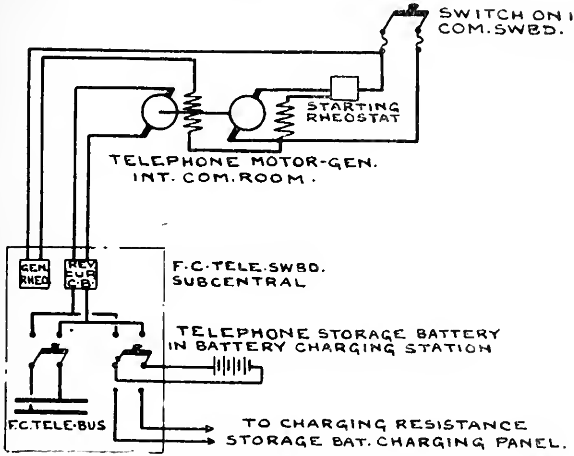
335. Source of energy.—On vessels up to and including the *Arkansas* and *Wyoming*, the fire-control telephone switch panel may be energized by either of two telephone motor generators. Later ships are supplied with one motor generator and a storage battery. The storage battery, like the motor generator, is arranged to supply the ship's service telephone system as well as the fire-control system. The battery is of sufficient capacity to supply current for telephones for a period of 30 days' continuous use.

The storage battery, consisting of an appropriate number of Edison cells, is so designed as to "float in" on the line. The battery should first be charged from ship's circuit to its normal potential, and then be thrown in across the motor generator lines with the telephone outlets. The motor generator leads are fitted with a reverse-current circuit breaker. If, for any reason, the motor generator is suddenly stopped, or should the voltage of the motor generator fall below the normal required, the battery, being *across* the line, will automatically take charge and supply the telephones, while the reverse-current circuit breaker will instantly open and thus prevent the battery being short circuited through the armature windings on the motor generator.

336. Specifications and telephone pamphlets.—More detailed information of fire-control and ship's-service telephones may be obtained from specifications and plans which are on file in the Bureau of Steam Engineering, copies of which may be obtained upon request, and from Bureau of Steam Engineering Pamphlet No. 1773. The following books are recommended:

American Telephone Practice, by Miller.

A B C of the Telephone, by Homans.



Arrangement of current supply for F. C. telephones.

CHAPTER 15.

RANGE FINDERS.

337. General.—Attention is called to Ordnance Pamphlet No. 357, which gives detailed descriptions of the various range finders in use. These instruments, like all other delicate appliances, require careful handling. Expertness and familiarity with the instrument depend on the amount of intelligent and zealous effort devoted to practice under service conditions by operators. The range-finder crews are most important members of the fire-control group. They should be carefully selected and schooled in their duties.

338. Care of range finders.—When not in use, and particularly during moist weather or hot sunlight, the range finders mounted in the open should be carefully protected by waterproof covers. Never expose instrument to intense heat or to rain where possible to avoid it. Never put a wet instrument into its box, or damp cloths and accessories in the box with it. The shutters over exposed lenses, and the hoods, in the case of instruments mounted in turrets and fire-control towers, should be kept closed. Stands should be rigidly secured to the deck. Working parts, such as base of cradle, rings, and rollers in cradle should be well lubricated. Only clean cloths (linen), clean chamois, or paper provided for the purpose should be used to wipe the lenses. Coverings of all openings should at all times be securely closed. Never expose the interior to open air except in dry weather, when it may be opened if necessary for a short time to dry out the instrument. No one except an expert should attempt to take the instrument apart, and force should always be avoided in dismounting or operating a range finder. Be extremely careful in handling the instrument, as it is very delicate and easily jarred out of adjustment. No one except a member of the range-finder party should operate, adjust, or handle the range finders used for fire-control purposes.

Notes on the Bausch & Lomb 3-Meter Base, Mark IV, Modification V, Range Finder.

(Although the following applies particularly to the above type, any Bausch & Lomb range finder may be operated by complying therewith.)

339. Operation of Bausch & Lomb range finders.—(1) Remove canvas cover.

(2) Wipe window glass with materials supplied.

(3) Open middle window slide on forward side of range finder.

(4) Put sunshades on end window glasses if ranges are to be taken toward the sun.

(5) Adjust instrument to height of observer as follows: Turn knob on cylindrical spindle case attached to tripod, one or two turns to the left, then turn large wheel under azimuth circle to the left until the eyepiece is at the proper height.

(6) Turn astigmatizer knob to "out position" if ranges are to be taken during daylight.

(7) Turn relief knobs to position marked "relieved position." If range finder is fitted with relief levers, turn them down.

(8) Unclamp range finder by turning knob on the right side of the mount to the left.

(9) Focus eyepiece so that object is perfectly clear and horizontal dividing line appears sharp.

(10) Turn change of magnification knob as desired between stops to the left for 28 magnifying power and to the right for

15 magnifying power. Use power which makes the object appear clearest.

(11) To take a range, stand with feet spread apart, 1 foot in advance of the other, chest firmly pressed against curved body rest. Place the forehead against the rubber face piece with the eye to the eyepiece. Grasp the altitude lever in the left hand, steadying it on the end of the curved body rest, right hand grasping the measuring knob. Swing the range finder in azimuth and move the altitude lever up or down until the object is seen in the center of the field, sharply cut by the dividing line.

(12) Turn measuring knob slowly and bring upper half of the image to coincide with the lower half, so that a perfect image is obtained.

(13) Read range from the inside and scale above the field, the range being indicated by a small white indicator below the scale.

(14) Check reading by outside scale.

(15) Observe the following rules:

(*a*) Always turn the measuring knob in the same direction, so that the upper half of the image will be brought into coincidence with the lower half from the same direction.

(*b*) Never allow upper half of image to pass by the coincidence and be brought back to it by turning the measuring knob in the opposite direction.

(16) After observing a range always throw the images out of coincidence before taking the next range.

(17) Never turn measuring knob hard against the stop in either direction.

(18) When range finder is not in use swing it to original position and clamp it. Turn relieving knobs to "clamped position" if necessary; lower instrument by turning large wheel to the right against a stop; clamp knob in cylindrical case attached to tripod; close window slide; remove sunshades, if used, and put on canvas cover.

(19) To take ranges of lights at night, turn the astigmatizer knob to the left to the "in" position.

(20) Use amber eyepiece if glare of sun is very bright or if range is being taken on a searchlight.

340. Organization of range-finder party.—The organization of a range-finder party should consist of the range-finder officer and such other officers (petty officers) and men as may be required for the operation of the instrument and the transmission of the ranges. Only men who have good eyesight should be eligible for duty. Men detailed for duty as range-finder operators should not be changed and should have the same permanence in their station as gun pointers.

341. Operation of range finders.—First develop accuracy in consecutive readings of fixed distances by taking a number of observations, recording each one carefully and honestly. An average of these gives mean and nearly the correct distance. The mean compared with each reading gives the variation from the mean distance, and the average of the variations gives the mean variation which is the measure of the operator's accuracy. The records of an operator should improve steadily. To guard against carelessness and to insure unprejudiced readings when training an operator, it is well to cover the scale from the view of the operator and have another operator read the results of each contact. Always move the scale the same way in making each contact. Always move the scale away from the contact after each reading. Work of this nature must be carried on both by day and by night; the astigmatizer must be used at the latter times. Always drill in conjunction with fire control when it is possible to do so. Several short drill periods per day are better than one long one. For a new operator two half-hour periods in the forenoon, two in the afternoon, and one in the evening are necessary. The expert operator should drill daily. After accuracy is obtained develop rapidity of operation.

342. The following drill routine is recommended.—(*a*) Test for "duplication" or "deficiency" of the image and correct, if necessary, by the height adjuster.

(*b*) Adjust by self-contained adjusting device.

(*c*) Pick out several well-defined objects from 2,000 to 15,000 yards distance.

(*d*) Each member of party take a series of 10 ranges on each of the objects, throwing the image out of coincidence before each range is taken.

(*e*) Compare average of 10 ranges with the true distance obtained from chart, and compare mean variations.

(*f*) Record data for each drill in a range-finder record book. (Note should be made of the state of the atmosphere.)

(*g*) Keep and compare each man's record from day to day.

(*h*) Keep window slide closed over window giving light to inside scale and have second observer record the ranges from the outside scale. Be sure that the outside scale is set to correspond with the inside scale.

(*i*) Take ranges simultaneously on the same object from two or more range finders and compare results.

(*j*) After the observer becomes expert take ranges on moving objects, when the ship is rolling and there is considerable vibration and wind. Take advantage when at sea of opportunities to get readings on passing vessels.

(*k*) The average man should become expert in accurately taking ranges after being drilled daily for about a month.

CHAPTER 16.

SPOTTING.

343. Necessity for spotting.—For the purpose of regulating the sight-bar ranges, range finders can not now be used exclusively for the following reasons:

(*a*) Errors occur due to faulty operation and adjustment and to varied conditions of atmosphere.

(*b*) A range finder can not be accurately calibrated with the sights so as to give directly the true sight-bar reading at various ranges.

(*c*) Owing to the errors of guns, the dispersion of shots necessitates observation of the impacts. As gunnery progresses it is probable that precision will improve, and so facilitate the control of gunfire.

344. Range finder and spotting both employed.—It is recognized that the range-finder method would be ideal for regulating the sight-bar ranges; it is also admitted that the method of spotting as employed at target practice is crude and artificial, but a compromise is necessary, and successful control at present depends upon the accurate use of both range finder and spotting.

345. Importance of spotter.—Of the fire-control party the spotter at present holds a most important position. Upon him, to a considerable degree, rests the responsibility of getting and retaining the initial advantage. As long as one spotter and one range finder remain, together with a means of communication, an efficient collective gunfire may be maintained. When communications are destroyed the effectiveness of the fire will depend on the ability of the division officers to control and spot the units under their charge.

346. Power of glasses.—Considering the various ranges and conditions of weather that may obtain in battle, the most suitable power for a day spotting glass is 10. On hazy days a somewhat lower power would give slightly better results, but not sufficiently better to warrant a change in the power of the glass. On bright days a higher power, 15 or more, may be used to advantage. Were it not for the reduction in size of the field and the loss of light which accompany an increase in power it would not be possible to establish an upper limit of magnification.

The Mark I spotting glass (which is similar to a $1\frac{1}{2}$ meter range finder in appearance) has both 10 and 15 powers.

The Mark III spotting telescope has a power from 20 to 30, in order that the rifleman using it on a rifle range may have a high-power glass to gauge the refraction.

347. Field.—The field of a day spotting glass should be at least 2°. The 10-power glass has a 4° field, which is none too great when opening fire. With a small dispersed and well-controlled fire a field of $2\frac{1}{2}°$ (that of a 15-power glass) might be sufficient. The field of a glass of 1 power is 40°, that of any other power can be calculated by dividing this 40° by the power; that is, a 10-power glass has a field of 4° (40 divided by 10).

$$(a)\ \frac{40°}{\text{power}} = \text{field of glass.}$$

348. Exit pupil.—To give good light and illumination, the exit pupil of the glass should be at least as large as the pupil of the eye. The pupil dilates in the dark; therefore a larger exit pupil is needed at night than during daylight. The diameter of the exit pupil can be obtained by dividing the diameter of the objective by the magnifying power.

The standard ordnance night binocular (Mark IV) has an objective 30 millimeters in diameter; a power of 5, and therefore an exit pupil of 6 millimeters (0.24 inch). Both the Bausch & Lomb and the Terlux 10-power day binoculars have objectives 45 millimeters in diameter, and therefore exit pupils of 4.5 millimeters (0.18 inch).

The exit pupil in a day glass should be at least 0.2 inch in diameter, while that in a night glass should be at least 0.25 inch. A large exit pupil would be advantageous, in that the pupil of the eye would not have to be maintained exactly in line with the exit pupil of the glass but for the fact that as the exit pupil increases the power decreases (using same diameter objective).

$$(b)\ \frac{\text{diam. objective}}{\text{power}}=\text{exit pupil}$$

349. Laws governing optical characteristics.—There is constant demand for glasses having high power, large field, and good illumination. The definite rules referred to above cover the characteristics of spotting glasses. High-powered glasses with large fields can not be constructed except as already outlined. While increasing the diameter of the objective does increase the illumination and exit pupil, it does not affect the field of the instrument. Increasing the length of the instrument does have a bearing, however, on the power. The power may be obtained by dividing the "focal length of the object glass" by the "focal length of the eyepiece."

$$(a)\ \frac{40}{\text{power}}=\text{field of glass}$$

$$(b)\ \frac{\text{diameter of objective}}{\text{power}}=\text{exit pupil}$$

$$(c)\ \frac{\text{focal length of objective}}{\text{focal length of eyepiece}}=\text{power}$$

350. Binocular vision.—Binocular vision is desirable for spotting. Objects which when seen with one eye appear flat (that is, at the same range) stand out when viewed with both eyes. For spotting purposes binoculars are therefore superior to telescopes. The Mark V periscope (Ordnance pamphlet No. 416, April, 1913) has binocular eyepieces, and is intended for spotting from fire-control towers.

351. Stereoscopic effect.—The Mark I spotting glass has been supplied in order to increase the stereoscopic effect obtained to a slighter degree with binoculars.

352. Mounting.—It is of extreme importance that all spotting glasses be rigidly mounted. While it is difficult to keep a long, high-power telescope on a target, a properly mounted Mark I spotting glass can be readily held there, and the spotter can be protected by a housing, as the objectives are 1½ meters apart.

353. Care of eyes.—Considerable concentration is necessary in spotting, and the eyes are likely to be strained unless frequently rested. The spotter must avail himself of opportunities for resting his eyes, so that when needed they will be in normal condition.

354. Methods—"Direct flight" method.—Where ranges permit spotting can be best done by "direct flight." A spotter takes a position clear of smoke and gas and, through glasses, observes the projectile in flight. He keeps the top of the target in the field of his glasses and observes and follows the projectile when it enters the field and at what point it passes the vertical plane of the target. Knowing then how much of a change in range and deflection are necessary, he gives the correction.

355. Following projectiles in flight.—On a clear day projectiles can be followed in flight by an experienced spotter, using glasses to about the following ranges:

	Yards.
14, 13, 12, and 10 inch guns	5,000
8, 7, and 6 inch guns	4,000
5 and 3 inch guns	3,000
3 and 6 pounder guns	2,000
1-pounder guns	700

At ranges from 5,000 to 12,000 yards a 12 or 14 inch projectile may generally be seen up to the highest point in its trajectory.

356. Calculations and diagrams.—Calculations and diagrams must be made by the spotter in order to properly train himself for his work.

357. Diagram—Day elementary practice.—12-inch (2,900 f. s. gun), mean range, 2,000 yards. Target 10 by 21 feet abeam, approximately 3 feet above deck of raft. Raft 2 feet high. From column 19, Range Tables, 100 yards on sight bar changes point of impact 4 feet. Hence target is 250 yards high on range scale. From column 18, 14 yards or 42 feet equals 12 knots on deflection drum. One knot then equals 3.5 feet on the target. Hence the width of this target (when abeam) is 6 knots. Make a diagram of the target to a convenient scale showing all dimensions with spotting corrections in yards and knots. Such a diagram is shown in figure 1.

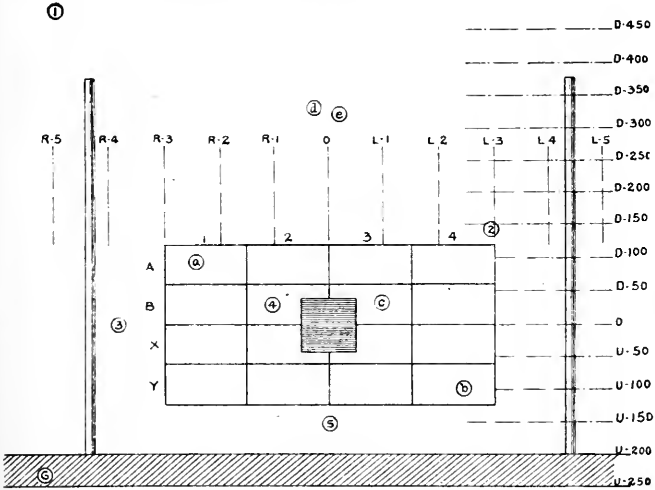


FIG. I.—Spotting diagram—direct flight method. 12″ 2,900 f. s. gun range 2,000 yards.

NOTE.—The width of screen shown in sketch is 10 feet. Scale, 1″=5 feet.

358. Diagram for night practice.—Preparatory to long-range target practice at night each group spotter should make spotting diagram for what is considered will be the mean range. Special study of the range tables is recommended (columns 18 and 19). For example, at 1,000 yards, 6-inch guns (2,600 f. s.), change of height of impact for 100 yards sight bar equals 2 feet. At 5,000 yards 1 knot deflection equals 12 feet, and 100 yards in range equals 18 feet change of height of impact.

359. "Vertical" or "splash" method.—This method is employed at short ranges, when projectiles have not been seen in direct flight, and at all ranges greater than 4,000 yards. The spotter from an elevated position, the higher the better, observes the slick formed when the splash subsides or the base line of the splash. This slick is pictured in the same vertical plane as the target, and an estimate is made of how much above or below the water line it appears. Knowing for various ranges how much "short" or "over" splashes must be to appear at certain vertical distances from the water line, a correction can be applied to the sight bar. (The change of range in the interval of time between shots must be combined with spotting correction, as discussed later (Art. 410), to give the actual sight-bar setting.)

Diagram, splash method.—Figure II illustrates the principle of the vertical or splash method.

FE=Height of spotter above water line of firing ship.

h=FW=Effective height of spotter, considering curvature of earth.

WE=Height of eye for visible horizon corresponding to range.

B=Splash of projectile falling distance b beyond target T.

A=Splash of projectile falling distance a short of target T.

FAL=Spotters line of sight to slick of A.

FRB=Spotters line of sight to slick of B.

y=Apparent distance of A below water line of target.

x=Apparent distance of B above water line of target.

Figure III shows front elevation as would be seen through glasses with horizon sketched in corresponding to h=120 feet. Range, 10,000 yards, target 30 feet high.

360. Calculations.—Referring to Figure II it is readily seen that values of y and x for "shorts" and "overs" may be calculated by the following formulas:

$$y=\frac{h\times a}{R-a} \qquad x=\frac{h\times b}{R+b}$$

To calculate value of h use Table 6, Bowditch, "Distance of visibility of objects at sea." With range in nautical miles, find height at which the horizon is visible. The difference between the height of the spotter above the water line and the height just found gives the effective spotting height.

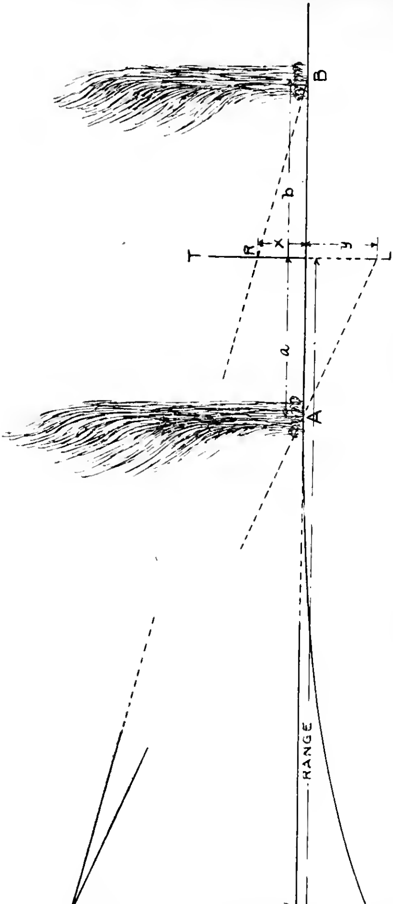


FIG. II.—Vertical or splash method.

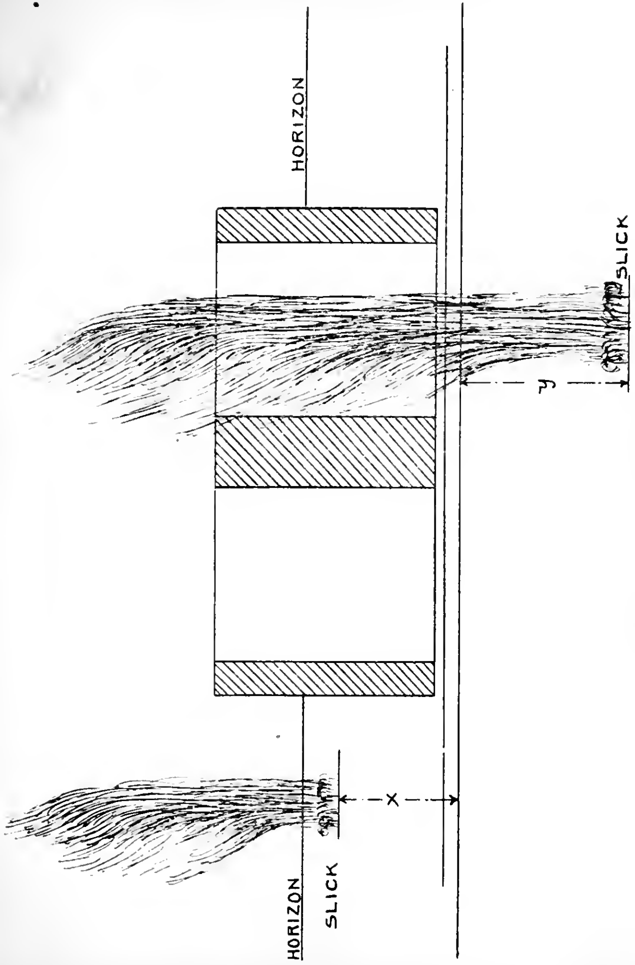


FIG. III.—Vertical or splash method, front elevation.

Tables have been calculated for "shorts," "overs," and "length of target in knots" for a range of 12,000 yards. For other ranges the calculations are made in a similar manner.

[Height of spotter's eye, 120 feet from water line; range, 12,000 yards; 2,000 yards=1 knot; a=1,000 yards; target, 30 feet high; effective spotting height=120—27=93 feet.]

"Shorts."

$y=\frac{h\times a}{R-a}=\frac{93\times 1000}{11000}=8.5$ feet below water line or about one-third height of target.

"Overs."

$x=\frac{h\times b}{R+b}=\frac{93\times 1000}{13000}=7.1$ feet below water line or slightly greater than one-fourth height of target.

Length in knots of 60-foot target on 12-inch (2,900 f. s.) deflection drum—12,000 yards, bearing abeam.

1 knot$=\frac{105\times 3}{12}=26.3$ feet and a target 60 feet long abeam is 2.3 knots.

Long on 12-inch deflection drum. When bearing 30° it would be 2.3×sine 30°—1.1 knots. Hence, a splash appearing a target length to the left of target would require a spot of 2 knots right; whereas when the target is abeam the spot would be 3.5 knots right.

361. Table of shorts and overs.—Target, 30 feet high; spotter's eye, 120 feet above water line; range in yards. Column A—Distance of "slick" below in feet. Relative proportion of target given approximately in Column B; a=yards short of water line of target. 12-inch gun. 2,900 f. s.

"Shorts."

Effective spotting height.	Range.	a=100		a=300		a=500		a=800		a=1,000		a=1,500		Danger space.
		A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.	*Yards.*
112 feet....	6,000	1.9	1-15	5.8	1-6	10.2	1-3	17.2	1-2	22.4	3-4	37.3	1-2	....
108 feet....	8,000	1.4	1-30	4.2	1-7	7.2	1-4	12.0	1-3	15.4	1-2	24.9	3-4	....
101 feet....	10,000	1.0	1-30	3.1	1-10	5.3	1-6	8.7	1-4	11.2	1-3	17.8	1-2	....
93 feet.....	12,000	.78	1-40	2.3	1-15	4.0	1-7	6.6	1-5	8.5	1-4	13.2	1-2	....
82 feet.....	14,000	.59	1-60	1.7	1-30	3.0	1-10	4.9	1-6	6.3	1-5	9.8	1-3	....
73 feet.....	16,000	.46	1-60	1.4	1-30	2.3	1-15	3.8	1-9	4.9	1-7	7.6	1-4	....
58 feet.....	18,000	.30	1-60	.9	1-30	1.7	1-15	2.7	1-12	3.4	1-10	5.1	1-6	....
47 feet.....	....	......	......	......	......	......	......	......	......	2.5	1-15	4.0	1-7	....

"Overs."

Effective spotting height.	Range.	a=100 A.	a=100 B.	a=300 A.	a=300 B.	a=500 A.	a=500 B.	a=800 A.	a=800 B.	a=1,000 A.	a=1,000 B.	a=1,500 A.	a=1,500 B.	Danger space.
112 feet....	6,000	1.8	1-15	5.3	1-6	8.6	1-4	13.1	1-2	16.0	1-2	22.4	11/15	223
108 feet....	8,000	1.3	1-15	3.8	1-8	6.3	1-5	9.8	1-3	12.0	2-5	16.6	1-2	150
101 feet....	10,000	1.0	1-30	1.9	1-15	4.4	1-7	7.5	1-4	9.2	1-3	13.1	2-5	108
93 feet.....	12,000	.77	1-30	2.2	1-15	3.7	1-8	5.8	1-5	7.1	1-4	10.4	1-3	80
82 feet.....	14,000	.58	1-60	1.7	1-16	2.8	1-10	4.4	1-7	5.5	1-6	7.9	1-4	61
73 feet.....	16,000	.45	1-60	1.4	1-16	2.2	1-15	3.4	1-9	4.3	1-7	6.2	1-5	50
58 feet.....	18,000	.30	1-60	.90	1-30	1.6	1-16	2.4	1-13	3.0	1-9	4.3	1-7	39
47 feet.....	20,000	......	......	......	......	......	......	......	......	2.2	1-15	3.2	1-10	31

Analysis of tables.—On inspecting the tables it will be seen that the values in column A vary directly as the distance of the splash is "short" or "over," so that at any range, if the spotter remembers the value of "*y*" for 100 yards, he can tell what it is approximately for 500 yards. At ranges short of 10,000 yards the effect of the curvature of the earth is small, but should be considered. At 15,000 yards, neglecting the earth's curvature, a short of 1,000 yards, *theoretically*, would appear 8.5 below, whereas it will really appear 5.5 below. If a spotter estimates the slick to be 5.5 under, and considered his height as 120 feet, he would give a spot of "Up 600" and then be 400 yards in error. This may sometimes account for "under spotting" at high ranges.

362. Initial deflection.—To obtain the initial deflection, attention is invited to the problems given in chapter 17.

The initial-deflection indicator, described below, is a ready means of obtaining the deflection due to speed of ship and target, not including the effect of wind.

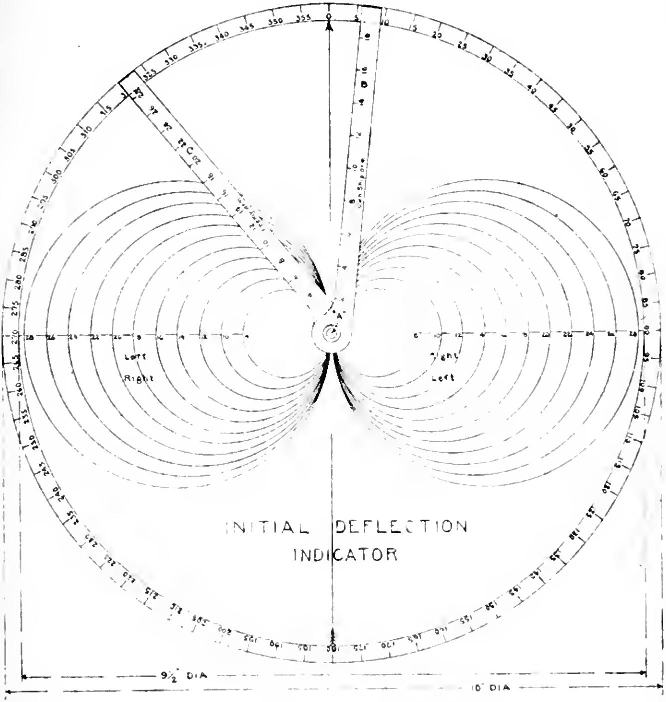
The construction of the initial-deflection indicator is as follows:

1. Construct on cardboard a compass rose, indicating degrees, and marking each 5° position. The inner diameter of this compass rose to be about 8 inches.

2. Construct the speed and bearing diagram as follows:

Cut a piece of cardboard to circular shape, the diameter being equal to the inner diameter of the compass rose previously constructed. Draw on this circular cardboard two diameters 90° apart. Mark one of these with an arrowhead for indicating the bearing. On the other diameter construct two sets of circles tangent to the bearing indicating diameter. The scale of these circles should be such that a circle of diameter of at least twenty times the unit may be constructed on each side of the center. The diameters should vary by two units.

3. Construct enemy arm from a strip of celluloid having a hole at one end for pivot, the remainder of the arm to be so cut that if extended the line would pass through the center of the pivot, as in the sketch. On this arm lay off and mark intervals from the center of the pivot on the same scale as that used for the speed circles.



B MOVABLE ARM OF CELLULOID PIVOTED AT "A"
C MOVABLE ARM OF CELLULOID PIVOTED AT "A"

4. Construct own ship arm similarly to enemy arm but lay off intervals from center of pivot on a scale one and one-half times as great as that used for enemy arm.

5. Secure all parts by pivot permitting motion of all parts except compass rose.

To obtain the deflection, place the arrowhead on the inner card pointing to the true bearing of the target; "*Own ship arm*" at the true course of the ship; "*Enemy arm*" at the true course of the enemy (target).

The intersection of the speed circle with "own ship arm" indicates the knots correction for movement of ship.

The intersection of the speed circle with "enemy arm" indicates the knots correction for enemy movement.

These corrections are right or left depending upon whether the direction of motion is to the right or left of the bearing as shown in red and black ink.

The total correction to be applied is the algebraic sum of the two corrections.

363. **Deflection due to wind.**—A convenient though not absolute rule for making allowance for the deflection caused by wind is to allow one-half of the force of the wind shown on the Beaufort scale. If, for instance, the wind is blowing with a force of 4 (Beaufort scale), 2 knots would be about the correct compensation. Data on the effect of a wind can also be obtained from the range tables, but this is believed to be no more accurate than would be obtained by the use of the foregoing rule.

364. **Thumb rule.**—A thumb rule for obtaining the initial deflection is as follows:

(*a*) Correction ship's speed equals product of speed of ship in knots, times three-fourths time natural sine of angle between course and bearing of target. This correction in knots applied to right, firing to starboard; firing to port.

(*b*) Correction target speed equals plotted speed of target in knots, times natural sine of angle between course and bearing of target.

(*e*) Correction for wind equals one-half force in knots by Beaufort scale, times sine of angle between direction of the wind and bearing of target. (This is for the true wind.)

A spotter in the top with a table of natural sines at hand for every 10° can quickly compute the initial deflection by using these thumb rules. If he has plenty of time, five minutes for example, with his range table he can accurately calculate the correct deflection for each caliber of guns fired.

365. Tables of deflections (length of target on deflection drum in knots), assuming firing and target ships on parallel courses.

12-inch, 2,900 f. s. gun, full charge, target 60 feet long.

Range.	Value of 1 knot (feet.)	Length of target in knots bearing—					
		90°	75°	60°	45°	30°	15°
Yards.							
6,000	11.8	5.1	4.8	4.4	3.6	2.6	1.3
8,000	16.3	3.7	3.5	3.1	2.6	1.9	.96
10,000	21.0	2.9	2.7	2.4	2.0	1.4	.7
12,000	26.3	2.3	2.2	2.0	1.6	1.1	.6
14,000	31.8	1.9	1.8	1.6	1.3	.9	.5
16,000	37.8	1.6	1.5	1.4	1.1	.8	.4
18,000	44.3	1.4	1.3	1.1	1.0	.7	.4
20,000	51.0	1.2	1.1	1.0	.8	.6	.3

Analysis of table.—An inspection of this table shows that the greater the range the smaller the length of the target in deflection; thus a 12-inch splash 60 feet to the left of the target abeam 6,000 yards distant would be spotted "Right 8," while at 15,000 yards, "Right 3." It is important to remember this change. Attention is called to the effect of bearing of target upon deflection. (See art. 360.)

366. Parallax.—When firing at short ranges, where the bearing of target changes rapidly, allowance must be made for position of spotter whether forward or abaft firing gun. For example, 12-inch gun fires off starboard beam at a target 2,000 yards distant; speed of target, 5 knots; gun, 10 knots. During the time of flight the ship advances 21 feet. Hence, if a spotter stood abaft the gun 21 feet, he would be in the original line of fire when the shell splashes, and could most accurately spot on in deflection.

367. Diagram of lateral displacements.—In Figure IV is shown the lateral displacement of splash and triangles by which lateral coordinates of points in "splash diagram" of short range are calculated. Where range is over 8,000 yards an inspection of Figure IV shows that the value of X is so small as to be negligible, i. e., ratio of $\frac{TS}{AT}$ small for splashes within 100 yards of target.

At 8,000 yards a splash 1,000 short is displaced only about 2 feet for difference of speeds of target and firing ship of 10 knots when abeam.

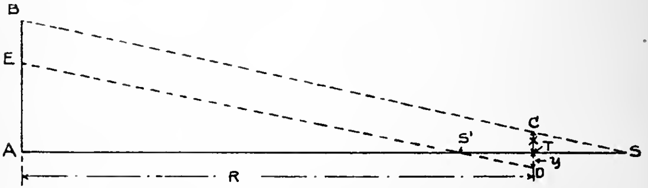


FIG. IV.—Lateral displacement of splash

368. Explanation of figure.—A ship moving 10 knots fires a 6-inch, 2,600 f. s. gun when at A. The target T, 15 by 21 feet, is 2,000 yards off the starboard beam, and moving on a parallel course 5 knots. The diagram shows gun making 5 knots and target anchored, which gives the same results. The spotter at A, 35 feet over gun, moves from A to B during time of flight of projectile from A to point of fall, S. His line of sight to splash BCS, passes a lateral distance x to the left of T.

Assume this projectile hit in corner of A1, 21 feet above the water; target 6 feet above water. From column 19, range tables, using mean value of 6 feet=100 yards, TS=350 yards, approximately. Then from column 18 with horizontal range= 2,350 yards (not distance of gun to the target) distance AB (movement of spotter) is found to be $\frac{20.5\times3\times5}{12}=25.6$ feet. By similar triangles, CT or $x=3.8$ feet. From a height of 35 feet the slick appears 5.2 above water line of raft. S′ represents splash short of target, and seen a distance y to right by spotter who has moved to E. Similar calculations are made for hits in corners of A4, Y1, and Y4. Having the vertical and lateral coordinates of these points a target may be projected on the water.

The coordinates of the points necessary to project the "splash diagram" are as follows (see columns 18 and 19, range tables):

Corner A1:

x=3.8 feet to left of A1.
y=5.2 feet above water line raft.

Corner A4:

x=3.8 feet to left A4.
y=5.2 feet above water line.

Corner Y1:

x=1.1 feet to left of Y1.
y=1.7 feet above water line.

Corner Y4:

x=1.1 feet to left Y4.
y=1.7 feet above water line.

369. Splash diagram for long range.—Having calculated tables for use in long-range spotting by the "vertical" or "splash" method construct a diagram to scale. The slick for range only is shown. (See art. 367.) These diagrams should be constructed similar to Figure VI for 6,000, 8,000, 10,000, 12,000, 15,000, and 18,000 yards for both high and low spotting positions. A study of them enables a spotter to spot without reference to tables. The diagram constructed is for a range of 10,000 yards, target 30 by 60 feet. Raft 130 feet long, 4-foot freeboard forward and aft. Scale, 1 inch equals 15 feet. Spotting correction to water line. Horizon appears 15 feet above water line from the spotting position.

370. Training for battle.—As a preparation and training for battle, the spotter should study the types of ships of his adversary, considering all the dimensions obtainable. Such data as lengths, distance of foremast to stem, height of smoke pipe, height of tops, turrets, searchlights, and main deck, are valuable. With these the spotter can construct battle diagrams to scale and use these known points and dimensions in spotting. In the first firing on the *San Marcos* a high explosive projectile was seen to detonate at the top of the smoke pipe, the known height of the impact was used in giving a spotting correction, which permitted the firing of a salvo after but one ranging shot.

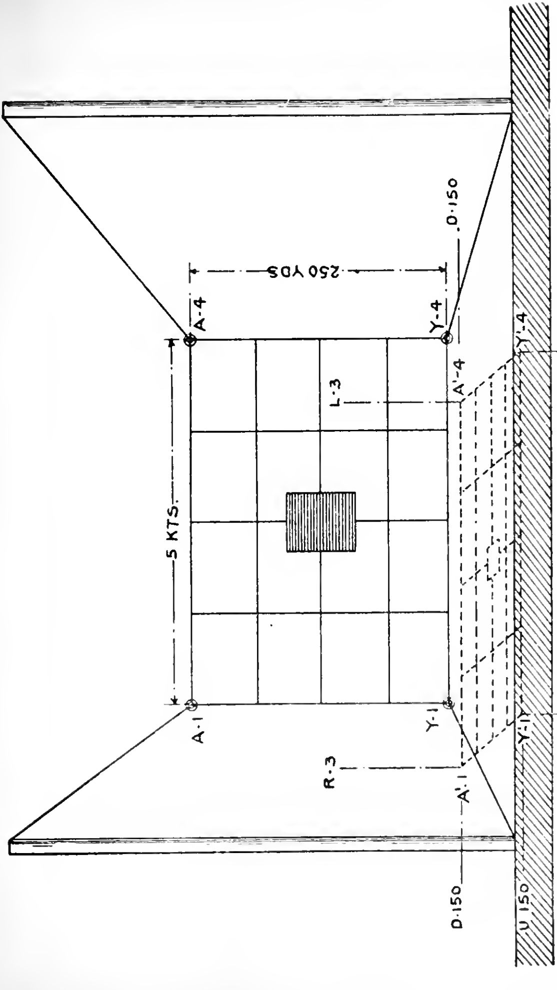


FIG. V.—Splash diagram. Range 2,000 yards. Scale 1″=5 feet.

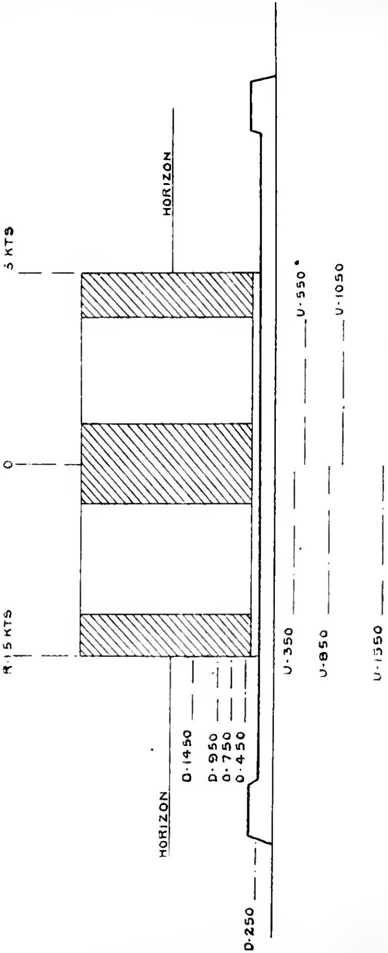


FIG. VI.—12″ battery, 10,000 yards. Spotting correction to center battle target. Scale 1″=15 feet.

371. Battle diagram.—A battle diagram (Fig. VII) has been made of a battleship of the *Pennsylvania* type for a mean range of 14,000 yards, 14-inch, 2,600 f. s. guns. The construction and study of such diagrams would form a most important feature of the training for battle.

372. Salvo firing method of "shorts."—Single shots are far easier to spot than salvos. To spot the latter successfully requires much training and practice. When a salvo strikes, the spotter observes the splashes and estimates the point of mean impact, throwing out wild shots. He estimates by the "vertical method" how far this point is from the water line of the target; he then gives a spot such that the next bunch will straddle and fall at or near the water line. He must immediately decide:

(*a*) The location of the mean point of impact or center of bunch with reference to the target.

(*b*) Which, if any, were wild shots.

(*c*) If the condition of the sea is affecting the slick. (See art. 404.)

373. Estimation of the amount of spot.—The sights are regulated by estimating the percentage of splashes short of the target, and by keeping the mean impact on the target.

374. Mean dispersion.—The amount of dispersion may be judged approximately by estimating the total dispersion between the limiting splashes in a salvo, throwing out wild shots, and dividing by three.

375. Chances of hitting.—For theoretically getting the proper percentage of shorts, attention is invited to the following table, based on the chances of hitting (see Alger's Exterior Ballistics, Chaps. XIII and XIV), assuming that the *mean dispersion in range* remains constant at various ranges. Such a table is calculated for mean dispersions in range of 40, 60, and 80 yards, corresponding approximately to total dispersions of 150, 200, and 300 yards; mean impact at center

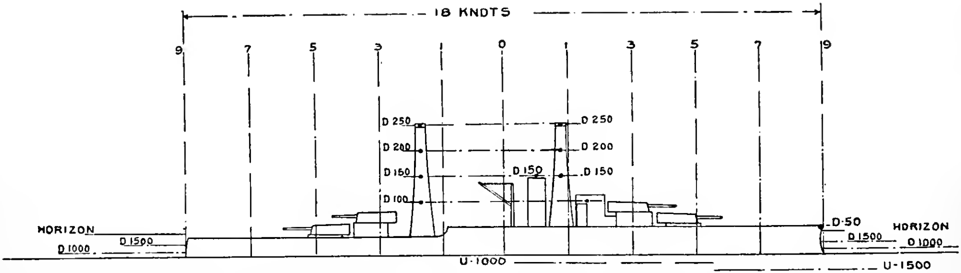


FIG. VII.—Battle diagram. Range, 14,000 yards. Spotter, 120 feet. 14″ (2,800 f. s.) gun.

Spots given for *hits* and *slicks* of *shorts* and *overs*. Deflection spots, bearing *abeam*. Dimensions, *approximate*. Scale, 1″ = 80 feet. Constructed from values in *spotting tables* and *range tables*.

of danger space and at water line; percentage of hits to be expected and percentage of *short* shots to attain this percentage of hits.

376. Spotting table—Method of shorts.—*12-inch 2,900 f. s. gun, target 30 feet high lateral errors not considered.*

	Mean point of impact at center of danger space.						Mean point of impact at water line.						Danger space (yards).
	Percentage.						Percentage.						
	40 yards.		60 yards.		80 yards.		40 yards.		60 yards.		80 yards.		
	Short.	Hit.	Short.	Hit.	Short.	Hit.	Short.	Hit.	Short.	Hit.	Short.	Hit.	
7,000 yards	4	93	12	77	19	63	50	50	50	49	50	46	180
10,000 yards	14	72	24	53	30	40	50	49	50	42	50	35	108
13,000 yards	25	49	32	36	37	27	50	42	50	32	50	25	70
15,000 yards	29	42	36	29	40	21	50	36	50	27	50	21	55
18,000 yards	35	31	40	21	42	16	50	28	50	20	50	15	39

NOTE.—These mean dispersions are less than have been experienced at recent practices.

The chances of hitting are based only upon vertical errors; due to lateral errors they are reduced considerably on a short target.

Assuming the mean point of impact on the target, it will be noted that as the mean dispersion is increased, the percentage of hits decreases very rapidly.

377. Analysis of table.—From the table it is seen that:

(*a*) A greater percentage of shorts is necessary at high than at low ranges.

(*b*) Where a mean impact is some distance from target, an increase in dispersion gives more hits. Mathematically, the mean dispersion for maximum efficiency equals 80 per cent of distance from mean point of impact to center of danger space.

378. **The advantages of keeping a number of shots short are:**

(*a*) Fire may be controlled more efficiently.

(*b*) Splashes rising in the air will tend to demoralize enemy and obscure gun sights.

(*c*) There may be ricochet and under-water hits. Shots that are over are lost.

379. Principles of spotting by shorts.—The following principles may be laid down for spotting by "shorts":

(*a*) At long-range target practice keep approximately one-third of the shots short.

(*b*) When a whole salvo is short or over target, give a spotting correction at least equal to twice the estimated mean dispersion plus distance from the target of splash nearest to the target.

(*c*) If the salvo straddles with 90 per cent of shots short, give a spot "up" of twice mean dispersion; and with 75 per cent short, a spot equal to mean dispersion; with 50 per cent short, make no correction, if again 50 per cent are short give "up" 50 or 100.

380. Method of halving.—In combination with the method of "shorts," corrections are sometimes made on the principle of "halving." In getting on the target, after a first spot each correction is halved until the salvo is brought on. For example, first salvo all over 700 yards, spot, "Down 400," second salvo, over, one-half of first correction or "Down 200," third salvo on the water line. With the rate of change constant, the spotter is absolutely sure to get "on" in time with this method which, however, is slow.

381. Selection of spotters.—If practicable, the chief spotter ought not to have a turret: other spotters should not have duties which will interfere with their training and work in battle. In making battery assignments consider what officers may be selected as spotters, and if they are given turrets detail junior officers who can take charge of the division in their absence. With the exception of the four senior officers in a battleship it is proper to assign any officer as spotter who has demonstrated his excellence.

382. In selecting spotters the following are suggested: (*a*) Only commissioned officers should act as spotters. (*b*) Note records as spotters in previous practices. (*c*) Have eyes of candidates examined and require normal vision. (*d*) The natural qualities to be desired in a spotter are even disposition, quick judgment, confidence, coolness, keenness, and intelligence under adverse conditions; courage of his convictions at all times. (*e*) A spotter should have a knowledge of gunnery including ballistics, and the theory and practice of fire control.

METHODS OF TRAINING.

383. Officer in charge of training.—The training of spotters should be under the supervision of the gunnery officer.

384. Essentials in training.—(*a*) Require spotters to construct necessary diagrams. (*b*) Hold meetings for discussion of spotting, calculation of initial sight-bar range, errors of gun fire, and a general exchange of ideas. (*c*) Outline scheme of spotting drills and keep up drills throughout the year even for experienced spotters. (*d*) Never criticise a spotter in action; any confusion will ruin a performance. After a drill or practice, mistakes should be carefully pointed out. (*e*) Give spotters every opportunity to practice and observe the fire of other ships. (*f*) It is desirable to train certain spotters for high and others for low spotting positions.

385. Training devices.—(*a*) The fundamental principle of any device for training spotters is that it should be realistic. Any device by which a small object is projected toward a target simulating a projectile will permit an interesting and instructive form of drill.

(*b*) The spotting board or range should be as long as conditions will permit.

(c) The target and height of the spotter's eye should be in the same reduced proportion as the actual range is to the spotting range. Never increase size of target to represent magnified image, as it destroys the true perspective.

386. Preliminary.—In the beginning set up a target to scale. With a wand point to the target, indicating hits and misses. Spotters note how much the projectile missed the target and give correction. These drills should be held until spotters can quickly and accurately give a spot. Diagrams for different calibers and ranges posted in a spotter's room will aid in keeping in mind the proportion of target and spotting data.

387. Training for night practice.—The training for spotting for night practice at short range is carried along the same lines as for day. With diagrams previously prepared and studied a target is set up on deck at as long a range as possible. The target is illuminated by a bull's-eye lantern. For simulating tracers, a wand is used, on the tip of which is placed a 3-candlepower light. This may be turned on or off to simulate a tracer passing over target. During the day the wardroom may be darkened and a similar range laid out 20 yards long with target built to scale, and drill conducted in the same manner. All persons who may be called upon to control torpedo-defense guns should be given this training.

388. Training for long-range spotting.—Division officers to train for spotting: Require all division officers to train for spotting in order that they may prepare themselves and petty officers for independent control. Never hold a drill without a number of officers present. Keep and publish records weekly. Encourage competition in spotting.

389. Training for long-range spotting is conducted as follows by: (1) Drill at the spotting board. (2) Drill on spotting range aboard ship. (3) Subcaliber practice. (4) Observation of practices. (5) Spotting practice. (6) Spotting at battle practice.

390. Spotting board.—A spotting board is a device by which long-range firing may be simulated upon a small scale, for the training of spotters. While the details of spotting boards vary, the following general principles of construction are common to all: (*a*) The scale upon which a board is constructed is the ratio of the length of the board to the range. (*b*) The dimensions of target, splashes, height of spotters, and horizon on the spotting board bear this same ratio in comparison to the actual heights, etc. (*c*) The general perspective must remain the same as at the long range.

391. Dimensions.—Board to represent a range of 10,000 yards for 12-inch guns firing at a target 30 by 60 feet. High spotting position, 120 feet. Low spotting position, 50 feet. Splashes, mean height, 175 feet; diameter, 20 feet. Eye to target, 30 feet. Scale of board, 1/1000. Target dimensions, 0.36 by 0.72 inch. Height of eye-high position, 1.2 inches; height of eye-low position, 0.3 inch, considering earth curvature. Mean dimensions of splashes, 2.1 by 0.48 inch. 50 yards on board equals 1.8 inches.

392. Drill at the spotting board.—Before the drill hour place spotting board where the light is good, little confusion, and no interruptions likely. Lay off a distance of 30 feet from target; at this mark place a rest for a 3-power glass so that the eye of the spotter will be about 1.2 inch above the plane of the board. In a new ship start drill with the board as soon as officers are settled in their duties. Give all officers, from gunnery officers down, drill at spotting. At first spot single shots, next salvos. In an hour 15 officers can spot two strings apiece, and at least this number should be given. Hold drill five times a week.

393. Procedure.—Before each drill arrange what splashes are to be used for the strings. Before each string, the spotter should study the appearance of shots short and over 1,000, 500, 200, and 0 yard. From this practice will be learned the ratio between the height of the target and that of the point of fall. Two officers are required to operate the splashes, and one to act as recorder. In turn each officer spots his two strings and his spots are recorded. The number of spots to get "on," and his error are determined.

EXAMPLES.

(*a*) *First string—Single shots.* (*Distance from water line.*)

No. 1. 1,500 short.

No. 2. 1,000 over. (Shows disadvantage of ranging shot that is far over.)

No. 3. 1,000 short.

No. 4. 0 and 10 L in deflection. (Shows difficulty of spotting range and necessity of spotting on in deflection.)

No. 5. 100 short and 10 R. (Shows difficulty of spotting range and necessity of spotting on in deflection.)

No. 6, 150 over and behind target, just beyond danger space; usually spotted a hit, danger of "overs."

No. 7. 50 short and 4 knots left, range spot in doubt. A fine ranging shot if deflections were correct.

No. 8. 200 over and 2 knots right, a good "over" ranging shot to spot "on" in range and deflection.

No. 9. 500 short and in front of target, usually underspotted.

No. 10. 100 short and in front of target, usually overspotted but a good ranging shot.

(*b*) *Second string.—Salvos.* (*Assume mean dispersion equal to one-third of distance between limiting splashes.*)

No. 1. 4 splashes, "on," 200 yards between limiting splashes. Good salvo, less than average dispersion.

No. 2. 4 splashes, "on," 50 yards between limiting splashes. Excellent salvo.

No. 3. 4 splashes, "on," 500 yards between limiting splashes. Large dispersion, effect on hits.

No. 4. 4 splashes, 500 over, 3 splashes bunched, 1 splash 50 yards short. Short shot wild, spotter apt to give no correction as he has 25 per cent of splashes short.

No. 5. 4 splashes, 1,000 yards short, 250 yards between limiting splashes. (Splashes in line.) Difficulty in spotting splashes in line.

No. 6. 4 splashes, 200 yards over, 5 knots left, 200 yards between limiting splashes. Error in deflection may cause error in spotting.

No. 7, 6 splashes, 2 splashes 100 yards short, 4 splashes bunched 300 yards over, 2 shots wild, spotter apt to give "no correction."

No. 8. 6 splashes, 300 yards short, 50 yards between limiting splashes. Small dispersion. Easier spotting. Necessity for accurate spotting.

No. 9. 6 splashes, 300 yards over, 50 yards between limiting splashes, necessity for accurate spotting.

No. 10. 6 splashes, 200 yards short, 500 yards between limiting splashes. Hits under these conditions were at random.

These two strings illustrate some of the underlying principles of spotting. Many others may be arranged.

394. Spotting-board problems.—Innumerable problems may be worked out on the spotting board in connection with fire-control drills, such as spotters giving corrections to fire-control party, determined from previously worked-out conditions; determination of number of shots or salvos to get "on" target; control of mixed caliber salvos; concentration of two ships and control of salvos by two spotters; rate of change of range; and change incidental to enemy or own ship changing course.

395. Spotting range.—For advanced training the spotting range is better than the spotting board. Select a clear line of sight along the deck. Heat waves and curvature of the deck may cause difficulties. As long a distance as possible is desirable; a fair average is 250 feet. Let 200 feet equal a mean range of 14,000 yards, 12-inch guns, target 30 by 60 feet, spotters 120 and 60 feet high (effective height, 82 feet and 12 feet): Target, 5.2 by 10.4 inches; spotter (high), 4.7 inches; spotter (low), 0.7 inch; splashes, 10 by 1 inch; 50 yards= 8.6 inches.

396. Details of range.—At one end of the range place a rest for the spotter's glasses about 4 inches high, corresponding to high spotting position. At 200 feet from this point mark the position of the target. Lay off 2,000 yards in front of and behind the target. Between 500 short and 500 over, divide into 50-yard intervals; then up to 1,000 yards, in 100-yard intervals. From 1,000 to 2,000 short or over in 200-yard intervals. In order to quickly lay off these, mark them on a canvas scale about 40 feet long. With this laid flat on the deck, and zero corresponding to the position of the target, the target and splashes can be easily placed. Make the target of mosquito cloth to simulate a net screen, or of tin, to resemble the outline of a battleship and mount it so it will stand upright.

It is necessary to have about 50 splashes. They may be made out of cardboard of various but proper shapes, about 10 inches high and 1 inch wide, mounted and hinged on thin metal bases. On the forward side of each an elastic band is so secured that the splash will naturally lie flat; on the after side through fair leads a line is made fast which leads to a position from where the splash operator can not be observed. On a wire a curtain is run in such a way that the spotter will not see the splash operators.

397. Drill on range.—To hold a drill, decide upon the problem to be solved, conditions, etc. Have splashes put in position so that the shots and salvos may be used as required by problem. A detail will be required to operate splashes under the supervision of an officer.

Examples.—(*a*) First string: Fire two ranging shots and eight salvos. At zero minutes fire a blank cartridge; after about 20 seconds a ranging splash rises, subsiding in 15 seconds; at 40 seconds fire another ranging shot, which is seen 20 seconds later, etc.; at 1 minute 20 seconds fire a salvo of four guns and continue at intervals until the last salvo has been spotted. Several officers spot and independently record their results.

(*b*) Second string: Give each spotter two ranging shots and five salvos to determine, first, how quickly he can get on; second, how well he can keep on.

(*c*) Third string: Devise a problem and use spotting range in connection with whole fire-control system of ship. Here with three scales for ranges of 10,000, 12,000, and 14,000 yards laid side by side and painted red, white, and blue, and several targets of proper sizes, the battle range may be quickly changed and a new target used. This is necessary to simulate ranging shots at about 16,000 yards, the range closed, and salvos operated at a closer distance. Figure VIII shows arrangement of target splashes, scales, etc.

398. Subcaliber practice.—At ranges at which angles of fall are equal to those of the larger guns, excellent spotting practice may be had. The spotter must be at a height proportional to the range; the target should be in proportion, and paper range strips made so that the shots will follow the spotter's corrections. Require the spotters to send spots to the subcentral and to control the regular fire-control lines.

399. Spotting with reduced charges.—Unless there is an understanding between the spotter and the fire-control party, there is likelihood of errors being introduced when using reduced charges. In using reduced charges, if a shell lands 200 yards short a spot of "up 200" is converted to the proper sight correction in the subcentral before it is applied to the sight-bar range, and sent to the guns. A simple way to avoid error is to have the clocks and dials in the subcentral set for the actual range, and with the dials in the subs marked with ranges for the reduced velocity. Another method is to make a drawing of proper size of the sight strips for the guns to be fired, making the graduations and lettering correspond to the correct angles of departure for the new initial velocity. Make blue prints of this drawing and carefully paste them over the sight strips; then boresight and shift the strips with blue prints attached, as necessary. No conversion of actual range is now necesary (i. e., the spot, or the range finder reading) to sight bar range, and in consequence there is no loss of speed or accuracy.

400. Spotting practice.—Just before spotting practice the final selection of spotters is made; two being particularly trained for high and two for low control. Each spotter at this time spots under conditions somewhat similar to those of battle practice, and experiences difficulties incident to smoke, gases, sun, refraction, mirage, etc.

401. Observation of other ships.—A spotter should be given every opportunity to observe the fire of other ships. At such times he must record each spot and make notes, and afterwards compare his record with the results reported by the observers.

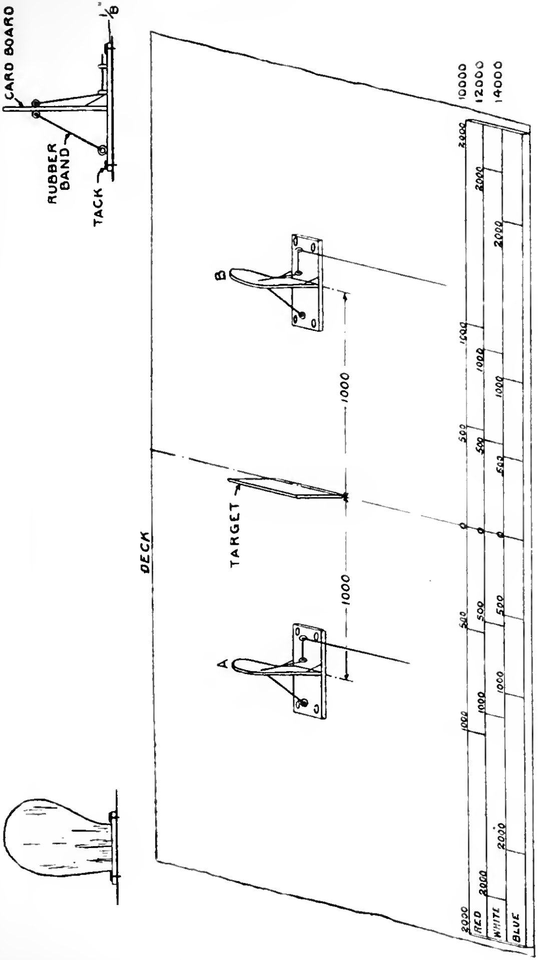
Discussions with other spotters and exchange of ideas at these times will be very instructive.

402. Keep the following points in mind (elementary practice):

(1) In spotting the first shot give the full correction.

(2) After the first shot do not correct until two shots have gone in practically the same place.

(3) Be on the *safe* side and *under spot.* Do not give a correction after each shot. Good pointing is what produces a good score at this practice. Without good pointing satisfactory results can not be obtained, and spotting will not help the performance. After the first shot is spotted "on" generally further corrections on a run should be unnecessary.



Target and splashes. Spotting range.

A—1,000 short on 12,000-yard scale. —1,000 over on 10,000-yard scale.

(4) Keep out of wind, be protected from rain, keep warm and clear of confusion, make yourself comfortable.

(5) Give corrections quickly and distinctly; make no comments.

(6) Look out for shells passing through holes in target. Accurate spotting in such cases will bring hits to a ship which may otherwise be counted misses.

(7) Be prepared to spot by the "splash method."

(8) If on one run or at one gun something goes wrong do not carry error over to the next run or gun.

(9) Be sure that system of communication is efficient and that there will be no confusion in transmitting spots.

(10) Be sure that a sight correction will always be applied before subsequent shots are fired.

(11) Look out for spotting with a following wind. It may be bad for both pointers and spotters.

(12) The most favorable weather conditions are wind on engaged bow, force 3–4, and sun behind the spotter.

403. Night target practice.—Low-control spotters should keep near firing guns. The important point in selecting a position is to be clear of smoke, gases, and blast. Keep shots clear of the side, edges, and the top of the target. High spots are particularly deceptive. The spotter, pointer, and searchlight operator must all simultaneously have a good view of the target.

404. Target practice, long range.—Many of the points mentioned in article 402 apply. Spotting at a net screen is difficult because of lack of opaqueness. When a straddle is obtained a spotter in a low position can control the fire quite efficiently. Once "on" in target practice do not attempt to give a spotting correction for each salvo; the fire should be rapid to be effective. Be very careful in working out the initial deflection. If the first shot is wide in deflection spot on in deflection, and come down in range unless the range is manifestly short. Take into consideration the height and character of the sea.

An impact on the crest of a sea while the target is in a trough may give an erroneous impression. When once "on" give a spot up or down 50 or 100 in order to make sure of conditions and as a check.

405. Hints in long-range firing.—(1) Before the ship opens fire the spotter should see that all turrets are trained on the proper target. Neglect of this precaution has occurred and resulted in reducing the firing ship's score and endangering other ships.

(2) The spotter should spot the shots back and forth across the target until he *knows* that he is getting hits. The most frequent mistake is for spotters to think that the shots are hitting when actually they are just short or over. But when once he is sure of being "on" he should not spot unnecessarily as this slows the firing and may introduce errors.

(3) Be very careful to spot the deflection at the instant the shots land.

(4) Between salvos watch the bow wave of the target, the wake and bow wave of the towing ship, and the bearing of objects, such as the ends of the bridge or the two boat cranes on towing ship. Changes of speed and changes of course can be detected in this way, and this information will be of great assistance to the tracking party and to the spotter.

(5) If spotting explosive shells the dark gases given off at detonation will cause the splashes to look like hits, and the spotter should be positive that the salvos are hitting.

(6) If firing ship is turning, the deflection can not be spotted correctly until the ship is steady on the new course.

406. Two or more calibers fired together.—It is impracticable at battle ranges to distinguish the splashes of turret guns of one caliber from those of another caliber, striking at the same time. In order therefore to get accurate spotting of the shots of a ship having guns of two or more calibers, it is desirable to arrange the fire so that the shots from the different calibers will not land together.

407. Trial shots.—To assist the spotter in getting on quickly, it is desirable before a battle practice, to fire trial shots from each caliber of gun that is to fire. All of the shots of a caliber should be fired with the sights set alike on all rounds fired. During the firing all range finders should take readings of the range. From the mean point of impact of trial shots the error between the range finder and the sight bar can be established. Turret officers and others should take advantage of these shots to practice spotting from what will be their battle stations. Every care should be taken in making allowance for temperature of powder, erosion, density, of air, etc., to land the trial shots as close as possible to the target. It must be clearly understood that on subsequent days a large error may exist between the range finder and the sight bar due to different atmospheric conditions or other causes, and the spotters should be prepared for these variations if they are found. Trial shots are especially desirable for ships having two or more calibers.

408. Hints on firing trial shots.—(*a*) Land first shot as near target as possible.

(*b*) If the first shot lands near the target do not change the sight bar. If it lands more than 300 yards from the target change the range to reduce the error to zero and fire subsequent shots without further change of sight bar.

(*c*) If it is necessary to change the sight setting require a report that the change has been made before permitting the next shot to be fired.

(*d*) If four shots are fired, or if three are fired and the first shot appears to be unreliable, throw out the first or cold shot in averaging the results.

(*e*) Record the positions of cross wires on target for each shot and if check telescopes are available, station an officer at them to get this data.

(*f*) Make careful observations of wind and transfer the splash of each shot to its proper position relative to the target had it been fired in a calm. Check drift.

(*g*) Take range finder readings during the firing and plot them to give a range curve, then pick the range finder range for each shot from this curve.

(*h*) Take range readings from all other range finders, plot their curves and determine separately the error of each from the standard range finder.

(*i*) Record the sight setting before and after each shot fired.

(*j*) Be sure that all observers know just what data is to be taken and how reported to the firing ship.

(*k*) Select the best and most reliable pointers to fire and allow plenty of time for them to get "on" and fire.

(*l*) Be sure they understand that they must be exactly on and that the sights will be set to land the shot near but not to hit the target..

(*m*) Test and check the boresighting both before and after the firing. Test for parallax, lost motion, inaccuracies in boresight telescopes, and nonrigidity of parts.

(*n*) Do not fire all shots at a very high range, 9,000 to 10,000 yards should be sufficient if the allowance of ammunition is small.

(*p*) Require spotters and turret officers to exercise at spotting from regular stations during the firing but do not make a spotting practice of it by changing the range after each shot.

(*q*) Select smooth-water conditions.

(*r*) Collect data regarding shell seating, recoil of guns, kick of turrets, etc.

409. Ranging shots.—Experience has demonstrated that it is much easier to spot a single shot than to spot a salvo. For this reason single guns are preferred for ranging. In ranging guard againt inaccurate pointing. The spotter must at all times have clearly in mind that the gun, even when correctly pointed, will have considerable dispersion and due cognizance of this must be taken in noting the fall of subsequent ranging shots.

It is probably better in all cases, using every available means and data at hand, to fire to hit the target on the first shot. Most spotters prefer to have ranging shots short, as it is, in general, easier to estimate shorts than overs; consequently, some ships purposely endeavor to throw the ranging shots short. This might be desirable were it possible to always control the fire so as to throw the first shot 100 or 200 yards short, but so many errors are always present that there is no absolute assurance as to exactly where the first shot will land, and a ranging shot landing some distance from the target will delay considerably the salvos.

410. Error in rate of change.—With a wrong rate of change it is almost impossible for the spotter to get or keep the shots on the target. The spotter should not, ordinarily, attempt to correct for the rate of change, but this correction should be made in the subcentral. The spot sent to the subcentral should always indicate the actual correction that should be applied to bring the shots on the target. If the shots persistently fall short or over the target, it should be evident in the subcentral that the rate of change is wrong, and the rate should be corrected. With no system provided for keeping the rate of change of range, the person controlling the fire of guns must allow for the rate of change in giving spots. If approaching the target make the "down" spots radical, if receding from the target be sure to make the "up" spots sufficient.

CHAPTER 17.

PROBLEMS IN FIRE CONTROL AND CALIBRATION.

411. Character of problems.—The following nine problems, with solutions, have been supplied by the department of ordnance and gunnery at the Navy Academy. They furnish a guide to the solution of problems of practical gunnery, involving the use of range table data.

412. Problem 1.—Four shots were fired on calibration practice from a 12-inch gun, initial velocity 2,700 foot-seconds, weight of shell 870 pounds, under the following conditions:

Actual distance of target from firing vessel 7,500 yards; height of center of bull's-eye above water level 10 feet; sight of gun set for 7,500 yards; bearing of target from ship, north (true); wind from southwest (true), velocity 15 knots per hour; barometer 30.50 inches; thermometer (temperature air) 60° F.; temperature of powder 100° F.; weight of shell 870 pounds (standard). Owing to lack of skill in the pointer each shot was fired with the cross wires of the telescopes 3 feet above the center of the bull's-eye.

Measured from the foot of the perpendicular to the water through the center of the target the shot fell as follows:

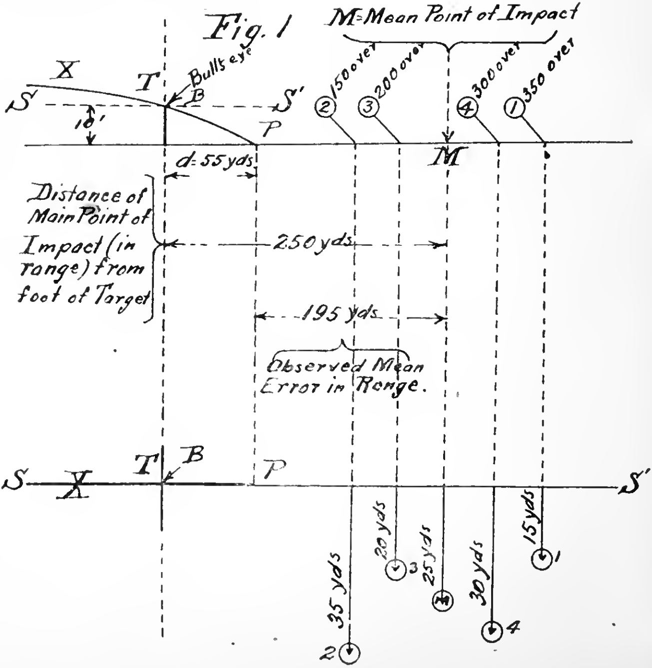
No. 1, 350 yards over, 15 yards right; No. 2, 150 yards over, 35 yards right; No. 3, 200 yards over, 20 yards right; No. 4, 300 yards over, 30 yards right.

Find the mean error of the gun under standard conditions in range and deflection and the mean dispersion in range and deflection.

Solution.

No. of shot.	Fall in range (yards).		Fall in deflection (yards).	
	Over.	Short.	Right.	Left.
1	350	....	15	....
2	150	....	35	....
3	200	....	20	....
4	300	....	30	....
	4)1,000	....	4)100	....

Mean point of impact 250 yards over, 25 yards right. Correction for 10 feet height of center of bull's-eye, from range table column 7, 55 yards.



Observed mean error.—In range, 195 yards over; in deflection, 25 yards right.

It is to be noted that the observed mean error in range as just found contains elements of error in range produced by the following causes: (1) Wind component in the plane of fire; (2) variation of weight of shell from standard weight; (3) variation from standard density of the air; (4) variation from standard temperature of the powder; and (5) cross wires not being on center of bull's-eye at the instant the shot was fired.

TO CORRECT OBSERVED ERRORS FOR VARIATIONS FROM STANDARD CONDITIONS.

Range Corrections.

NOTE.—All data from range tables computed for range of 7,500 yards.

1. **Wind component in line of fire.**—Component of wind in line of fire is 15×cos. 45°. knots=10.6 knots.

From the range table, column 13, a 12-knot wind in the plane of fire, if blowing with the shell, would increase the range 15 yards. Hence the present wind would increase the range 15/12×cos. 45×15=13.3 yards.

2. **Change of range due to variation of weight of shell.**—In this case, the shell being of standard weight, the change of range due to this element would be 0 yards.

3. **Change of range due to density of air.**—From Table II, page 165, Alger's Exterior Ballistics, the density of the air for temperature 60° F. and barometer 30.50 inches is 1.031 or 3.1 per cent greater than standard. The range tables are based upon temperature 59° F. and 29.53 barometer.

From the range tables, column 12, an increase of 10 per cent in density would shorten the range 122 yards. Therefore, the decrease in range due to 3.1 per cent increase in density of air=122/10×3.1=37.8 yards.

4. **Change of range due to temperature of powder.**—From the range tables, column 10, the standard temperature of the powder is 90° F., and an increase of 10° in the temperature would increase the muzzle velocity by 35 foot-seconds. It is also noted in range tables that a change in muzzle velocity of 50 foot-seconds would change the range 215 yards. Hence, increase in muzzle velocity is 35/10×(100–90)=35 foot-seconds, and increase of range due to this increase of muzzle velocity will be 215/50×35=150.5 yards.

5. **Correction for point of aim.**—From the tables again, column 19, the increase of range due to raising the point of impact 18 feet is 100 yards. Therefore the increase due to aiming 3 feet high is 100/18×3=16.7 yards.

6. **Summary of correction for range.**—Compared to the range of a standard shell, the shots fired under the conditions of the problem would fall, for each variation in conditions, as follows:

	Yards.	
	Over.	Short.
Wind	13.3	....
Weight of shell	0	....
Density of air	....	37.8
Temperature of powder	150.5	....
Error in aim	16.7	....
Sum	180.5	37.8

	Yards over.
Correction to mean observed error in range=difference	142.7
Mean observed error in range	195.0
True mean error in range (under standard conditions)	52.3

7. **To correct the observed mean error in deflection.**—By similar process from range table, column 16, the wind component would produce a deflection of $7/12 \times 15 \times \sin. 45° = 6.2$ yards right; which applied to the "observed mean error in deflection" of 25 yards, would give the "true mean error in deflection" under standard conditions to be $25 - 6.2 = 18.8$ yards right.

8. **Final results for this one gun.**—The final results for this gun show that if it were aimed at the bull's-eye of the target, as before explained, its shot would, under standard conditions, fall 52.3 yards beyond (over) and 18.8 yards to the right of where they should fall, i. e., under standard conditions its mean error in range is 52.3 yards over and its mean lateral error or mean error in deflection is 18.8 yards right. From column 18 of range tables, for lateral motion of target perpendicular to line of fire for speed of 12 knots, the deviation is found to be 60 yards. (Column 18 is used because all deflection drums are graduated in knots, considering gun stationary and target moving perpendicular to the line of fire.) Hence, for a lateral deviation of 18.8 yards right at 7,500 yards range the deflection drum scale should be corrected $18.8 \times \frac{12}{60}$ knots$=3.8$ knots.

If the distance of each shot from the mean point of impact be measured and the mean of these distances be found, we have a quantity called the "mean dispersion from the mean point of impact." This information is desirable because it gives an idea of the accuracy or consistent shooting of a gun. For example, one gun of a battery may have its mean point of impact, with reference to a certain target, 100 yards over and 25 yards right, but all the shots may fall within a very few yards of this point and be closely grouped around it.

Another gun of the same battery may have its mean point at the same point, i. e., 100 over+25 right, but its shot may be so scattered or dispersed with reference to the mean point of impact that the average of their distances from the mean point of impact is much greater than that of the first gun.

It is usual to compute the dispersion in range and deflection separately.

As an example, we will find the "mean dispersion from the mean point of impact" of the gun fired in the "problem." (See fig. 1.)

No. of shot.	Distance from mean point of impact. In range.	Distance from mean point of impact. In deflection.
	Yards.	*Yards.*
1	100	10
2	100	10
3	50	5
4	50	5
	4)300	4)30

Mean dispersion from point of impact: Range, 75 yards; deflection, 7.5 yards.
The above quantity is often called the "mean deviation from the mean point of impact."

413. Problem 2—To find possible number of hits on target of a certain size.—The mean errors (deviations) in range and angles of fall of the guns of a certain ship, when firing at a range of 7,800 yards were as follows:

Caliber.	Mean error in range.	Angle of fall.
	Yards.	° ′
6-inch	50	11 08
8-inch	39.5	8 04
12-inch	40	5 41

From each caliber 100 shells are fired at a vertical target screen which is 30 feet high and sufficiently long to catch all shot in deflection, the screen being 7,800 yards distant.

If the mean point of impact of each caliber is at the *center of the target screen*, find the maximum possible number of hits that can be made on this size screen by *each* caliber.

Solution.—We first find the danger space of a 30-foot target for each of the given guns with their angle of fall:

6 inches .... $\omega=11°\ 08'$
8 inches .... $\omega=\ 8°\ 04'$
12 inches .... $\omega=\ 5°\ 41'$

Referring to Alger's Exterior Ballistics (p. 37), two formulæ are given to determine the danger space:

$$D=h \cot \omega$$
$$\text{and} \quad D=h \cot \omega \left(1+\frac{h \cot \omega}{X}\right)$$

where D=danger space and h=height of target.

The first formula gives D accurately enough for present purposes, and we will use it.

6 inches.

D= 30 cot 11° 08′	log 30	=1.47712
	log cot 11° 08′=	.70598
D=152.44 feet.	log D	=2.18310
=50.81 yards.		

8 inches.

D=30 cot 8° 04′	log 30	=1.47712
	log cot 8° 04′=	.84855
D=212.67 feet.	log D	=2.32567
=70.89 yards.		

12 inches.

D=30 cot 5° 41′	log 30	=1.47712
	log cot 5° 41′	=1.00209
D=301.445 feet.	log D	=2.47921
=100.48 yards.		

Again referring to Alger's Exterior Ballistics, Chapter XIII, on Accuracy and Probability of gunfire, and to the table on page 129 in which, in the case we are considering, a equals one-half the danger space of the target, and γ equals the mean error in range:

Case I, 6-inch gun.

In this case, $a=\frac{50.81 \text{ yards}}{2}=25.25$ yards.

and γ=mean error in range, or 50 yards.

$$\frac{a}{\gamma}=\frac{25.45}{50}=.509$$

Entering the table on page 129, referred to above, we find the value of P corresponding to this value of $\frac{a}{\gamma}$ to lie betveen 3.10 and .368.

By interpolation:

$$\frac{.368-.310}{.1}\times.09=.00522$$

or the corresponding value of P for .509 is .315. That is, we may expect, under the given conditions, 31.5 per cent of 6-inch hits.

Case II, 8-inch gun.

$$a=\frac{70.9}{2}\text{ yards}=35.45\text{ yards}$$

$$\gamma=39.5\text{ yards.}$$

$$\frac{a}{\gamma}=\frac{35.45}{39.5}=.897$$

$$P=.526$$

That is we may expect, under the given conditions, 52.6 per cent of 8-inch hits.

Case III, 12-inch gun.

$$a=\frac{100.48}{2}=50.24\text{ yards}$$

$$\gamma=40\text{ yards}$$

$$\frac{a}{\gamma}=\frac{50.24}{40}=1.256$$

$$P=.683$$

That is, we may expect, under the given conditions, 68.3 per cent of 12-inch hits.

414. Problem 3.—To find angle of departure for an elevated target.—An aeroplane is hovering over a point 2,000 yards distant, in a horizontal line, from a 3-inch gun firing a 15-pound shell with an initial velocity of 2,500 f. s. If the altitude of the aeroplane be 1,000 feet, what should be the angle of departure to hit it? All conditions are standard $f=1$, $B=1$.

Solution.—In this problem the angle of position is such that the principle of "rigidity of trajectory" holds true. Hence the range on an inclined plane may be assumed to be practically the same as the range on a horizontal plane, which, in this case, is 6,000 feet, without an appreciable difference in the angle of departure.

Referring to Alger's Exterior Ballistics (p. 79), Case V, given the initial velocity, weight, and diameter of projectile, horizontal and vertical coordinates of target the problem is to find the angle of departure:

$$\begin{aligned} \text{I.}\quad V &= 2{,}500 \text{ f. s.} \\ w &= 15 \text{ pounds.} \\ d &= 3 \text{ inches.} \\ x &= 6{,}000 \text{ feet.} \\ y &= 1{,}000 \text{ feet.} \end{aligned}$$

Formulæ to find α:

$$Sz = \frac{x}{C'} + Sv$$

$$\sin^2\alpha x = C'\left[\frac{Az - Av}{Sz - Sv} - Iv\right]$$

$$\tan p = \frac{y}{x}$$

For getting z, Az, Av, and use of Ballistic Tables No. 1 in Alger's Exterior Ballistics, refer to Chapter V, Alger.

For discussion of principles of "rigidity of trajectory" see pages 14 and 29, Alger.

$$\begin{aligned} \omega &= 15 \quad \log 1.17609 \\ d^2 &= 9 \quad \log\ \underline{.95424} \\ C' &= \qquad \log\ .22185 \\ x &= 6000 \log \underline{3.77815} \\ \frac{x}{C'} &= 3600 \log 3.55630 \\ Sv &= \underline{3297.6} \\ Sz &= 6897.6 \\ Z &= 1582.5 \\ y &= 1000 \log 3.00000 \\ x &= 6000 \log \underline{3.77815} \\ p &= 9^\circ\ 27'\ 45'' \log \tan\quad 9.22185 \\ V &= 2500 \end{aligned}$$

$$z = 1582.5$$
$$Av = 138.07 \qquad Tv = \quad .05524$$
$$Az = 428.75$$
$$\Delta A = 290.68 \qquad \log 2.46341$$
$$\frac{x}{C'} = \Delta S = 3600 \qquad \log 3.55630$$
$$\frac{\Delta A}{\Delta S} = .08074 \qquad \log 8.90711$$
$$Iv = .05524$$
$$\frac{\Delta A}{\Delta S} - Iv = .02550 \qquad \log 8.40654$$
$$C' = \qquad \log \ .22185$$
$$2\alpha x = 2^\circ\ 25'\ 59'' \ \log\sin \ 8.62739$$
$$\sin 2\ \alpha x = .04245$$
$$\tan p = .16667 \ \log\cos \ 9.99405$$
$$.20912 \ \log \ 9.32039$$
$$2\alpha - p = 11^\circ\ 54'\ 14'' \ \log\sin \ 9.31444$$
$$2\alpha = 21^\circ\ 21'\ 59''$$
$$\alpha = 10^\circ\ 40'\ 59''$$

415. Problem 4.—To find range and deflection for opening fire under service conditions.—Enemy's course NNW., speed 15 knots. Your course NE., speed 15 knots. Wind from east with velocity of 12 knots. Temperature of powder, 75° F.; air, 50° F.; shell standard, 12 inches; barometer, 30.44; $\delta = 1.05$.

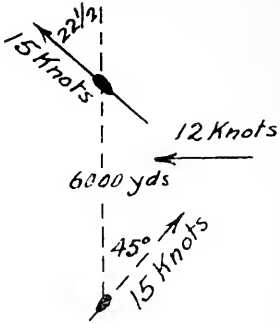
At the instant you are 6,000 yards south of the enemy you intend to fire a trial shot. How would you set your sights in range and deflection?

Solution.

[From Table II, Alger's Exterior Ballistics.]

Barometer, 30.44. Thermometer, 50° F.	$\delta = 105$. Taking 1.00 as normal, density of atmosphere is 1.05 — 1.00=5 per cent above normal.

Temperature of powder=75° F. Normal temperature of powder is 90° F. Therefore, this powder is 90 — 75=15° below normal.



Resolving forces ⊥ and ∥ to plane of fire we have:

Speed of ship ∥ to plane of fire=15 cos 45 =10.61 knots.
Speed of ship ⊥ to plane of fire=15 sin 45 =10.61 knots.
Speed of target ∥ to plane of fire=15 cos 22½=13.86 knots.
Speed of target ⊥ to plane of fire=15 sin 22½= 5.74 knots.
Speed of wind ⊥ to plane of fire= 12.00 knots.

From 12-inch Range Tables, range 6,000 yards:

(*a*) Column 14. Change of range for motion of gun in plane of fire, speed 12 knots=37 yards.

$$\therefore \text{ Change for 10.61 knots}=\frac{10.61\times37.00}{12}=32.71.$$

(*b*) Column 17. Deviation for lateral motion of gun ⊥ to plane of fire, speed 12 knots=42 yards.

$$\therefore \text{ Deviation for 10.61 knots}=\frac{10.61\times42}{12}=37.14.$$

(*c*) Column 15. Change of range for motion of target in plane of fire, speed 12 knots=47 yards.

$$\therefore \text{ Change for 13.86 knots}=\frac{13.86\times47}{12}=54.29 \text{ yards.}$$

(*d*) Column 18 deviation for lateral motion of target ⊥ to plane of fire, speed 12 knots=47 yards.

$\therefore$ Deviation for 5.74 knots$=\frac{5.74\times 47}{12}=22.48$ yards.

(*e*) Column 16. Deviation for lateral wind component of 12 knots =5 yards.

(*f*) Column 12. Change of range for variation of density of air of ± 10 per cent=83 yards.

$\therefore$ Change for 5 per cent$=\frac{5\times 83}{10}=41.5$ yards.

(*g*) From "Explanatory notes" in front of Range Tables a change in temperature of powder of 10° F. causes a variation in muzzle velocity of 35 f. s.

$\therefore$ Variation of muzzle velocity for 15° F.=52.5 f. s.

Column 10. Change of range for variation of muzzle velocity of ±50 f. s.=175 yards.

$\therefore$ Change for 52.5 f. s.$=\frac{52.5\times 175}{50}=183.75$.

These results are tabulated as follows:

12-inch, 6,000 yards.

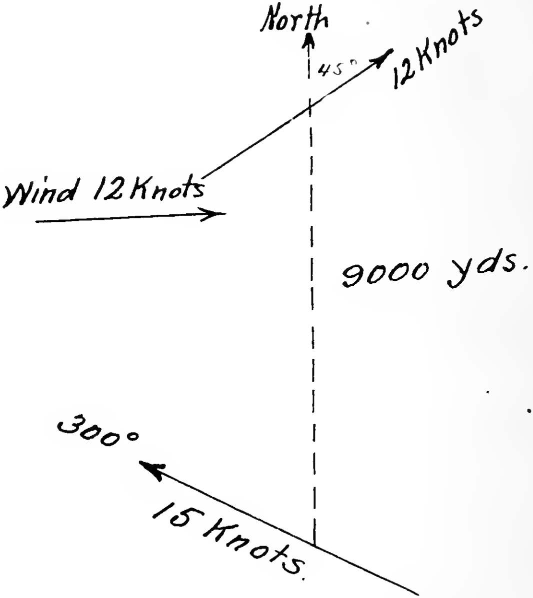
	Argument.	Over.	Short.	Right.	Left.
Change of range for motion of gun in plane of fire	10.61	32.7			
Deviation for lateral motion of gun ⊥ to plane of fire	10.61			37.1	
Change of range for motion of target in plane of fire	13.86		54.3		
Deviation for lateral motion of target ⊥ to plane of fire	5.74			22.5	
Deviation for lateral wind component	12				5.0
Change of range for variation in density of air ... per cent	+5		41.5		
Change of range for variation in temperature of powder ... degrees	−15		183.8		
Final result {246.9 short / 54.6 right}		32.7	279.6	59.6	5.0
			32.7	5.0	
			246.9	54.6	

∴ Sight bar should be set 6,000+246.9=6,246.9 yards.

Actually the setting would be 6,250 yards.

The deflection scales being graduated for "knots speed of target." 54.6 yards must be converted to knots speed of target.

Column 18. Deviation for motion of target ⊥ to line of fire, speed 12 knots=47 yards.



$\therefore$ 1 yard $=\frac{12}{47}$ knots.

$\therefore$ 54.6 yards $=\frac{54.6\times12}{47}=13.94$ knots.

The graduation 50, being zero deflection, to compensate for 54.6 yards, the drum must be set at 50−13.94=36.06.

Actually, the setting would be 36.

416. Problem 5.—To find range and deflection for opening fire under service conditions.—Plot this situation before working the problem.

You are chief fire-control officer of a battleship carrying 12-inch and 6-inch guns, and have been ordered by the captain to open fire with the 12-inch the instant the range is 9,000 yards, bearing north.

The speeds and courses of the enemy and yourself at the instant of firing are as follows: *Enemy*, course 45°, speed 12 knots; *firing ship*, course 300°, speed 15 knots, and this information is known to you sufficiently in advance to allow for variation from standard conditions in setting your sights. If the barometer is 29 inches, thermometer 75° F., temperature of the powder 95°, and the wind, from the west, is blowing 12 knots over the surface of the water, what would be the range at which you would set the 12-inch sight bars for the opening shot?

If the deflection scales of your guns are graduated for the speed of the target in knots, and the middle line of zero deflections is marked 50, how would you set the 6-inch and 12-inch deflection scales for opening fire in the problem above?

Solution.

[From Table II, Alger's Exterior Ballistics.]

Barometer 29.00 } $\delta = .95$ { Taking 1.00 as normal density of
Thermometer 75° F. } { atmosphere, $1.00 - .95 = 5$ per cent below normal.

Temperature of powder 95° F. Normal temperature of powder is 90° F. Therefore this powder is $95° - 90° = 5°$ above normal.

Resolving forces ∥ and ⊥ to plane of fire we have:

Speed of ship ∥ to plane of fire $= 15 \cos 60 = 7.5$ knots.

Speed of ship ⊥ to plane of fire $= 15 \sin 60 = 12.99$ knots.

Speed of target ∥ to plane of fire $= 12 \cos 45 = 8.49$ knots.

Speed of target ⊥ to plane of fire=12 sin 45=8.49 knots.

From 12-inch range tables for range of 9,000 yards:

(*a*) Column 14. Change of range for motion of gun in plane of fire for speed of 12 knots=52 yards:

$\therefore$ Change for 7.5 knots$=\frac{7.5\times52}{12}=32.5$ yards.

(*b*) Column 17. Deviation for lateral motion of gun ⊥ to line of fire speed 12 knots=63 yards.

$\therefore$ Deviation for 12.99 knots$=\frac{12.99\times63}{12}=68.198$ yards.

(*c*) Column 15. Change of range for motion of target in plane of fire speed 12 knots=74 yards.

$\therefore$ Change for 8.49 knots$=\frac{8.49\times74}{12}=52.355$ yards.

(*d*) Column 18. Deviation for lateral motion of target ⊥ to line of fire speed 12 knots=74.

$\therefore$ Deviation for 8.49 knots$=\frac{8.49\times74}{12}=52.355$ yards.

(*e*) Column 16. Deviation for lateral wind component of 12 knots ⊥ to plane of fire=11 yards.

(*f*) Column 12. Change of range for ± 10 per cent variation in density of air=174 yards.

$\therefore$ Change for 5 per cent variation$=\frac{174\times5}{10}=87$ yards.

(*g*) From explanatory notes in front of range tables a change in temperature of powder of 10° F. causes a change in muzzle velocity of 35 f. s.

$\therefore$ Change for 5°$=\frac{5\times35}{10}=17.5$ f. s.

Column 10. Change of range for ± 50 f. s. change in muzzle velocity=254 yards.

$\therefore$ Change for 17.5 f. s.$=\frac{17.5\times254}{50}=88.9$ yards.

These results are tabulated as follows:

	Argument.	Over.	Short.	Right.	Left.
Change of range for motion of gun in plane of fire	7.5	32.5	......	......	......
Deviation for lateral motion of gun ⊥ to plane of fire	12.99	......	......	......	68.2
Change of range for motion of target in plane of fire	8.49	......	52.4	......	......
Deviation for lateral motion of target ⊥ to plane of fire	8.49	......	......	......	52.4
Deviation for lateral wind component	12.0	......	......	11.0	......
Change of range for variation of density of air ... per cent	+5	87.0	......	......	......
Change of range for variation in temperature of powder ... degrees	+5	88.9	......	......	......
Final result {156 yards over	....	208.4	52.4	11.0	120.6
Final result {109.6 yards left	....	52.4	......	......	11.0
		156.0	......	......	109.6

∴ Sight bar should be set at 9,000−156=8,844. Actually it would be set at 8,850 yards.

The deflection scales of all guns are graduated for "knots speed of target," therefore the 109.6 yards must be converted to knots speed of target.

Column 18. Deviation for motion of target ⊥ to plane of fire speed 12 knots=74 yards.

∴ 1 yard=12/74 knots on drum.

∴ 109.6 yards$=\frac{109.6\times 12}{74}=$17.77 knots on drum.

The graduation 50 being zero deflection to compensate for 109.6 yards left we should set drum at 50+17.77=67.77. Actually it would be set at 68.0.

For the 6-inch guns the method is the same, using the 6-inch range tables for 9,000 yards.

From columns 16, 17, and 18 we find that due to wind, speed of ship, and speed of target ⊥ to plane of fire the shell would be displaced 118.03 yards to the left of target. (In this case we are not concerned with the error in range.)

	Argument.	Right.	Left.
Deviation for lateral motion of gun ⊥ to plane of fire	12.99	....	76.86
Deviation for lateral motion of target ⊥ to plane of fire	8.49	....	72.17
Deviation for lateral wind component	12.00	31.0	....
	....	31.0	149.03
			31.00
			118.03

From Column 18 the deviation for 12 knots speed of target=102 yards.

∴ For 118 yards it would be $\frac{118 \text{x} 12}{102}=13.88$.

∴ Deflection scale should be set at 50+13.88=63.88. Actually it would be set at 64.

417. Problem 6.—(1) To find change in sight-bar range when shot does not hit bull's-eye; (2) to find fall of shot when sights are not corrected for wind and speed.—Using the 12-inch range table, determine the following:

(1) A gun is fired at a vertical target screen 2,000 yards distant with sights set for a range of 2,000 yards. The shell pierced the target 6 feet above the bull's-eye. What sight-bar range must be used if the next shot is to hit the bull's-eye?

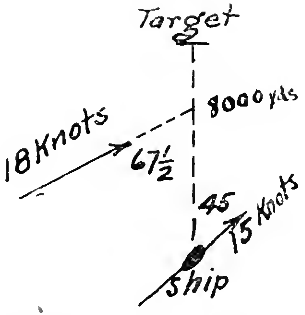
(2) At a certain instant a ship, steaming at 15 knots on a northeast course, is directly south of a stationary target which is 8,000 yards away. An 18-knot breeze is blowing from west-southwest at the time. Find the changes in *range* and *deflection* due to (1) speed of ship and (2) wind; and state where the shot would fall if the ship fires, at the instant noted above, with the sights set for 8,000 yards and no deflection.

Solution.—(1) From 12-inch range tables, range 2,000 yards:

Column 19. Change in height of impact for variation of ±100 yards in sight bar=4 feet.

∴ Change for 6 feet height of impact=150 yards.

∴ Set sight bar at 2000−150=1,850 yards.



(2) Resolving forces ⊥ and ∥ to plane of fire.

Speed of ship ∥ to plane of fire =15 cos 45=10.61 knots.
Speed of ship ⊥ to plane of fire =15 sin 45=10.61 knots.
Speed of wind ∥ to plane of fire =18 cos 67½=6.89 knots.
Speed of wind ⊥ to plane of fire =18 sin 67½=16.63 knots.

From 12-inch range tables, range 8,000 yards:

(*a*) Column 14. Change of range for motion of gun in plane of fire, speed 12 knots=47 yards.

$$\therefore \text{Change for 10.61 knots} = \frac{10.61 \times 47}{12} = 41.56 \text{ yards.}$$

(*b*) Column 17. Deviation for lateral motion of gun ⊥ to plane of fire, speed 12 knots=56 yards.

$$\therefore \text{Deviation for 10.61} = \frac{10.61 \times 56}{12} = 49.51 \text{ yards.}$$

(*c*) Column 13. Change of range for wind component in plane of fire, speed 12 knots=17 yards.

$$\therefore \text{Change for 6.89 knots} = \frac{6.89 \times 17}{12} = 9.76 \text{ yards.}$$

(*d*) Column 16. Deviation for lateral wind component of 12 knots=8 yards.

$\therefore$ Deviation for 16.63 knots$=\frac{16.63\times 8}{12}=11.09$ yards.

These results are tabulated as follows:

	Argument.	Over.	Right.
Change of range for motion of gun in plane of fire........	10.61	41.56	....
Deviation for lateral motion of gun ⊥ to plane of fire.....	10.61	....	49.51
Change of range for wind component in plane of fire.....	6.89	9.76	....
Deviation for lateral wind component..................	16.63	....	11.09
	....	51.32	60.60

(*a*) Effect due to movement of ship: 41.56 over, 49.51 right.

(*b*) Effect due to wind: 9.76 over, 11.09 right.

Combining (*a*) and (*b*) we find the shell would fall: 41.56+9.76=51.32 yards over. 49.51+11.09=60.60 yards right.

418. Problem 7.—To find size of target to catch all properly aimed shots.

If the mean error in range of a pointer's gun be 25 yards, at a range of 1,700 yards, what should be the height of a vertical target screen to catch all properly aimed shots, the point of aim being the center of the target, the angle of fall being 1° 23′?

Definition of terms:

P=Probability of hitting.

a_y=One-half height of target.

γ_x=Mean deviation in range=25 yards=75 feet.

γ_y=Mean vertical deviation.

ω=Angle of fall=1° 23′.

From Alger's Exterior Ballistics, page 129, probability table, if the probability of hitting (P) is 100 (.999), the distance a_y must equal four times the mean vertical deviation, γ_y.

From Alger's Exterior Ballistics, page 139, art. 146:

$$\gamma x = \gamma y \cot \omega.$$

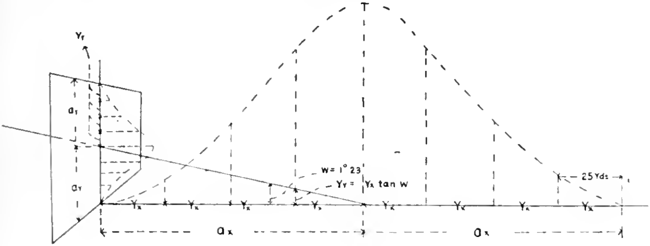
Solving:

$\gamma x = 75'$	log	1.87506
$\omega = 1^\circ\ 23'$	tan	8.38289
$\gamma y = 1'.81$	log	10.25795

But $\frac{ay}{\gamma y}$ must equal 4.

$\therefore\ ay = 4 \times \gamma y = 4 \times 1'.81 = 7'.24.$

$\therefore$ Height of target $(2ay) = 14.48$ feet.



NOTE.—It will also be noted that $4 \times ay$, or $4 \times 75' = 300'$, is equal to half the danger space.

419. Problem 8.—To find change in range due to variation from standard (1) temperature of powder, (2) initial velocity, (3) weight, (4) density of air.—Using the 12-inch range table, determine the following:

(1) What would be the change of initial or muzzle velocity if the temperature of the charge were 101° F. instead of 90° F., for which the range tables were calculated?

(2) What will be the change of range due to this change in muzzle velocity if the angle of departure be 3° 12′?

(3) If the gun is fired at this elevation (3° 12′), standard condition, except that the shell weighed 820 pounds instead

of 870 pounds, how much will the range be increased or decreased?

(4) All conditions being standard except the density of the air, which is 5 per cent greater than normal, what will be the range of the shell if it is fired with an angle of departure of 3° 41′.9?

Solution.—(1) The temperature of the charge is 101°—90°=11° above normal.

From explanatory notes in front of range tables we find that a change of 10° F. in temperature of powder changes the initial velocity 35 f. s.

∴ 11° above normal increases the initial velocity by 38.5 f. s.

(2) From columns 1 and 2 an angle of departure of 3° 12′ gives a range of 8,000 yards with normal initial velocity.

To find change due to initial velocity, increased as in (1)—that is, by 38.5 f. s.—proceed as follows:

Column 10. Change of range for variation of ±50 f. s. initial velocity=229 yards.

$$\therefore \text{Change for 38.5 f. s.} = \frac{38.5 \times 229}{50} = 176.33 \text{ yards.}$$

(3) Note.—Charge remaining the same, weight of shell increased, will it go farther or less with the same angle of departure? The following *net result* was determined from proving-ground data:

For each case the initial velocity is reduced with heavier shell and the range for short ranges is decreased and for long ranges is increased.

Column 11. Variation for ±10 pounds in weight of projectile=39 yards.

∴ Variations for (870—820) 50 pounds=195 yards increase in range.

(4) From columns 1 and 2 an angle of departure of 3° 41′.9 gives a range of 9,000 yards under standard conditions.

Column 12. Change of range for variation of density of air of ±10 per cent=174 yards.

$\therefore$ Change for 5 per cent $= \frac{5 \times 174}{10} = 87$ yards decrease.

Therefore actual range $= 9{,}000 - 87 = 8{,}913$ yards.

420. Problem 9.—To find range and deflection for opening fire under service conditions.—Draw a diagram of the situation before solving.

	Firing ship.	Target ship.
Speed	18 knots.	15 knots.
Course	Northeast	East northeast.

Wind from the northwest, blowing 15 knots per hour over the water.

Barometer, 30.02″. Temperature of air, 78° F. Temperature of powder, 83° F.

(1) What should be the readings of the range and deflection scales for opening fire with the 12-inch guns at the instant the enemy bears N. 30° E. and is distant 8,000 yards?

(2) What should be the reading of the 6-inch deflection scales at this moment if fire is opened with the 6-inch also?

Solution.

[From Table II, Alger's Exterior Ballistics.]

Barometer 30.02 / Thermometer 78° F. } $\delta = .978$. Taking 1.00 as normal, density of atmosphere $= 1.00 - .978 = 2.2$ per cent below normal.

Temperature of powder, 83° F.; normal temperature powder is 90° F.; therefore this powder is $90 - 83 = 7°$ below normal.

Resolving forces // and $\pm$ to plane of fire. (Traverse tables *may* be used):

Speed of ship // to plane of fire $= 18 \cos 15° = 17.38$ knots.

Speed of ship $\pm$ to plane of fire $= 18 \sin 15° = 4.66$ knots.

Speed of target // to plane of fire $= 15 \cos 37\frac{1}{2}° = 11.90$ knots.

Speed of target $\pm$ to plane of fire $= 15 \sin 37\frac{1}{2}° = 9.13$ knots.

Speed of wind // to plane of fire = 15 cos 75° = 3.88 knots.
Speed of wind ⊥ to plane of fire = 15 sin 75° = 14.49 knots.

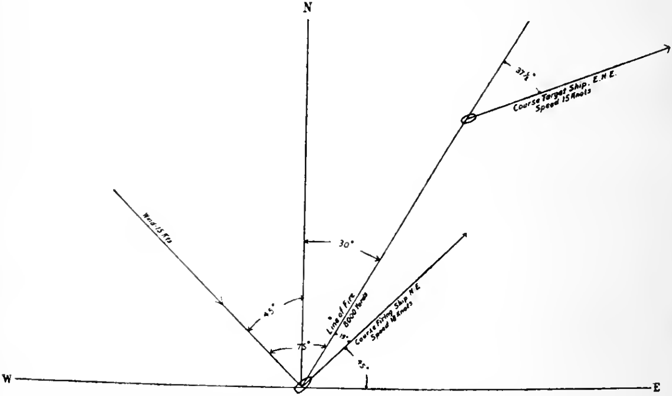
(1) From 12-inch range tables for range of 8,000 yards:

(*a*) Column 14. Change of range for motion of gun in plane of fire, speed 12 knots = 47 yards.

$\therefore$ Change for 17.38 knots $=\frac{17.38\times 47}{12}=68.07$ yards.

(*b*) Column 17. Deviation for lateral motion of gun ⊥ to line of fire, speed 12 knots = 56 yards.

$\therefore$ Deviation for 4.66 knots $=\frac{4.66\times 56}{12}=21.75$ yards.



(*c*) Column 15. Change of range for motion of target in plane of fire, speed 12 knots=65 yards.

$\therefore$ Change for 11.90 knots $=\frac{11.90\times 65}{12}=64.46$ yards.

(*d*) Column 18. Deviation for lateral motion of target ⊥ to line of fire, speed 12 knots=65 yards.

Therefore deviation for 9.13 knots $=\frac{9.13\times 65}{12}=49.45$ yards.

(*e*) Column 13. Change of range for wind component in plane of fire, speed 12 knots=17 yards.

∴ Change for 3.88 knots $=\frac{3.88\times 17}{12}=5.50$ yards.

(*f*) Column 16. Deviation for lateral wind component, speed 12 knots = 8 yards.

∴ Deviation for 14.49 knots $=\frac{14.49\times 8}{12}=9.66$ yards.

(*g*) Column 12. Change of range for variation of density of air of + or − 10 per cent = 136 yards.

∴ Change for 2.2 per cent $=\frac{2.2\times 136}{10}=29.92$ yards.

(*h*) From explanatory notes in front of range tables a change in temperature of powder of 10° F. causes a change in muzzle velocity of 35 f. s.

∴ Change for $7°=\frac{7\times 35}{10}=24.5$ f. s.

Column 10. Change of range for variation of ±50 f. s. initial velocity = 229 yards.

∴ Change for 24.5 f. s. $=\frac{24.5\times 229}{50}=112.21$ yards.

These results are tabulated as follows:

	Argument.	Over.	Short.	Right.	Left.
Change of range for motion of gun in plane of fire	17.38	68.07	......	......	......
Deviation for lateral motion of gun ⊥ to plane of fire	4.66	......	......	21.75	......
Change of range for motion of target in plane of fire	11.90	......	64.46	......	......
Deviation for lateral motion of target ⊥ to plane of fire	9.13	......	......	......	49.45
Change of range for wind component in plane of fire	3.88	......	5.50	......	......
Deviation for wind component ⊥ to plane of fire	14.49	......	......	9.66	......
Change of range for variation in density of air	+2.2%	29.92	......	......	......
Change of range for variation in temperature of powder	−7°	......	112.21	......	......
	......	97.99	182.17 97.99	31.41	49.45 31.41
Final results: 84.18 yards short, 18.04 yards left	......	......	84.18	......	18.04

Therefore sight bar should be set at 8,000+84.18=8,084.18 yards. Actually it would be set at 8,100 yards.

The deflection scales of all guns are graduated in "knots speed of target," therefore the 18.04 yards must be converted to knots speed of target.

Column 18. Deviation for lateral motion of target 1 to line of fire, speed 12 knots=65 yards.

$$\therefore 1 \text{ yard} = \frac{12}{65} \text{ knots on drum.}$$

$$\therefore 18.04 \text{ yards} = \frac{12 \times 18.04}{65} = 3.33 \text{ knots.}$$

Therefore the deflection drum should be set at **50+3.33=53.33.** Actually it would be set at 53.

(2) For the 6-inch deflection the method is the same, using the 6-inch range tables for 8,000 yards.

From columns 16, 17, and 18 we find that due to wind, speed of ship, and speed of target 1 to plane of fire the shell would be displaced 12.75 yards to left of the target. (In this case we are not concerned with the error in range.)

	Argument.	Right.	Left.
Deviation for lateral motion of gun 1 to plane of fire.....	4.66	24.46	....
Deviation for lateral motion of target 1 to plane of fire...	9.13	....	66.19
Deviation for lateral wind component	14.49	28.98	....
	....	53.44	66.19 53.44
			12.75

Column 18. Deviation for lateral motion of target 1 to plane of fire, speed 12 knots=87 yards.

$$\therefore 1 \text{ yard} = \frac{12}{87} \text{ knots.}$$

$$\therefore 12.75 \text{ yards} = \frac{12 \times 12.75}{87} = 1.76 \text{ knots.}$$

Therefore the deflection drum should be set at **50+1.76=** 51.76. Actually it would be set at 52.

CHAPTER 18.

STATION BILLS.

421. Scope of chapter.—The following is a brief outline of a fire-control bill for an all-big-gun ship. Numerous variations of the plan herein outlined will be found, and it is not at all correct in detail for all ships. The method of using the system of communications varies. Some vessels use clocks in subcentral, while others rely on curves for tracking the enemy, or for graphically keeping the range and change of range. The general plan of fire control in all, however, is the same.

422. Station bill and lookouts.—In drawing up the station bills particularly for torpedo defense, proper regard for conditions of service should be observed. Officers and men must be given stations that they could occupy and an arrangement of reliefs must be provided as would be the case in war when an engagement might be imminent.

(*a*) *Fire-control—Fire-control tower group.*

Designation.	Personnel.	Duty.	
		Collective fire.	Group fire.
Chief fire control, J. A. phone.	Officer..	Chief fire-control officer talks to fire-control switchboard.	Chief fire-control officer spot one group if necessary.
Fire-control tower spotter, J. C. phone.	...do.....	Relief spotter ring salvo signals.	Spot either group as needed and ring salvo signals.
J. D. control..........	Man.....	Talker to turrets......	Do.
J. W. control..........	...do.....	Talker to range finders and timekeepers.	Do.
Torpedo director......	Officer..	Fires torpedoes........	Do.

(b) Subcentral group.

Designation.	Personnel.	Duty.	
		Collective fire.	Group fire.
Subcentral	Officer	Charge of subcentral, on J. A. phone.	Charge of subcentral.
Rate plotter	...do	Plot range-finder observation on rate of change board.	Same as collective fire.
Clock	Man	Operate main clock	Operate clock for after group.
Dials	...do	Operate main dials	Operate dials for after group.
Check clock	...do	Operate check clock	Operate clock for forward group.
Check dials	...do	Operate check dials	Operate dials for forward group.
Tracker	Officer	Tracking board	Track for after group.
Tracker assistant	...do	Assist at tracking board.	Track for forward group.
Timekeeper	Man	Mark time for range finders; repeat and record ranges and bearings; phone to range finders.	Same as collective fire.
Tube man	...do	Repeat voice-tube communications.	Do.
Switchboard	...do	Operate fire-control phone switchboard.	Do.
Fire-control repairs	Electrician.	Gyro compass and repairs.	Do.

(c) *Subgroup.*

Designation.	Personnel.	Duty.	
		Collective fire.	Group fire.
Sub	Officer or petty officer.	In charge	In charge.
Sub (1)	Man	Telephone range and deflection to turrets; operate deflection transmitter.	Telephone range and deflection to after group; operate range and deflection transmitter to after group.
Sub (2)	do	Operate range transmitter; stand by voice tubes.	Operate range and deflection transmitter to forward group; telephone range and deflection to forward group.

(d) *Fore-top group.*

Designation.	Personnel.	Duty.	
		Collective fire.	Group fire.
Fore-top spotter	Officer	Spot all turrets	Spot forward group.
Fore-top talker	Man	Tube to subcentral	Same as collective fire.
Bearings	do	Bearing indicator	Indicates bearing for forward group.

(e) *Main-top group.*

Designation.	Personnel.	Duty.	
		Collective fire.	Group fire.
Main-top spotter	Officer	First-relief spotter	Spot after group.
Main-top talker	Man	Tube to subcentral	Same as collective fire

(f) Torpedo-control group.

Designation.	Duty.
Torpedo officer	Torpedo room.
Torpedo director officer	At torpedo director.

(g) Range-finder group.

Each crew consists of an officer and man (or two men).

For collective fire any one or all may be designated to range.

For group fire the system is flexible, and any two may be designated, each for one group. Communicate by phone or voice tube to the fire-control tower and subcentral.

(h) Turret group.

In case the fore-top spotter, the main-top spotter, and the fire-control-tower spotter are disabled, but ship is still able to fight all guns:

For collective fire the turret officer of the highest turret spots from his turret.

For group fire the turret officer of the highest turret in each group spots for that group.

423. Operation of system.—On approaching the target the taking of ranges and bearings is commenced on order from the fire-control station. At the order "mark" stop watches are started by men at each range finder, at the station where the bearing of the target is obtained, on the line of communication in the subcentral, and in the fire-control station. The number of timekeepers is less than those enumerated above in some cases. With proper means of communication to stations numerous variations in details are found. Loss of one means of communication does not entail the loss of the services of any station, but necessitates the shifting to the best auxiliary method of communication. At every half minute, if possible, a range-finder reading is obtained. One range finder, the best, is used, the others standing by, or the mean of readings of all instruments is taken. Bearings of the target are taken every half minute, if a bearing indicator, which constantly indicates the bearing of the target, is not installed. These bearings are relative to the ship, and in degrees from 0° ahead around to 360°. Information regarding the range and bearing of the target is sent to the plotting board, and plotting to obtain rate of change of range and course and speed of the enemy is begun. The range clocks are located near the range dials, so that the dial operators may watch the clocks. The clocks are rated for the proper rate of change of range as soon as a rate is determined. If all guns are being used on the same target, all dials are set simultaneously with the master clock when the clock operator calls out the range and only one range clock is used, the other being a stand-by.

The man at the deflection board, taking the approximate rate at which the enemy is approaching, referred to a course parallel to the ship's course, and using bearing of the enemy as the other factor, automatically obtains the necessary deflection.

The ranges are sent to subs by the range dials and from the subs are sent out by visuals, telephone and voice tubes giving the information several seconds later.

The chief fire-control officer designates the turret to fire ranging shots, and at the order to begin ranging "fire" is displayed on all visuals. The turret designated to fire ranging shots is notified from the subs, if a previous notification has not been given. When a ranging shot is fired the spotter sends down the spot by visual indicator, telephone, and voice tube and directs "fire second ranging shot" or "open salvo," as necessary. The chief fire-control officer is informed of the spotter's first correction, the spot is given to the plotters, who

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make their corrections and pass the result to the range-clock man.

As soon as any change in range or deflecion is sent out by the visuals to the turrets, "set" is called out from the subcentral over the J. B. phone. If no change is to be made, the word "set" or "no change" is called out immediately.

As soon as the chief fire-control officer gets the word "open salvo," as described above, he orders the salvo signals begun. The person controlling the salvo signals wears a phone and waits for the word "set" from the subcentral, then sounds the bells and buzzers in accordance with the prearranged plan.

If it is found that the rate of change obtained does not keep the salvos straddle of the target, the plotted line is changed one-half the change indicated by the spots. No changes in range are sent out to the turret after a "stand-by" signal unless a change of more than 100 yards is required, in which case the subcentral directs "hold the fire," and the salvo-control officer holds the fire until he hears "set."

Each turret employs a definite system in locally controlling the fire. Some latitude is given to the turret officers, and minor features vary somewhat in turrets, although the general scheme is the same for all. In each turret are three salvo bells and three buzzers, one bell and one buzzer near each elevating pointer and one bell and buzzer in the turret officer's booth. Thus, each elevating pointer and the turret officer are notified simultaneously regarding salvos. In the turret officer's booth are sets of switches, one for signal lights and one for firing circuits. In case single-barreled salvos are used, the turret officer throws a double-throw switch, which flashes a light close to the eye of the pointer of the gun designed to fire and another overhead in the rear of the opposite gun, thus notifying the opposite gun that the other is to fire. In case double-barreled salvos are used, the turret officer flashes the light close to the eye of the firing pointer and throws the necessary firing-circuit switch to fire double barreled. In case it is desired to cut out a turret or turrets, the necessary switches are thrown by salvo operator in fire-control station, and consequently bells and buzzers are not rung in the turret or turrets cut out.

424. Cease firing.—At "cease firing" the chief fire-control officer directs "cease firing" over the telephone. The word is passed over voice tubes and phones to turrets, and "cease" is displayed on visuals. The salvo signals are stopped, and the "cease firing" gongs are rung from the fire-control station.

425. Torpedo firing.—The course and speed of the enemy are tracked and the results sent to the torpedo-director officer, who keeps the directors set, so that torpedoes may be fired at any time.

TORPEDO DEFENSE.

426. Personnel of group control parties.—Each group has an independent fire-control party as follows:

One officer, spotter.

One officer in charge of searchlight control.

One range keeper and talker.

One petty officer or man to operate distant control of searchlight.

One spotter's lookout.

Each group is equipped with telephones and voice tubes, each gun and fire-control group having its own circuit. Each has a searchlight assigned to it, and a crew consisting of a man and helper who focus the light and stand by to elevate and train as necessary in case distant control fails to function.

The system is elastic and the eight groups (four on a side) may be combined at discretion. Each group is entirely independent of every other group except as regards salvo signals unless combined.

427. Operation of system.—The chief fire-control officer and assistant fire-control officers are stationed on the bridge. The former gives orders directly to the assistant fire-control officers. These officers wear the telephones. An officer or petty officer operates the master key for controlling the salvo signals, which enable the guns in all groups to fire at the same time. The operator of the master key gives two short rings shortly before firing to "stand by," and a prolonged ring to "fire." During this prolonged ring all guns receiving the signal fire when "on." Attempt is not made to fire all guns simultaneously as this would interfere with accurate shooting. The time of the firing interval is regulated by the chief fire-control officer.

The officer in charge of a group receives the order "commence firing" from the chief fire-control officer. The group spotter then orders a certain gun of his group to fire ranging shots, the talker passing the word to the gun designated, together with the initial range and deflection.

After firing sufficient ranging shots to get on, the sights of all guns being kept corrected, the group spotter orders "open salvo." The order is passed down by the talker to all guns of the group. When order "open salvo" is given the group spotter closes the group key, and the guns of that group receive the salvo signal when the master key is operated from the bridge. In case it is desired to have the guns of a group cease firing, or it is desired to again fire with an individual gun, the group key is opened, and the salvo signals cease and the necessary instructions are sent to the gun or guns over the lines of communication by the group fire-control officer. By this means an individual and elastic means of control is provided.

As the spotter for each group sings out a spot, the talker applies it to the range and deflection board which he holds in his hands and passes the corrected range and deflection to the group of guns.

Each gun should have a standard range and deflection for zone fire, at which sights should be set and maintained whenever quarters are sounded for torpedo defense, until other ranges and deflections are ordered. Attention is invited to the advisability of firing short rather than over.

CHAPTER 19.

ERRORS OF GUNFIRE.

The following is a reprint of Ordnance Pamphlet No. 409, of August, 1912, on Dispersion and Errors of Gunfire, with minor additions:

428. Dispersion, elements of.—On investigation it will be found that all the errors that exist in gunfire may be grouped under two heads:

I. Range errors and lateral errors.

II. Dispersion errors, both vertical and lateral.

I. It is convenient to call the range errors and lateral errors "Fire-control errors," as their values are dependent largely on fire control. Even if it were possible to have no dispersion there would always be fire-control errors. The magnitude of these errors may be obtained from target-practice records. Without discussing these errors it is important to understand that no matter what the dispersion errors are, the fire-control errors should be kept as small as possible to insure the maximum hitting.

II. Dispersion errors will always exist. They are due to many causes, the principal of which are:

(*a*) Variations in the powder, projectile, cartridge case, primer, etc.

(*b*) Variations in the gun.

(*c*) Variations in sight, and mounting.

(*d*) Personal errors of pointers and sight setters.

The various elements of these dispersions will be taken up in order.

429. Powder errors:

1. Variation in weight of charge.

2. Variation in temperature of charge.

3. Variation in density of loading.
4. Hygroscopic condition.
5. Variation in age of powder.
6. Imperfect blending.
7. Variation in indexes.
8. Variation in weight and distribution of ignition charge.
9. Variation in form of charge.
10. Unsuitability of powder.
11. Variation in muzzle velocities.

430. Variation in weight of charge.—A variation in the weight of charge may occasion a large variation in pressure, giving a large error in muzzle velocity.

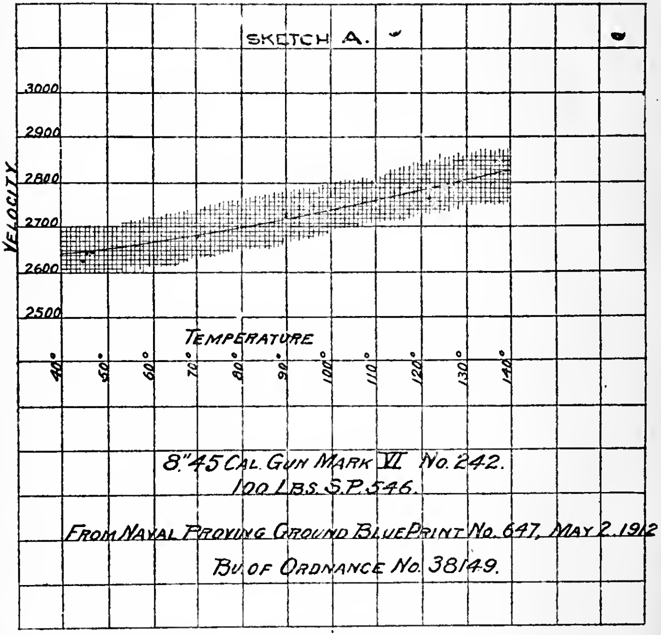
Great care is taken in establishing the correct weight of charges assigned to the various guns. Especial care is taken in the magazines in assembling the weight of charge correctly, but it may happen through some mischance that either the wrong powder or the wrong weight of charge is used in the gun. Every precaution should be taken to prevent this, as aside from introducing dispersion a small increase in weight of charge may occasion dangerously high pressures.

431. Variation in temperature of charge.—All powder charges are "fixed" at a uniform temperature of 90° F., the temperature closely approximating to that of magizines on board ship.

It will be found that if the temperature varies from 90° F. errors will be occasioned in the initial velocity.

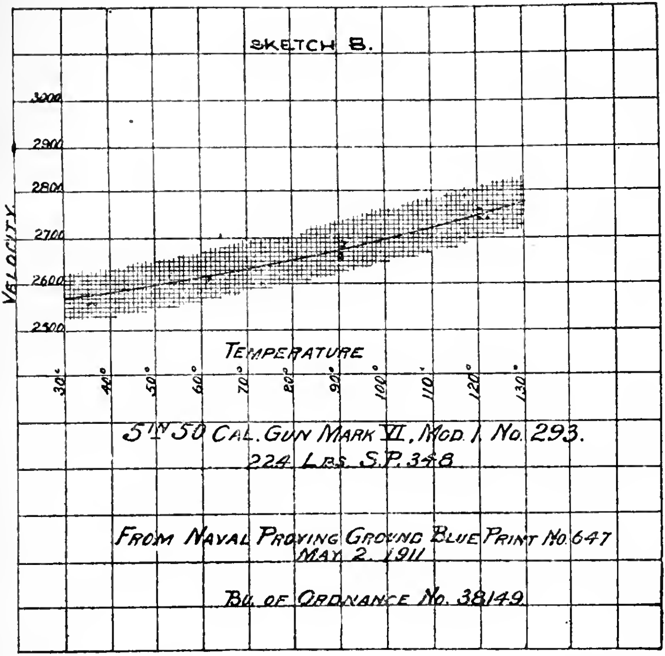
Tests were conducted at the naval proving ground with 4-inch 50-caliber Mark VIII, 5-inch 50-caliber Mark VI, and 8-inch 45-caliber Mark VI guns, to determine the size of this error. From the appended sketches A and B it will be seen that for small variations from 90° F., a change of 1° F. in the temperature will occasion a change in the initial velocity of about 2 foot-seconds.

It is not important that the magazines should be kept at 90° F., but it is very important that all magazines should have the same temperature, or that proper allowance be made where temperatures differ. It could readily happen that one magazine was 10° F. hotter than another. This increase in temperature will cause an increase in initial velocity of 20 foot-seconds, producing in a 12-inch 2,700 foot-second gun a vertical



error, at 10,000 yards, of about 35 feet. It is evident that this error is very serious and that every effort should be made to keep the temperatures of magazines uniform.

It is important that the temperature of magazines be not only the same, but that the powder should have attained uniform temperature throughout. At the naval proving ground a powder heated 19 hours gave 30 foot-seconds less velocity than when heated 24 hours, although the thermometer in each case registered 90° F.



432. Variation in density of loading.—In general an increase in the density of loading occasions an increase in the pressure and an increase in the initial velocity. With the projectile properly seated and the correct weight of powder charge the density of loading is constant and should occasion no error.

The density of loading is different in different guns, but no error is introduced through this cause, as the weight of charge and the density of loading are interdependent, and any error in the density of loading is eliminated when the charge for a gun is fixed.

As a gun erodes the projectile seats farther down the bore, and a decrease in the density of loading occurs, causing a falling off in pressure and velocity.

The density of loading a gun is given by the formula

$$\Delta = \frac{\bar{\omega} \times 27.68}{\text{Volume of chamber (in cubic inches)}}$$

in which $\bar{\omega}$=weight of charge in pounds.

For a long time it was considered that a density of loading of about 0.5 was correct for nitrocellulose powder. It was deemed necessary, in order to secure proper inflammation of the charge, to have considerable air space around the powder. Further experience has shown that much higher densities of loading can be used. It is not possible from present experience to state what the maximum allowable density of loading should be. A high density of loading should be avoided with quick powder as erratic pressures are likely to be produced. but if slow powder is used the pressures are reliable.

The following satisfactory densities of loading have been obtained: Six-pounder gun, 0.80; 3-inch field gun, 0.77; 5-inch .40-caliber gun, 0.72.

The greatest density of loading obtained in any gun in service is about 0.67. In bag guns the density of loading is limited by the design of the powder chamber and the breech opening. To facilitate loading there must be a definite clearance between the diameter of the powder bag and the smallest diameter of the gas-check seat. With cylindrical charges for good loading conditions this clearance should be about 0.75 inch, and not less than 0.5 inch.

The following table shows the effect on pressure and velocity of changing the density of loading.

Charge.	6-inch .50-caliber gun, No. 338, chamber 75.4 cubic inches larger than No. 353.		6-inch .50-caliber gun, No. 353, chamber of standard size.	
	Pressure.	Initial velocity.	Pressure.	Initial velocity.
	Tons.	*Foot-seconds.*	*Tons.*	*Foot-seconds.*
31 pounds	11.8	2,439	12.6	2,488
32 pounds	13.4	2,567	14.6	2,630
35 pounds	15.3	2,704	16.3	2,785
37.5 pounds	17.4	2,842	18.9	2,949
40 pounds	19.4	2,984	20.9	3,022

433. Hygroscopic condition.—There should be little variation due to hygroscopic condition of powder if the powder is kept in air-tight tanks and is not exposed until shortly before it is fired.

As an extreme case, the following test was conducted to show the effect of moisture on the powder charge. The test was conducted in a 5-inch 50-caliber gun, with a weight of charge of 25 pounds. Two charges were dampened by immersion in water, the free water being drained off.

5-inch 50-caliber guns (charge 25 pounds).

Powder.	Temperature.	Pressure.	Initial velocity.
		Tons.	*Foot-seconds.*
Dry	60° F.	13.7	2,789 } Mean I. V.=2,795.
Do	60° F.	13.8	2,802 }
Damp	60° F.	11.0	2,645 } Mean I. V.=2,628.
Do	60° F.	11.5	2,612 }

It should be understood that the foregoing test is not comparable to that of a powder which has deteriorated through exposure to moisture. The test is merely to show the difference in pressure and velocity between wet and dry powder. Powder exposed to moisture deteriorates, and of course loss of pressure and velocity depend upon the extent of the deterioration.

The slowing down of the powder in the test referred to is due entirely to the absorption of moisture, and this absorption would become greater with powder in which the volatiles were low.

434. Variation in age of powder.—As powder ages it generally loses some of its volatiles and the thickness of the web decreases slightly. This results in making the powder somewhat quicker, giving increased pressure, with a small change in muzzle velocity.

If all the powder of an index is subjected to the same conditions of stowage, however, the change in velocity will be uniform throughout. It is considered that no error is introduced by ageing of powder on board ship, provided the powder passes satisfactory tests, although the velocity and pressure may differ from that on proof. If the powder should begin to deteriorate, large errors would be occasioned in muzzle velocities, but the tests on board ship would detect this deterioration and prevent the use of this powder. The life of powder depends very largely on the conditions of stowage. The average life of an index under fair stowage conditions may be taken as about 10 to 12 years. With stabilized powder the life will probably be 20 years.

It is very important that the powder tanks and cartridge cases be kept air-tight, so as to maintain stowage conditions similar. The life of powder is lengthened, too, by keeping the tanks air tight. (See art. 2803 (1), Naval Instructions, 1913.)

435. Imperfect blend.—Before powder is tested and assigned to service it is thoroughly blended. It is found in the manufacture of powder that the different lots vary slightly in nitration and to some extent in volatiles. Several lots are blended into one index before being proof fired. The blends give very uniform results, and there should be little or no error resulting from this cause. If an imperfect blend were made of widely dissimilar powders, large variations would be obtained in initial velocities, depending upon the dissimilarity of the powders blended and the imperfect blending. These conditions do not obtain, however, in the powders issued to service.

436. Variation in indices.—It should be understood that the foregoing remarks (item 1–6) apply to any one index of powder. The difference in the temperature, age, etc., of any index will produce a variation, but the whole index should be similarly affected. If, however, part of the firing of a gun is done with one index of powder and part with another, there may be introduced an additional error, due to using the different indices.

With all the care in manufacture and inspection that obtains, it is found that it is impracticable to make the different indices exactly alike; in fact, an index is simply the blending of a number of lots of powder. Different indices require different weights of charge to give service velocity. In fixing the weights of charge of different indices to give service velocity there is likely to be a small error, which should not exceed, however, about one-half of 1 per cent of the muzzle velocity.

In addition to this error, the different indices may not be similar as regards temperature, age, etc. The use of additional indices introduces more errors. It would be desirable, of course, on board ship to have only one index of powder for each caliber of gun, but this is not practicable. Provision should be made in fire control for using different indices. One index should be exhausted before firing is taken up with the next index. Any variations occurring in the new index could then be compensated for by the spotter.

437. Variation in weight and distribution of ignition charge.—There should be no variation from this cause in the powders assigned to service. Numerous tests have been conducted to establish the correct weight of ignition to give proper inflammation. This weight is now standardized for the various calibers of guns. To show the effect, however, of varying the weight of ignition charges, the following data are given. It will be noted from these data that there is considerable variation in pressure and velocity occasioned by using different weights of ignition charge.

Ignition charge.	Pressure.	Velocity.
6-inch 50-caliber B. L. R. (same weight of charge throughout).	*Tons.*	*Foot-seconds.*
100 grams at breach end of charge	18.85	2,914
Do	18.80	2,907
3 ounces at each end of charge	19.60	2,927
Do	19.50	2,924
6 ounces at each end of charge	19.80	2,922
Do	20.10	2,923
8-inch 35-caliber B. L. R. (charge, 53 pounds).		
Regular ignition, 14 grains	12.03	2,098
Do	12.06	2,108
Do	12.60	2,098
7 grains each end of each section—29 grains in all	12.06	2,128
12-inch 40-caliber B. L. R. (charge, 346 pounds).		
Ignition at each end of each section	17.15	2,754
Total, 6.92 pounds	17.61	2,768
Usual ignition	18.25	2,806

438. Variation in form of charge.—There should be no variation from this cause in service, as a definite form of charge is adopted for each gun. Tests have been made at the naval proving ground to determine whether better results are obtained with the charge put up in a large or a smaller number of bags. Little variation in either pressure or velocity resulted, however, provided sufficient weight of ignition was added to the charge.

439. Unsuitability of powder.—In general, it is the intention that all powder should be consumed in the gun, but it sometimes happens that unburned powder is blown from the gun. This condition is approached in most modern guns in the effort to get a high muzzle velocity without undue maximum pressure. It is evident that the same velocity could be obtained with a quicker powder, giving a higher maximum pressure, and this condition tends to give more uniform muzzle velocities; but the maximum pressures are kept down in the effort to reduce erosion. In all but especial cases, however, the whole charge should be consumed in the gun.

It becomes a delicate matter to get a powder that will give the velocity required and still keep below the maximum pressure allowed. It frequently happens, too, that owing to the unsuitable design of a gun it is difficult, if not impossible, to select for that gun a thoroughly efficient powder. The selection of the most suitable web thickness is further complicated by the fact that in two similar powders of the same web thickness there may be considerable variation in volatiles, or other characteristics, causing considerable differences in ballistic properties.

440. Variation in muzzle velocities.—It is found that with conditions as nearly perfect as they can be made there results nonuniformity of muzzle velocities. The first round fired may show 2,700 foot-seconds and the next round 2,710 foot-seconds. This variation in velocities results mostly from the nonuniformity of the burning of the powder, although other causes contribute to it, as will hereafter be seen.

In general, it may be said that the average variation in muzzle velocity is less than one-half of 1 per cent of the average velocity. If the average of 10 shots gives 2,800 foot-seconds, it is not to be expected that the average shot will vary more than ±14 foot-seconds, although particular shots may have greater variation. In fact ± one-half of 1 per cent is about the greatest mean variation of any powder in service.

The following table shows the average variation from the mean in the muzzle velocities of a few guns and powders. These variations change with the different powders tested.

14-inch, 45-caliber, 2,600 foot-seconds, mean of 9 shots, gave ±3 foot-seconds.

12-inch, 50-caliber, 2,900 foot-seconds, mean of 11 shots, gave ±11 foot-seconds.

10-inch, 40-caliber, 2,700 foot-seconds, mean of 5 shots, gave ±5 foot-seconds.

8-inch, 45-caliber, 2,750 foot-seconds, mean of 11 shots, gave ±4 foot-seconds.

7-inch, 45-caliber, 2,700 foot-seconds, mean of 6 shots, gave ±11 foot-seconds.

6-inch, 50-caliber, 2,800 foot-seconds, mean of 24 shots, gave ±8 foot-seconds.

The effects at 6,000, 9,000, and 12,000 yards are:

	Service.	6,000	9,000	12,000
		Yards.	*Yards.*	*Yards.*
14-inch 45-caliber	2,600± 3	11	16	21
12-inch 50-caliber	2,900±11	39	56	70
10-inch 40-caliber	2,700± 5	18	26	32
8-inch 45-caliber	2,750± 4	14	19	23
7-inch 45-caliber	2,700±11	37	50	60
6-inch 50-caliber	2,800± 8	25	34	39

441. Reduced charges.—Reduced charges are fixed by selecting weights which at the proving grounds actually give desired reduced velocity. For 12-inch they have hitherto been made up in three sections instead of four, but with one-third more ignition in each so that the total ignition is the same as for service. The Bureau of Ordnance is considering the advisability of making up reduced charges in four sections, with bags of service length, but less girth. This, however, is merely a matter of whether the full number of sections is better for drill purposes than getting approximately service weight in each, but with one less section. The velocity would be the same in either case, but there would be the advantage of the larger bag being necessarily closer to the mushroom, and therefore more certainly ignited.

442. Unconsumed powder.—Powder burns with increasing surface until the holes enlarge into each other. Slivers are formed, some with three concave sides from the inside web, and others with two concave and one convex side from the outside web. These burn with diminishing surface, and this fact (especially since formed when the projectile is moving so fast) makes their contribution to the energy of the projectile relatively quite inefficient. In delaying their formation as long as possible, it is sometimes found advisable to use the heavier charge, burn it with increasing surface until very late, and let the slivers go. In certain guns, notably Army mortars, this is the rule rather than the exception. Unconsumed powder outside of a gun does not mean low velocity because of that amount of powder having been depended upon to burn. It is expedient to use the same web for reduced charges, and in most cases more of it remains unburned than with a full charge. More powder generates pressure quicker, and this pressure in turn quickens the burning enough to burn up an even larger amount of powder. Both service and reduced charges can give no velocity errors because of leaving unconsumed powder, for they have been actually fired at the proving ground and give the stated velocities without regard to unconsumed powder.

443. Projectiles:

1. Variation in weight.
2. Variation in diameter of bourrelet.
3. Variation in rotating bands.
4. Variable form of projectile.

34776—18——16

5. Position of center of gravity.

6. Projectiles not concentric with bore of gun.

444. Variation in weight.—There may be a variation in the weight of the projectiles used. The standard weight of projectiles includes the weight of the bursting charge. The error introduced by firing projectiles of different weights is not very great for small variations. A 12-inch projectile, for instance, 3 pounds overweight, will produce at 10,000 yards an error in range of but 12 yards. This is an error which can be readily eliminated, however, and should not exist. A considerable variation in weight would produce a large range error.

445. Variation in diameter of bourrelet.—The standard clearance between the bore of the gun and the diameter of the bourrelet of the projectile is 0.015 inch for all modern projectiles. Some of the older projectiles have a clearance of 0.05 inch, and these projectiles should not be fired with the later ones.

It has generally been assumed that the smaller clearance gives better flight, but the variation to be expected within the small limits mentioned has not been established. It has been shown, however, that projectiles centered by means of a bourrelet give more efficient flight than those which are not so centered, the coefficient of form being reduced by about 5 per cent.

446. Variation in rotating bands.—If rotating bands on projectiles differ either in width, thickness, or form there may be occasioned a variation in pressure and muzzle velocity. In general, if the forcing is increased—that is, if more copper is to be engraved—there will result an increase of breech pressure and a decrease in muzzle pressure. The error in muzzle velocity may be slight, but in general increased forcing will cause an increase in the muzzle velocity.

The following tests were made at the naval proving ground to determine the effect of using various types of rotating bands in different guns:

In a 12-inch 35-caliber Mark II gun having depth of rifling of 0.05-inch projectiles were fired having rotating bands of standard width, but increased in thickness from 12.12 to 12.17 inches. The cross-sectional increase in copper to be engraved was from 1.35 square inches to 2.47 square inches. There resulted an increase in the pressure of 0.8 ton. There was little change in velocity.

A similar test was held in 12-inch 45-caliber Mark VI gun, in which the depth of rifling was 0.05 inch. There resulted in this gun an increase in pressure of 0.4 ton, causing an increase in the velocity of 22 foot-seconds.

Tests were also conducted in 14-inch 45-caliber Mark I gun, with depth of groove of 0.075 inch. Bands of similar width, but of standard thickness, 14.175 inches and of diminished thickness, 14.122 inches, were fired. There resulted a decrease in the standard pressure of about 1 ton, with no change in velocity.

A similar test was conducted with 12-inch 50-caliber Mark VII gun, with depth of rifling 0.075 inch. The bands were the same width; one was of standard thickness, 12.18 inches, and one of diminished thickness, 12.12 inches. The thin band caused a drop in pressure of 0.7 ton, with a loss in velocity of 37 foot-seconds.

Tests of a 6-inch 50-caliber gun, weight of charge 42½ pounds, gave the following data:

Diameter of band.	Pressure.	Velocity.	Average.
Inches.	*Tons.*	*Foot-seconds.*	*Foot-seconds.*
6.112	13.26	2,802	
6.112	15.30	2,810	2,811
6.112	14.06	2,822	
6.112			
6.135	14.03	2,822	
6.136	16.01	2,825	
6.144	16.04	2,843	

It should be understood that these tests were held over wide variations; but as there are in service guns of the same caliber having different depths of rifling, it might well happen that rotating bands designed for one rifling were inadvertently used in guns having a different depth of rifling. If thick and thin rotating bands were used in the same gun it is evident there might be wide variations in pressure and muzzle velocities. All bands should be gauged to see if they are correct for the guns in which they are to be fired.

For 12-inch guns there are some 12.12″ bands in service and some 12.18″. Grooves in the guns are 0.05″ deep or 0.075″ deep except in some special cases. The large bands go with the deep grooves. The dimensions are the body of the band, the lip being still larger. Large bands are at present favored because they act as a "shell stop," holding the shell at approximately its right seating even in a worn gun, while with a smaller band the same amount of erosion allows the shell to ram in farther and lose more velocity. From firings in a new 12-inch gun with 0.12″ grooves it was found that each one one-hundredth on the band gave an additional 4.8 f. s. from 12.12 to 12.18″ and about 4.0 f. s. from 12.18 to 12.25″, so, among shell supposed to be banded alike, ordinary tolerances in workmanship can give no appreciable velocity differences. Thicker bands increase the serviceable life of the gun, as steady flight is maintained on a larger number of rounds with the same gun. The action of larger bands is to increase the pressure developed before the shell starts, and as pressure accelerates velocity of combustion the powder is burned earlier throughout than normal. It thus resembles in its action a powder of thinner web and develops additional pressure and velocity more than sufficient to overcome the slightly increased friction of the band. Provided that the bands do not strip and that the muzzle velocity is the same, they can have no effect on flight, because all sizes come out of the gun the same diameter.

The larger-sized bands often fail to stick in the seat when the gun is elevated, but a single rope yarn around the band will prevent their slipping back. Minor changes in design are being undertaken to overcome this difficulty.

447. Form of projectile.—The form of projectile is of great importance. The outside contour of all the projectiles fired from a battery should be the same. The length and diameters should be alike within the allowed tolerances.

The effect of changing the form of the point of the projectile from 2-caliber radius to 7-caliber radius was very marked. There resulted an increase in the range of 16 to 20 per cent, with all the attendant advantages.

Tests were conducted giving the projectile a still sharper point, with a radius of 10 calibers. This resulted in a further increase in the range of about 7 per cent. This increase, however, did not offset the disadvantages of the longer point.

If projectiles of the same weight are fired with different outside contours there will result wide variations in range. It is very important that all projectiles fired from a battery have the same form.

Owing to the changes which have taken place in the development of projectiles, it may happen that the projectiles supplied a vessel are not all alike. There are always some differences due to manufacturing tolerances even if the projectiles are otherwise alike.

448. Position of center of gravity.—Variation in the fore-and-aft position of the center of gravity will cause variation in range, even although the outside contours of the projectiles are alike. The position of the center of gravity and the force of the resistance of the air determine the overturning moment that a projectile encounters in flight. A change in the position of the center of gravity will change this overturning moment, and so cause a variation in both range and deflection. It is likely, however, that this error is small for small variations in the position of the center of gravity. Even although the fore-and-aft position of the center of gravity is the same in projectiles, it may be eccentric in the projectiles. Eccentricity may be produced by a hidden cavity in the steel, or by a variation in wall thickness. Tests are made to detect any eccentricity, and such projectiles are rejected. Any error caused by a small eccentricity ought to be of small magnitude.

It will be found that there is considerable variation in the position of the center of gravity due to the changes in the development of the projectile, use of different fuzes, different forms of cavity, etc.

449. **Projectiles not concentric with bore of gun.**—It may happen, especially after a gun is somewhat worn, that the projectile's axis is not concentric with that of the bore of the gun. There is always, of course, a slight divergence, due to clearance of the bourrelet diameter, but this may be augmented if the rotating band does not center the base of the projectile in the bore of the gun. It is not possible to tell how great this variation is, but it is likely that the projectile rarely leaves the gun with its axis in the exact line of the bore of the gun.

CARTRIDGE CASES, PRIMERS, ETC.

450. **Cartridge cases.**—There may be a slight variation in the capacity of cartridge cases, due to the tolerances allowed in manufacture. This changes the density of loading, and so affects pressures and velocities. The allowed tolerances in manufacture are as small as they can practicably be made, and any error resulting from this cause must be small.

In cartridge cases of 5-inch and 6-inch guns, where the projectile is loaded separately, it has been found necessary to have a mouth cup in the cartridge case to prevent the end of the case from being split or deformed by the powder gas. The fitting of these mouth cups has a considerable effect on velocities and pressures. The following data was obtained from firing a 6-inch 40-caliber gun, weight of charge 17 pounds:

Using a distance piece and a felt wad, and a loose mouth cup, the pressure was 5.5 tons with a velocity of 1,598 foot-seconds. With the charge put up in the usual way with a tight-fitting mouth cup, the pressure was 6.6 tons, and the velocity 1,651 foot-seconds. The effect of the loose-fitting mouth cup was virtually to decrease the density of loading with a decrease in pressure and velocity. The variation shown in this test, however, is greater than may be expected in service, even with loose-fitting mouth cups, as the mouth cup is in general not more than about 1 inch from the base of the projectile, and the decrease in the density of loading, due to the loose-fitting cup, is relatively small.

A similar variation may occur in guns of 5-inch caliber and smaller, due to the projectiles not being seated alike in the cartridge cases. No great error can occur in this way, however, as when the cartridge case is loaded in the gun the projectile will likely be pushed back to its proper place in the cartridge case. Any unseating of the projectile would cause a decrease in the density of loading; with consequent falling off in pressure and velocity.

451. Primers.—There is considerable difference between the speed of primers, the percussion primer being much faster than the electric primer.

Tests were made at the naval proving ground with an 8-inch/35 gun, using Mark VIII lock. Combination primers were tested by electric firing and percussion primers by percussion firing and the time intervals measured. With combination primers the interval from the moment contact was made at the primer until the flame issued from the mouth of the mushroom was 0.031 second, averaging four primers. These primers gave intervals of firing from 0.013 to 0.073 second. Two other primers gave intervals of 0.040 and 0.030.

A similar test in a 6-inch/50 gun gave for an average of 16 primers an interval of 0.044 second. It is believed that this figure is a fair average for electric or combination primers.

With percussion primers the interval from the moment contact was made at the primer until flame issued from the mushroom gave 0.004 second, as an average of four rounds, the rounds varying from 0.003 to 0.004. Two other rounds gave 0.0044 second and 0.006 second.

It is evident from the foregoing that the percussion primer is much faster than the electric primer, and so far as concerns this point only percussion firing is more desirable than electric. It will be found, however, in measuring the complete firing interval that the difference between the electric and the percussion intervals is very small, and the flexibility of electric firing makes it necessary in most cases.

452. Firing interval.—The firing interval may be taken as the time from the instant when the pointer wills to fire until the projectile leaves the muzzle. For measuring, this interval has been divided into three parts:

(*a*) Time from instant when pointer wills to fire until closing of firing key has been completed.

(*b*) Primer interval.

(*c*) Interval from flame issuing from mushroom until projectile leaves muzzle.

Item (*a*) was measured at the naval proving ground. The average of five pointers gave 0.179; times of firing from 0.138 to 0.236. With a firing key or tripping a sear the interval would evidently be the same whether electric or percussion firing were used. This interval varies greatly, depending upon the personality of the pointer, a slow pointer requiring more than the average interval. It is believed that the value given of 0.179, however, is a fair average for service pointers.

The value of interval (*b*) has already been stated.

The value of interval (*c*) varies for different guns, but may be taken as about 0.020.

Adding these intervals, it will be found that the firing interval for electric firing is about 0.243 seconds, while that for percussion firing would be about 0.203 seconds.

It is evident, therefore, that although the percussion primer is ten times as fast as the electric, the gain in the firing interval by its use is very small.

453. Guns:

1. Variation in rifling.
2. Seating of projectile.
3. Density of loading.
4. Temperature of chamber, bore, etc.
5. Vibration of gun.
6. Variation in chamber capacity.
7. Ellipticity of bore.
8. Shell leaving bore with its axis inclined.
9. Erratic flight of shell.
10. Short hangfire.

454. Variation in rifling.—In the guns of a battery it may happen that there is a variation in muzzle velocities caused by some guns being rifled differently from others. The rifling may be of different twist; the form, depth, and number of grooves may differ, and the amount that the grooves are narrowed at the muzzle may differ. All of these variations in rifling affect the muzzle velocities. There may be an error from 10 to 25 foot-seconds due to this cause. All guns of a battery should be rifled alike, and this condition generally obtains, but the twist of the rifling as well as the form, dimensions and number of grooves have been changed at different times for various reasons, and it will be found in a few instances that some guns of a battery are rifled differently from others.

455. Seating of projectile.—As guns erode the projectiles seat farther down the bore. There results a decrease in the density of loading, with consequent falling off in pressure and velocity. Tests made at the naval proving ground show the loss of velocity to be expected in 8-inch 45-caliber Mark VI guns, and 12-inch 45-caliber Mark V guns, when the distance of shell seating beyond normal is known. The standard shell seating is shown on the drawings, and the distance the shell seats beyond normal can readily be measured, and the decrease in the velocity of a gun can be estimated. Projectiles used in these tests had rotating bands with lips of 8″.36 and 12″.30, respectively. If larger lips are used the protectiles will not seat so far down the bore, and a small part of the loss in velocity and pressure is restored. Practically all of this loss in pressure and velocity can be restored by using rotating bands of proper form to compenate for the erosion.

So far as accuracy of fire is concerned, it is important only that all projectiles used should be alike, and that in firing, the distance from the face of the tube to the base of the projecile should be he same in the guns of a battery.

Sketches C and D show the loss of velocity to be expected in 8-inch 45-caliber Mark VI, and 12-inch 45-caliber Mark V guns. In a new gun there may be a considerable error in velocity occasioned by the projectile not being home. Numerous tests have been made to ascertain this error, and it is found that there is a wide variation in the results obtained. It is impossible to state the magnitude of this error, as it depends not only on the distance of the projectile from normal seating, but also on the design of the powder chamber, and on the density of loading. Sufficient data has been obtained to show that it is important for accurate fire to have the projectile seated at the same place each time. In general, the projectile not being home causes an increase in the density of loading, with consequent increase in pressure and velocity. In some types of powder chambers, however, and under certain conditions of loading, the increase in density of loading is more than offset by the loss of gas escaping around the projectile, and there results a decrease in pressure and velocity. The error occasioned by the projectile not being home is not so apparent at short-range firing, but it causes serious dispersion at battle ranges.

The following data is from tests held at the naval proving ground:

6-inch 50-caliber Mark VIII gun.

Shell not home by—	Loss pressure.	Velocity.
	Tons.	
2.9 inches	0.2	Loss, 3 foot-seconds.
2.9 inches	.0	Increase, 7 foot-seconds.
2.9 inches	.4	Increase, 9 foot-seconds.
5.5 inches	1.2	Increase, 56 foot-seconds.
5.9 inches	.9	Increase, 32 foot-seconds.
5.9 inches	.8	Loss, 44 foot-seconds.

7-inch/45 Mark II gun, with shell properly seated, gave a velocity of 2,721 foot-seconds. Shell not home by 4.4 inches, increased velocity 27 foot-seconds. Not home by 5.2 inches, increased velocity 42 foot-seconds.

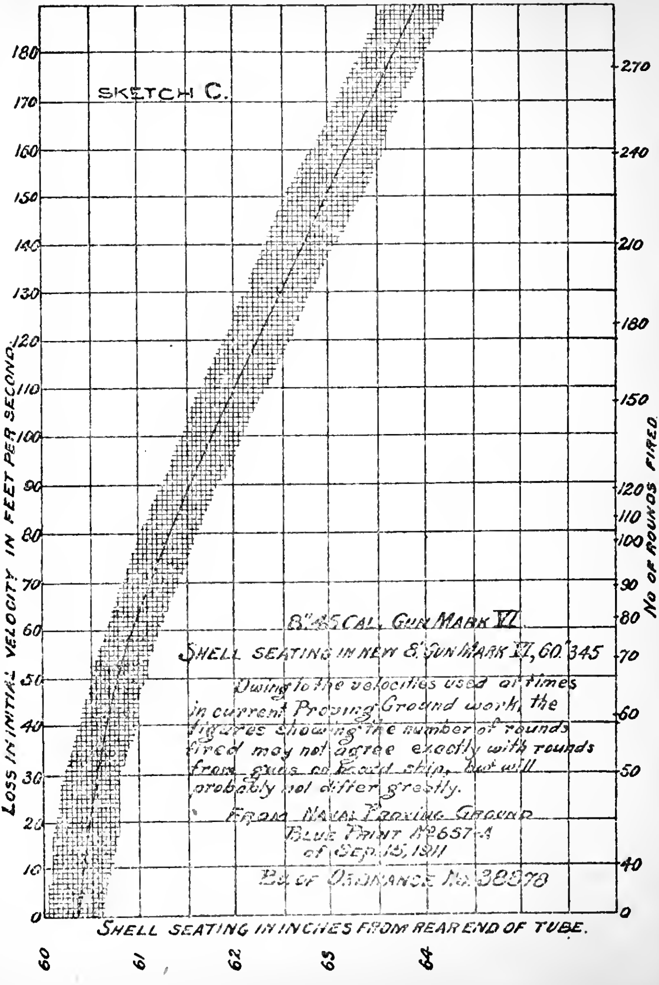
8-inch/45 Mark VI gun gave a velocity of 2,721 foot-seconds. Shell not home by 0.6 inch caused loss of velocity of 11 foot-seconds. Shell not home by 1 inch caused loss of velocity of 11 foot-seconds. Shell not home by 2 inches caused loss of velocity of 11 foot-seconds.

5-inch/Mark VII gun. Shell not home by 1 inch caused loss of velocity of 5 foot-seconds.

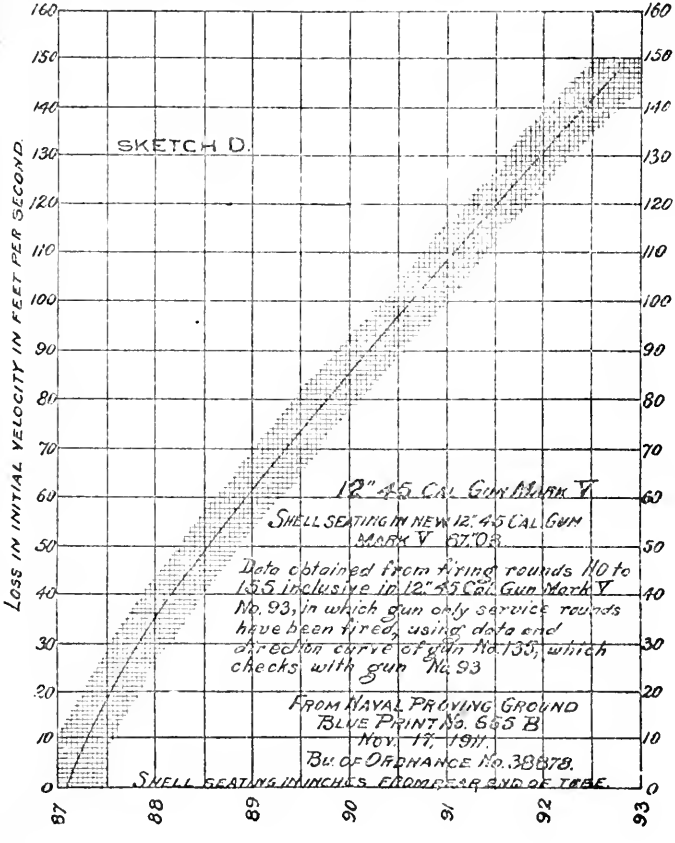
12-inch/35 gun: Shell not home by 6 inches—loss of velocity 40 foot-seconds.

Foreign reports have been received of an 11-inch gun. Shell not home 0.8 inch caused increased velocity of 27 foot-seconds. Shell not home 41.4 inches caused loss of velocity of 295 foot-seconds with but one-third normal pressure.

Smoke rings are not believed to be in any way connected with improper shell seating, because they are not observed when shells are fired purposely unseated at the proving

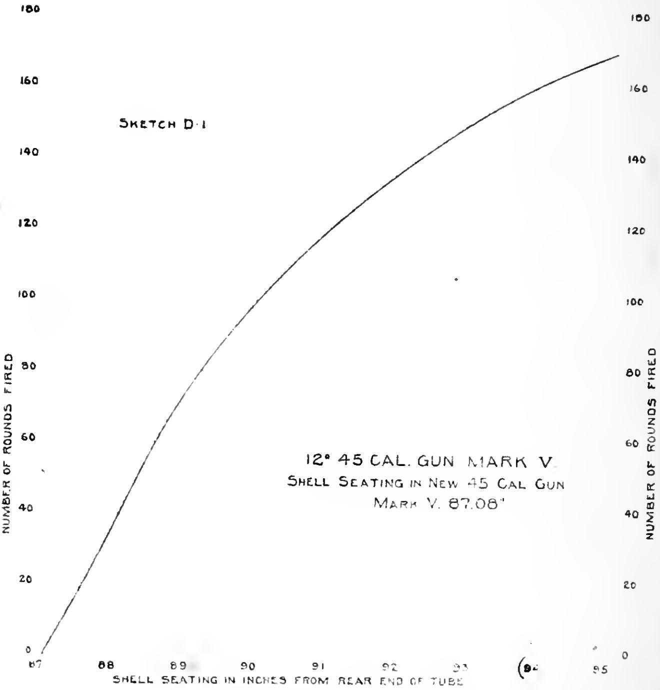

SKETCH C.
8" 45 CAL. GUN MARK VI
SHELL SEATING IN NEW 8" GUN MARK VI, 60."345
Owing to the velocities used at times in current Proving Ground work, the figures showing the number of rounds fired may not agree exactly with rounds from guns on board ship, but will probably not differ greatly.
FROM NAVAL PROVING GROUND
BLUE PRINT No. 657-A
of SEP. 15, 1911
Bu. of ORDNANCE No. 38878
LOSS IN INITIAL VELOCITY IN FEET PER SECOND
No OF ROUNDS FIRED
SHELL SEATING IN INCHES FROM REAR END OF TUBE.
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
0 40 50 60 70 80 90 100 110 120 150 180 210 240 270
60 61 62 63 64

ground, and because they occur oftenest and best with blank charges when there is no shell at all. Greasing the muzzle of a saluting gun is supposed to make them.



The scale of "rounds fired" corresponding to different seatings can be found from sketch D′.

456. Density of loading.—In general as the density of loading is increased there will result an increase in pressure



and velocity. With the standard weight of charge an increase in density of loading could be obtained on board ship only by having the shell improperly seated. Some guns of a battery, however, have different makes of breech mechanism, and this may cause a change in the density of loading. With the shell properly seated and the correct weight of charge, there should be no variation in density of loading. As guns erode, however, and the shell seats farther down the bore, there results a decrease in the density of loading, with consequent loss of pressure and velocity.

457. Temperature of chamber, bore of gun, etc.—Numerous tests have been made to determine the temperature of the gun and mushroom head after repeated firing.

5-inch/51 gun was fired 20 times as rapidly as possible. Temperature of mushroom after last shot was 275° F. Temperature of gun before firing was 98.6° F.

10 shots were fired in a 5-inch/50 gun in 1 minute 18 seconds. Temperature of mushroom before firing, 100° F., after firing 196° F. Temperature of chase of gun before firing, 101° F., after firing, 131° F. Temperature at muzzle, 158° F.

29 rounds were fired from a 5-inch/51 gun in 3 minutes 45 seconds. Temperature of breech face, before firing, 82° F.; temperature of breech face, after firing, 296° F.; temperature of chase, before firing, 84° F.; temperature of chase, after firing, 162° F.; temperature of muzzle, after firing, 304° F.

A powder charge was placed in the chamber immediately after firing the 29th round. The charge was left in contact with hot mushroom for four minutes, and it was then taken out unharmed.

3-inch/50 gun was fired 25 rounds. Temperature of muzzle before firing was 72° F., and after firing, 234° F.

50 rounds were fired from the same gun. Temperature of muzzle before firing was 95° F., after firing, 378° F.

A foreign 3-inch/46 gun was fired 110 rounds rapidly, the maximum temperature reaching 394° F.

Most automatic rifles reach temperatures of 700° or more, depending upon the speed and length of firing. It is found that cartridges placed in these guns, after rapid fire, will fire, due to the heat.

So far as concerns the ballistics of the gun it is evident that the heat of the bore will increase the temperature of the powder charge, and so cause an increase in velocity, provided the charge is left for any considerable time in the bore of the gun. With guns fired under similar conditions this error, however, should not be very great.

So far as concerns safety it would appear that little danger is to be anticipated in the firing of large-caliber guns under service conditions.

458. First and subsequent shots.—The first round from a gun will have slightly less velocity than those fired immediately afterward. After the second round no increase can be detected, and it was only by persistent averaging for a number of years that a difference between the first two was definitely established. It is about 25 f. s. for the 3-inch, diminishing to not over $4\frac{1}{2}$ f. s. for 12-inch, for which gun it therefore means about 25 yards at 10,000. The effect is greatest in winter and least in summer, the above being year-round averages.

NAVY GUNS.

Caliber.	Number of examples.	Number showing increase.	Number showing decrease.	Number showing no change.	Sums of increases.	Sums of decreases.	Average difference.
13-inch	3	3	0	0	128	0	+42.7
12-inch	22	13	6	3	223	123	+ 4.5
10-inch	13	10	3	0	98	7	+ 7.0
8-inch	22	15	7	0	287	168	+ 5.4
7-inch	14	11	1	2	223	2	+15.8
6-inch	69	43	21	5	975	353	+ 9.0
5-inch	39	29	8	2	655	118	+13.8
4-inch	16	13	3	0	349	45	+19.0
3-inch	32	28	2	2	907	55	+26.6
	230	165	51	14	3,845	871	+12.9

ARMY GUNS

12-inch	15	9	6	0	253	62	+12.7
10-inch	17	9	7	1	324	96	+ 7.5
8-inch	7	6	1	0	146	120	+ 3.7
6-inch	32	19	12	1	385	121	+ 8.3
5-inch	25	17	8	0	306	99	+ 8.3
3-inch	22	13	8	1	346	157	+ 8.6
	118	73	42	3	1,760	655	+ 9.4

Leaving out of account the 13-inch, of which only three examples occur, it will be seen that the Indian Head records indicate a plus difference which is much greater for small than for large guns; while the Sandy Hook records indicate a plus difference which is about the same for all calibers. However this may be, the evidence seems conclusive that the difference is not sufficient to call for any allowance, or indeed to admit of any allowance being made for it.

Apart from the effect of the warming round, it has been suspected that it makes a difference whether the bore is dry or oily. According to an English writer, the fouling from one round of black powder caused a velocity loss of 25 f. s. (p. 287 Bryuck), but Russian experiments seemed to show the reverse, that oil in the bore decreased the velocity 36 f. s. in a light gun. The effect is probably much less in 12-inch guns. At Indian Head the results of the first round fired each day from a 12-inch, using always the same powder, were compared. There were 32 observations, some with bore oily and others with it dry, and in contradiction to the Russion experiments, the oil seemed to increase the velocity 11 f. s. Since this is less than many of the variations, the results are not to be taken as showing much more than the fact that the difference, if there is one, is very small.

459. Vibration of gun due to droop or flexibility.—It will be found that all guns have a muzzle-droop which can be measured. This droop is greatest in the longer and heavier guns, and the amount of gun droops is known and recorded. There is not only a droop, but a slight deflection to one side in almost every gun. The droop is partly elastic, for when a gun is placed upside down it also droops a certain amount. In almost all cases, however, the greatest droop occurs when the gun is in the normal position. This droop varies somewhat from time to time as the stresses in the gun are varied by firing.

NOTE.—As the gun is fired, forces acting in the bore tend to straighten it, and the various forces set up vibrations which cause the muzzle to describe a curved figure to the right and above its position in the state of rest. From proving-ground data it is also proved that practically all of this muzzle movement take place after the projectile has left the bore of the gun and thus has no effect on its flight. There is no doubt that flexibility is undesirable, and every effort is made to reduce it as much as practicable in designing guns. The droop with wire-wound guns is about twice that of built-up guns. From all data at hand, it is evident that the only error caused by droop is due to the variation in droop among various guns on board ship. As an example of an extreme case (the *Wyoming*) the variation in droop (between least and greatest) would cause a difference in range of 35 yards at 10,000, and these are the worst guns in service for droop.

Droop varies with life of gun, apparently.

	Droop. Inch.
0 rounds	0. 690
18 rounds	. 720
29 rounds	.725
44 rounds	. 600
70 rounds	. 690

Type gun has greater droop than other 12-inch 50-caliber guns. Average droop of 12-inch 50-caliber guns is 0.435 inch.

Maximum droop is about 0.510 inch. Minimum droop is about 0.360 inch.

460. Variation in chamber capacity.—There is a slight variation in the capacity of chambers of different guns of a battery, due to the tolerances in manufacture. There may also be slight differences in the chamber capacity due to modifications that have been made in the design of the forward slopes of the powder chamber. Further changes in the capacity may be occasioned by the fitting of different marks of breech mechanisms to the same type of gun. All these changes in capacity produce the same result. If the capacity of the chamber has been diminished the density of loading is increased, and there occurs a slight increase in pressure and muzzle velocity. With an increase in chamber capacity the reverse occurs.

461. Ellipticity of bore.—If the bore of a gun is elliptical a considerable error may be caused.

A 5-inch 51-caliber Mark VII gun did not true up at the muzzle during manufacture for about 82° of the circumference. The diameter of this part of the muzzle was 0.010 inch too great, running to 0.003 inch at 21 inches from the muzzle. This gun was fired with an exactly similar standard gun at a range of 850 yards. The powder and all other variables were alike in the firings.

The standard gun was fired five times and gave the following errors at 850 yards:

Mean vertical error, 4.68 inches.

Mean lateral error, 4.98 inches.

The elliptical gun was fired six rounds at the same range and gave the following errors:

Mean vertical error, 14.46 inches.

Mean lateral error, 13.42 inches.

Similar results were obtained in the test of a 3-inch 50-caliber gun, the muzzle of which had one diameter 0.008 inch too great.

As guns erode it is found that the bores are worn more or less elliptical. In general it will be found that the greatest diameter (facing the muzzle) is the one running northwest and southeast this diameter for right-handed twist being in general slightly greater than the vertical diameter. The least diameter is the horizontal one.

A 12-inch 45-caliber Mark V gun, after firing 183 rounds, showed on star gauging that the vertical diameter was 0.036 inch greater than the horizontal at the origin of rifling. At the muzzle the vertical diameter was 0.016 inch greater than the horizontal.

If all guns of a battery were fired the same number of rounds it is likely that little error would be introduced by ellipticity, as all guns should wear in the same manner.

462. Projectile leaving bore with its axis inclined.—It is likely that a projectile never leaves the bore of a gun with its axis in the exact line of the bore of the gun. There occurs an initial angular deviation which may be in any direction. The bourrelet diameter of the projectile is very close to the diameter of the bore of the gun, and this error in modern projectiles should be small.

Owing to the fact that the gun starts to recoil before the projectile gets entirely clear of the bore, there may be an additional deviation given to the projectile by the jump or the vibration of the gun. There may be a still further deviation occasioned by the nonsymmetrical escape of gas as the projectile leaves the muzzle. It is impracticable to ascertain the extent of these errors, however.

463. Short hangfire.—No variation should be occasioned by short hangfires, provided the pointer maintains continuous aim. If the hangfire is of considerable duration, however, even while maintaining continuous aim, there may be an error introduced owing to the fact that the vertical and horizontal speed of displacement of a gun may be different from that existing when the other guns of the battery were fired.

464. Erratic flight of shell.—It occasionally happens that a shell will prove erratic in flight. In the case of new guns this defect is generally to be found in the banding of the projectile. The band may be either stripped from the projectile or sheared. In either case the projectile does not get correct rotation and erratic flight or even tumbling may occur.

In the case of eroded guns the rotating band has to withstand much heavier stresses, and there comes a time in the life of the gun when the rotating band is unable successfully to withstand the excess stress. The rotating band is generally sheared before the projectile leaves the gun, and as the projectile gets little or no rotation, tumbling and erratic flight will occur. Correct flight can generally be restored by using rotating bands of augumented dimensions. This method is not practicable, however, for any extended series of firings.

465. Muzzle movement.—Recent determinations of the muzzle movement during recoil made by fixed markers scribing on horizontal and vertical plates secured to the muzzle of a 14-inch gun shows that the total vibration is over an inch. Nothing happens until the shell is well clear. The droop is $\frac{3}{8}$ to $\frac{1}{2}$ inch in 12-inch 50-caliber and 14-inch in 45-caliber guns, and evidently, from the above, the shell must leave a curved bore taking the direction of the final tangent. A great number of firings at plates 350 feet distant show that the droop is greater than that calculated from the trajectory by approximately the amount needed to corroborate the above reasoning. The droop exists when the projectiles are ranged, and such values are selected for the coefficient of form as will make range tables agree with actual firings, so that average natural droop, unless variable, is eliminated. When guns are ranged at the proving ground, the quadrant is on the stiff part of the breech; afloat they are elevated with reference to the line of bore sight, which is a sort of chord. This has the effect of making guns afloat shoot just a little further, which effect, however, is, if anything, desirable in making up for the small loss in range that the wear causes.

466. Heating of the gun.—If the top of a gun is heated more than the underside, due to exposure to sunlight, the effect of unequal expansion is to make the gun curve downward away from the sun. According to a British ordnance writer, the top of a gun is 3.6° F. warmer in summer and this may even reach 7.2° F. in the Tropics. He calculated for British 12-inch 50-caliber guns that the droop is affected 0.010 inch per degree Fahrenheit. As the total temperature difference in summer is less than 3.6° F., it could not be more than part of this between different turrets boresighting at the same time, and droop could not be affected more than a few hundredths of an inch at most.

(From article in Journal of United States Artillery No. 107 (p. 73), 1° C.=47′, therefore $1° \text{ F.}=0.47' \times \frac{5}{9}=0.26$ minute, and (p. 64), 0.092″=2.35 minutes; therefore $1° \text{ F.}=0.26 \times \frac{0.092}{2.35}=0.0102$ inch.)

The only sights that temperature changes should affect are certain of the older ones where the parallel motion mechanism is partly of brass and partly of steel, but the calculated error in these would be very small.

467. Effect of change of temperature on straightness of guns.—Experiments have been recently made at the proving ground to obtain data related to the effect of sunlight on the straightness of guns. As a result of three experiments, it appears that considering other unavoidable causes for variation that due to change in temperature may usually be neglected. For instance, in the case of a 12-inch 50-caliber gun, pointed south, between 11.45 a. m. and 3.45 p. m., with a maximum temperature at 2 p. m. of 94° F., the change in range did not exceed 25 yards. The maximum variation through the 24 hours was shown by the ellipse, 5 minutes high, and 9 minutes wide (see experiment No. 2), which corresponds to 125 yards' range, and 29 yards' deflection, at 10,000 yards. With the gun tested, there was but little deviation before 7

a. m. The deflection maxima took place at 10 a. m., and 4.30 p. m., and the droop maximum at 1.30 p. m. The movement was faster in the evening than in the morning, and scarcely anything after 8 p. m. It is not kown whether or not the heat from firing a round or two is sufficient to cause these effects to disappear.

To see if there was any possibility of there being a difference between the action of turret guns, where the breech is covered, and guns on the proving ground battery, where the whole gun is exposed, a 24-hour droop record was made with an 8-inch 45-caliber gun uncovered, and again with a tarpaulin over the breech. There was no practical difference, although examining the records critically, the one with the breech covered was perhaps very slightly larger. The gun faced north, and the record was much smaller than for 12-inch, the dimension being approximately $\frac{1}{10}$-inch each way in both instances, or about one-third as large as for the 12-inch.

Briefly, the experiments were as follows:

Date.	Gun.	Maximum temperature.	Gun pointed.	Remarks.
		°*F.*		
July 4, 1913	12-inch, 50-caliber.....	96	South...	Self-recording device on muzzle; the point traced an ellipse 0.35 inch wide by 0.25 inch high.
June 28-30, 1913.	12-inch, 50-caliber.....	94	...do.....	Telescope on muzzle sighted on screen 316 feet away. Computed curve at muzzle was irregular, not closed, and was 0.56 inch wide by 0.38 inch high.
June 19, 1913	12-inch, 35-caliber.....	....	...do.....	Telescope on muzzle screen 327 feet away. Computed curve irregular 0.21 inch wide by 0.11 inch high.

468. Sight and mounting:

1. Drift error.
2. Sight error and telescope error.
3. Mount error.
4. Jump.
5. Weather variations.
6. Trunnions not horizontal.
7. Movement of mount due to pitch and roll.
8. Motion of target.
9. Firing through powder gases.

469. Drift.—The drift of a projectile varies with the initial velocity, form of the projectile, final twist of rifling, angle of elevation, etc.

Owing to the fact that it is not possible to give the exact values to the weather variations that obtain during a firing, it is not possible to give more than an approximate value for the drift, although this value should be within small limits. It is known, therefore, that the drift used in graduating sights is slightly inaccurate, but it is within as close limits as are practicable of attainment. The drift is not of great importance so long as all guns firing are of the same caliber, but when different calibers are fired together variations in the drift may produce lateral dispersion unless means are provided for bringing the calibers together. Fortunately, in high-power guns the amount of drift is small until the longer ranges are reached. A 12-inch 2,700 foot-seconds gun has a drift of but 13 yards in 7,000 yards, but at 10,000 yards this drift becomes 32 yards. At the longer ranges, therefore, care should be taken in firing different calibers of guns together to see that lateral dispersion is not introduced by inaccuracy of drift.

470. Sight error and telescope error.—There is an error in all sights. This should be measured in dry dock and be recorded in minutes of arc. In guns having sights attached to slides most of the sight error is caused by the distortion or spring of the parts of the sights or by lost motion or improper installation.

In turret guns having parallel motion sights there may be an additional error caused by the arms not being parallel in the different positions of elevation of the gun.

It is, of course, highly desirable that this error in sights should be reduced to a minimum, as accurate long-range firing can not be expected without accurate sights.

There is always the possibility that sights may be improperly graduated either for range or deflection, but these graduations are made with extreme care, and inaccuracies from this cause are hardly possible. If desirable, however, these graduations can readily be verified when the ship is in dry dock.

Errors in telescopes may be occasioned by parallax or by the parts of the telescope being deranged. Owing to the strong construction of telescopes, however, the parts are not liable to much derangement and parallax can readily be avoided.

471. Mount error.—There is a limited amount of flexibility in every mount, and it is possible that the gun does not assume quite the same direction relative to the slide each time on returning to battery.

The clearance between the gun and the slide is very small, however, about 0.02 inch on the diameter, and this error must be insignificant. All guns are balanced, usually slightly breech heavy, so that the bearing conditions should be the same after each shot.

472. Jump.—Jump is the increase of the angle of departure resulting from angular motion of the gun in the vertical plane caused by firing. The angular motion comes partly from the recoil of the gun (which moves to the rear, various distances up to about 2.7 inches, according to the caliber, before the projectile leaves the muzzle) and partly from elastic yielding of the mount or the support for the mount. It is assumed that the support for the mount is sufficiently rigid and that any jump will be occasioned by the yielding of the mount.

The conditions at the proving ground and those on board ship are quite different. At the proving ground the supports for the mount are rigid, and any jump occurring is due to the yielding of the mount. It is generally assumed, too, that the jump is the same at all angles of elevation, and at different angles of train, though it is evident that there may be more or less variation from this, depending upon various considerations.

The value of the jump, whether at the proving ground or on board ship, is very small. It is so small, in fact, that it is difficult to measure it at the proving ground and impracticable of measurement on board ship. The jump at the proving ground is, in general, not more than two or three minutes of arc. It is likely that on board ship this value is not greater than five minutes of arc. In a 12-inch, 2,700-foot-second gun there would be occasioned, at 10,000 yards, an error from this cause of about 100 yards. It must be understood that this jump would not produce dispersion unless it varied from round to round, and varied in the different guns. It is evident, therefore, that with properly designed mounts, which are well supported on board ship, the error due to jump is not of great consequence.

In addition to the jump in the vertical plane, it is likely that there may be some small lateral errors occasioned, but these may be neglected.

473. Weather conditions.—It will always be impossible accurately to state the effect of the weather on firing. It is impossible to obtain accurate values for the force of the wind and the readings of the barometer, thermometer, etc., in the different parts of the trajectory of projectiles, and the state of the science is such that even, were the correct values known, their effect on the trajectory could only be approximated. In any particular firing all that can be done to minimize weather variations is to select conditions as favorable as possible, and to fire rapidly several shots, taking the mean result of the firing.

The range tables and books on exterior ballistics furnish the best information available of the effect of weather variations on the trajectory. It is evident, however, that the weather variations may produce dispersion, even were all other variations eliminated.

474. Trunnions not horizontal.—It has been found that some mounts in a ship are placed with the axes of their trunnions at angles with one another. In all new vessels it is prescribed that the axes of the trunnions shall not diverge more than 15 minutes of arc from parallelism to a common horizontal plane. Even with mounts correctly installed with their trunnion axes parallel to a common horizontal plane it may happen that the guns are fired in a seaway with the trunnion axes considerably inclined to the horizontal. The effect of this is to introduce a lateral error, which may be right or left, depending upon whether the ship is pitching or 'scending.

If the guns are elevated 3° from the horizontal and fired while the ship is pitching 3° there will be introduced an error of sin. $3° \times$ sin. $3°$ ($\frac{1}{19}$ by $\frac{1}{19}$)$=1/361$ of the range. At 7,000 yards this causes a lateral error of 19 yards. At longer ranges (greater elevations) or with greater pitches this error increases. It will be noted that if the ship had been 'scending the salvo would have struck 38 yards from the first impact.

There is also introduced a small vertical error, but this is of slight importance.

It is important that all mounts have their axes parallel to a common horizontal plane and that the guns be fired each time with this plane relatively at the same angle to the horizontal.

475. Movement of mount due to pitch and roll.—Should a gun be fired even while maintaining perfect continuous aim there is an error introduced due to the actual vertical displacement of the mount caused by rolling or pitching. The pitching error is greatest as the speed of the vertical displacement due to pitch is considerably greater than that caused by roll—probably about four times as great. It is also evident that the guns in the ends of the ship are affected the most by the pitch and that the guns mounted farthest outboard are affected most by the roll.

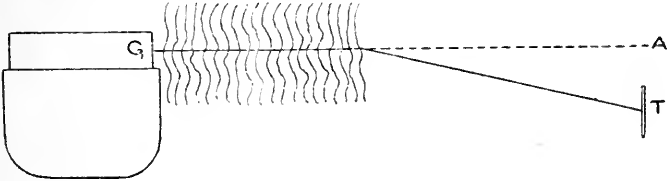
In this connection it is important to note that center-line mounting of guns is very desirable as the vertical displacement of these mounts is inappreciable for small rolls of 2 or 3 degrees on each side of the vertical. The error due to a roll of 2 or 3 degrees would be not more than a foot on a target at 7,000 yards. For a 3-degree roll the 8-inch guns mounted outboard on battleships of the *Connecticut* type would have an error on a 7,000-yard screen of about 6 feet, provided the guns were fired in the middle of the roll. If some of the guns were fired in the middle of the down roll and others in the middle of the up roll, the impacts would be separated 12 feet on a 7,000-yard screen. This error, due to trunnion displacement, is really the component of the trunnion motion acting on the motion of the projectile, and of course the error increases with the time of flight.

There is also a slight lateral error introduced by the lateral displacement of the trunnion.

476. Motion of target.—It is evident that the vertical motion of the target must be taken into account. If a 27-foot target, at a range of 7,000 yards, is fired at with a gun having a mean vertical error at that range of ±10 feet, the percentage of hits would be 71.7. If, however, the target has a vertical motion of 5 feet above the mean and 5 feet below the mean position, the probability of hitting is reduced to 67 per cent. The motion of the target has the virtual effect of increasing the mean error of the gun about 1 foot.

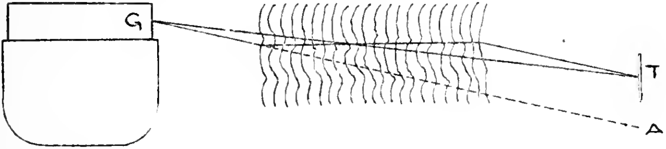
With greater motion of the target the probability of hitting is further reduced.

477. Firing through powder gases.—Should a gun fire through smoke or gas or at a time when the strata of the air



Sketch E.

between the gun and target are of unequal and varying densities, refraction will take place and accurate shooting is impossible. Most of the gas which is discharged from the gun is heavier than air and therefore causes a bending of the rays of light toward normal. If the gun is entirely surrounded



Sketch F.

by gas, the projectile will go high, as may be seen from sketch E.

Target will be seen along G–A when it should be along G–T. If, however, there is a volume of air on each side of the refracting gas, the projectile will go low, as shown in sketch F.

The error caused by this refracting gas and the strata of air at different densities is very considerable. From data obtained at 1,600 yard elementary practice where the gun was ready and the target fired at as soon as the gas thinned so that the target was visible, it is known that the error at 7,000 yards, caused by firing under similar conditions, would be about ±25 feet on the vertical screen. This error is so serious that it must be avoided wholly in order to permit accurate shooting.

478. Personal errors of pointer and sight setters.—There will always be personal errors of pointers, some of whom will fire when either the vertical or horizontal wire of the telescope is not on the target, and dispersion, both vertical and lateral, is introduced. Dispersion will also be introduced if the sight setter, due either to personal error or bad transmission, sets the sights incorrectly in range or deflection. If the angular error of pointing is known, the dispersion due to this cause can readily be obtained from the range tables.

Due to some individuality of gun, sight, or mounting there may be a definite constant error for a particular unit, this error being either vertical or lateral. Were it possible to eliminate all other sources of error this constant error could be detected on calibration; but it is evident that so many errors are present in every firing, and such a large number of rounds would have to be fired to get a satisfactory average, that none but very large errors could be found by calibration.

There is no reason to believe that the constant errors of guns and mounts, even if they do exist, are of large magnitude, and there is no way of detecting them without expending large quantities of ammunition and eliminating all other errors.

It is practically impossible to predict, under any given conditions, the dispersion that will occur on firing. If correct values could be assigned to the various elements producing dispersion, the probable dispersion would be obtained by taking the square root of the sum of the squares of the various elements. It is not practicable to make more than an approximation to the value of most of these elements. The only practicable way of obtaining dispersion data is to calculate from a series of firings the dispersions that were obtained. With data on the dispersions of a number of guns, under different conditions and at different ranges, it is possible to estimate roughly the dispersions that will be obtained under any given conditions.

CHAPTER 20.

REWARDS AND SCORES.

479. Battle efficiency pennant.—After the end of the competition year the battle-efficiency pennant will be awarded to the vessels of the battleship, torpedo, and submarine classes obtaining the highest combined final merit in both gunnery and engineering in their respective classes. The weights of the various forms of practice with guns and torpedoes for the year, and the method of combining gunnery and engineering, are included in the annual rules.

Before combining the merits of gunnery and engineering each will be reduced to a scale of 100.000; the ship attaining the highest merit in gunnery or engineering in the class will, for purposes of combination, be given 100.000, and the merit of the other vessels will be scaled accordingly.

It is probable that the President may send a letter of commendation to the commanding officer of the pennant winner of the battleship class.

Those officers, not to exceed nine in number, who, by their continued efficient work, have been directly responsible for the winning of the battle-efficiency pennant, will if recommended by the commanding officer, have a copy of the President's letter placed on file with their records.

480. Gunnery trophy.—By direction of the President of the United States the department offers trophies for excellence in naval gunnery to five classes of vessels. All forms of practice for the year are given weight in determining the final merit for the various classes. The trophies are awarded at the end of the competition year, July 1.

The battleship class includes all vessels carrying turrets.

The torpedo class includes all torpedo boats and destroyers.

The submarine class includes all submarines.

The cruiser class includes all vessels carrying 5-inch or larger guns, but not having turrets.

The gunboat class includes all vessels, except torpedo craft, carrying no guns larger than 4 inches in caliber.

When a trophy is received on board a winning vessel there shall be appropriate ceremonies.

Should a vessel holding a trophy be placed out of commission the trophy will be returned to the department.

Letters commending efficiency in gunnery will be issued to officers deemed worthy of such distinction.

481. Battle inefficiency.—The time has arrived, in the development of combined gunnery and engineering efficiency, when generally speaking, there is no good reason why great differences in the combined final merits for the year, should exist among the ships of the same type. Among ships that have performed similar duties, when one ship falls markedly below the other ships of the same type, in the final merit for combined gunnery and engineering for any one year, there have existed inefficiencies in discipline, organization, training, or routine, to cause such a failure. In battle no amount of explanation can compensate for a failure to steam or a failure to hit.

THE NAVY E.

482. By whom worn.—In order to distinguish the members of turret, gun, and torpedo crews that do exceptionally good work, the members of these crews will wear a white E on their blue uniforms and a blue E on their white uniforms, as specified in the uniform regulations.

The members of the crew who are authorized to wear this mark of distinction will be designated by the department.

their names will be published in the report of the practice, and they will wear the E until the completion of the next elementary practice.

In determining the men entitled to wear the distinctive mark for excellence in gunnery, the turret and handling-room crew will be taken as a unit, not the turret-gun crews only.

In determining the men entitled to wear the Navy E for excellence in torpedo work, the torpedo crews in the same torpedo room on battleships and armored cruisers will be taken as the unit, and on torpedo and submarine craft the torpedo crews of the vessel will be taken as the unit.

483. How supplied.—When the list of men entitled to wear the Navy E is published, ships on which they are serving will be supplied, without charge, with a sufficient number of both blue and white E's for the use of the men entitled to wear them. If a regular ship's tailor is allowed the ship he will be required to sew these marks on without expense to the men.

484. Limit of wearing.—The commanding officer will have all the Navy E's worn by members of the crew for the preceeding year turned in and destroyed upon the completion of the elementary practice.

485. Where painted.—Winning turrets, guns, torpedo rooms, or torpedo tubes shall have one block letter E not more than 18 inches high painted on them in a conspicuous place. This E for the preceding year shall be removed upon the completion of this practice.

PRIZES.

486. Appropriation chargeable.—For a fiscal year all prizes for Navy crews will be charged to the appropriation "Gunnery exercises," for that year, all prizes for the Marine Corps to the appropriation "Pay, Marine Corps," for that year.

487. Value of prizes.—First, second, and third class gunnery prizes will be issued to meritorious crews, and the prizes awarded them will be made known as soon as possible after the completion of a form of practice. The present value of prizes is as follows:

First prize $20 per man.

Second prize $10 per man.

Third prize $5 per man.

Men entitled to prizes.—Every member of prize crew, including the turret captain, gun captain, gunner's mate, and electrician, whether regular or supernumerary, is entitled to a prize, unless absent through fault of his own.

A man stationed with more than one prize crew shall receive but one prize. This shall be the highest prize awarded to a crew with which he is stationed.

CHAPTER 21.

GUN POINTERS AND TURRET AND GUN CAPTAINS.

488. Gunnery and torpedo records.—The instructions for keeping gunnery and torpedo records shall be closely followed.

GUN POINTERS.

489. Pointers that fire.—No pointer shall fire at elementary practice unless it is probable that he will be on board at the next form of battle practice.

490. Pay of gun pointers.—See Navy Regulations, 1913, 4442 (11) and 4427 (19).

491. Assignment of gun pointers to other duty, restrictions against.—See Naval Instructions 2501 (2).

492. Optical examination of gun pointers.—See Naval Instructions, 2501 (3).

493. Pointers must serve at class of gun at which they qualified.—Attention is invited to the provision of the executive order which specifies that a gun pointer shall receive extra pay only when duly qualified and regularly detailed by the commanding officer and serving as gun pointer at a gun of the class at which he qualified. Thus, if a secondary gun pointer or an intermediate gun pointer is stationed as a pointer of a heavy gun, he must serve in such capacity without extra pay until he qualifies at the heavy gun on the next form of practice at which the department directs that pointers will be qualified. He does not, however, thereby relinquish his qualification as intermediate gun pointer or secondary gun pointer by reason of his employment at a heavy gun.

The above does not apply to a pointer shifted from one type of gun to another of the same class.

494. Qualifications.—Gun pointers will be qualified in accordance with the standard determined by the department for this practice. The commanding officer will authorize the extra pay allowed to such men as are qualified regular gun pointers upon receiving the notification from the department.

If there is any doubt about a pointer's allowed score the matter will be submitted at once to the Navy Department for decision, with recommendations both of the umpires and the ship's officers, and that pointer's gunnery record will not be filled out until the score is decided.

495. Recommendations for special qualification and change in a pointer's qualification.—All changes in qualifications of pointers shall date from the day on which the practice allowing pointers to qualify is completed.

In order to prevent manifest injustice to pointers, as, for instance, where the fire-control party is at fault or sights are out of adjustment, etc., umpires and commanding officers will report all such cases, giving full details, so that the department may take final action in the matter.

496. Qualified pointers not stationed at guns.—When a qualified pointer has been removed from his position as pointer of a gun by order of the commanding officer, and is present on board ship during the practice at which pointers are allowed to qualify, he shall, so far as his qualification is concerned, be considered as having fired but failed to qualify; but this rule shall be applied only in case the pointer was removed for a cause affecting his skill as a pointer. Pointers of intermediate or secondary guns that have received training and have been qualified on larger vessels may not be fitted for such positions on small craft having an irregular, quick motion.

There should be no hesitation in substituting unqualified candidates for qualified pointers in cases where inaptitude is evident.

497. Duration of qualification.—Pointers are required to qualify at each practice allowed them for qualification. A gun pointer's qualification shall last until the next opportunity for qualification, provided this occurs within two years. If no opportunity occurs for renewal, his qualification shall expire two years after the date of the practice at which the pointer qualified.

498. Absence of pointer through his own fault.—A pointer who fails to fire at such a practice through a cause due to his own fault—as, for example, when absent without leave—shall be considered as having fired, but failed to qualify, and his qualification shall be void after the date of completion of the practice of his ship, and this fact shall be entered on his gunnery record.

499. Absence of pointer not his fault.—A pointer who fails to fire at a practice where he is allowed to qualify through no fault of his own—as, for instance, where a pointer is duly excused by the commanding officer (on the recommendation of the medical officer) and does not fire on account of his physical condition—shall retain his qualification until two years from date of the completion of the practice at which he last qualified.

500. Extra pointers.—When a regularly qualified pointer is serving on board a ship as an extra pointer and has no opportunity to fire for qualification, the practice shall be considered, in so far as concerns the qualification of this particular pointer, as not having been held; but, as elsewhere specified, he shall draw his extra pay only when actually performing the duties of gun pointer.

501. Reenlistment of qualified gun pointer.—A qualified gun pointer reenlisting for four years within four months from the date of his discharge, and regularly detailed as a pointer at a gun of a class at which he was qualified at the time of his discharge, shall be entitled to the corresponding extra pay during the unexpired portion of the period of his qualification, the interval of time between the date of his discharge and reenlistment to be included in this period.

502. Employment of qualified pointers.—The sole object of the above rules is to create a class of gun pointers that will be as nearly permanent as possible. Pointers may be removed for any cause affecting the efficiency of the battery, and of this the commanding officer will be the sole judge. It sometimes happens that men whose scores entitle them to a qualification as gun pointer by the standards fixed by the department may be considered by their officers as inferior to other men available for the position. There should be no hesitancy in removing such a man when the efficiency of the ship will thereby be increased. In case any regularly qualified gun pointer on board any vessel is not regularly assigned as a pointer of a gun of the class in which he has qualified, or is removed from his station at a gun, it is directed that the fact be at once reported to the department. If the fact that the man is not employed is due to the lack of a vacancy in the class of gun at which he has qualified, the commander in chief of a foreign station should immediately transfer the pointer to another vessel where he can be utilized, and so state in forwarding the letter.

No qualified gun pointer stationed at a gun which is likely to be used shall be landed as a member of the ship's landing force.

In no case shall a man's conduct or any other consideration except his efficiency as a pointer be permitted to affect his assignment as a gun pointer or to influence his removal from that station.

503. Turret training pointers.—In turrets two men will be detailed as training pointers. The training pointers so detailed will act as sight setters for each other, when practicable, and the first and second pointers (elevating) will similarly act as sight setters for each other. Ordinarily at elementary practice the training pointers will each train for one of the pointers at each gun, and the score of the turret run for which he trains will be taken as his score in considering his qualification as training pointer. In case one or more of the pointers for whom a training pointer trains makes a low score that is manifestly not due to a fault on the part of the trainer, a special report of the circumstances will be considered by the department in awarding the training pointer his qualification.

504. Training pointers in superposed turrets.—For the purposes of elementary practice there will be four men detailed as training pointers in each superposed turret. Two of these training pointers will train for the eight-inch guns and the others for the twelve-inch, as in double turrets.

505. Training pointers' extra pay.—Training pointers will receive extra pay under the same conditions as elevating pointers.

TURRET AND GUN CAPTAINS.

506. Assignment of turret and gun captains to other duty, restrictions against.—See Naval Instructions, 1913, 2501 (2).

507. Pay of gun captains.—See Navy Regulations, 4427 (20) and 4442 (11).

508. Acting appointments as turret captain, first class, and chief turret captain.—(1) Acting appointments as turret captains to fill vacacies in the complement will not be issued until after the candidates have been examined and recommended by a board of officers, the examinations to be held on board the ship to which the candidates belong. Permanent appointments and advancement will be governed by the same regulations that apply to other petty officers, but turret captains, first class, may be given acting appointments as chief turret captains only after passing a satisfactory examination of the same character as for turret captain, first class, but of a more advanced nature.

(2) Commanding officers will select candidates that appear to possess the necessary qualifications from intelligent men of mechanical bent and good promise as leading men and will have them detailed to the turrets for training in the duties of turret captain for a period of at least three months. After this probationary training the names of those who are considered desirable candidates will be sent to the commander in chief, or to the squadron or division commander, who will order their examination before a board which he shall appoint, to consist of not less than three officers, the majority of the board to be turret officers detailed from a ship or ships other than those on board which the candidates are serving. When practicable at least two candidates, but preferably more, will be nominated for each vacancy in the complement in order that the examination may be competitive. The candidates who pass the examination will be eligible for acting appointments as turret captains, first class.

(3) In no case will an acting appointment as turret captain, first class, or chief turret captain be given unless the examination of the candidate shows that he is not only thoroughly familiar with the safety precautions to be observed in the service of the guns and the method of procedure in the case of a failure to fire, but also that he has been sufficiently drilled to make instant application of his knowledge and that he is competent to take full charge of the turret at target practice or in action in the absence of the turret officer.

(4) A candidate for appointment as turret captain shall be required to demonstrate his ability before the board by

actually drilling turret and handling-room crews, preparing a turret for target practice or action, operating all the mechanism, shifting of gas-check pad, going through the procedure in case of a failure to fire, and in other ways showing his practical ability to meet the various conditions and requirements in the care and handling of a turret. In regard to qualifications that can not be practically demonstrated the candidate will be closely questioned by the board orally, in order that the readiness of his knowledge may be ascertained.

(5) The following headings are given as covering the subjects on which the candidates for appointment as turret captains shall be examined (in the report of examinations these subjects will be referred to by letter only):

A. Ability to station and drill the turret and handling-room crews.

B. Ability to prepare the turret for action.

C. Dexterity in the operation of all the mechanism of the turret.

D. Familiarity with such details of the care of the turret mechanism as come under the cognizance of the gunner's mate of the turret.

E. A thorough knowledge of the safety precautions to be observed in the service of the guns and of the method of procedure in case of a failure to fire.

F. Ability to bore sight the guns and adjust the telescopes.

G. Ability to shift and adjust a gas-check pad and breech mechanism.

H. A ready knowledge of how properly to direct changes to be made in the compensation for range and lateral errors, in order to bring the shots on the target again after they have begun to fall off.

I. A thorough knowledge of the firing circuit, with ability to detect and remedy local defects.

J. Ability to fill the recoil cylinders and a thorough knowledge of the lock.

K. A knowledge of the care and preservation of the shell rooms and magazines and of the various powder tests and inspections.

L. Ability to adjust knife-edges.

M. Knowledge of the methods of receiving ranges and battle orders and communicating them to the sight setters and pointers.

N. Ability to ring and adjust Morris-tube, dotter, and subcaliber apparatus and to superintend the training at them.

O. A practical understanding of the general terms used in ordnance and gunnery and the rules for conducting target practice, with a knowledge of the danger spaces at elementary and battle ranges.

(6) Reports of examination will be in the following form. No other report is required. These reports will be sent by the senior member of the board to the commanding officer of the ship to which the candidate belongs. The report will then be filed with the man's service record, unless there be a vacancy in the complement and he be given an acting appointment as turret captain, first class, or chief turret captain to fill this vacancy, in which case it will be forwarded to the Bureau of Navigation, together with Form No. 1–B.

Report of examination.

Candidate's name ________________________ Rate ________
Attached to U. S. S. ______________________
Date of examination __________________. ______, 191__.

(Scale of marks: 5, excellent; 4, very good; 3, good; 2, fair; 1, indifferent; 0, bad.)

Subject.	Marks.	Subject.	Marks.	Subject.	Marks.
A..........	....	F..........	....	K..........	....
B..........	....	G..........	....	L..........	....
C..........	....	H..........	....	M..........	....
D..........	....	I..........	....	N..........	....
E..........	....	J..........	....	O..........	....

We certify that we deem the candidate not to be / to be fully qualified to take charge of a turret at target practice or in action, in the absence of the turret officer, and do not / do recommend him for acting appointment as Turret captain, first class. / Chief turret captain.

(Signatures of members of the board.)

509. Gun captains.—(1) By an Executive order dated July 25, 1903, enlisted men of the Navy, and extended to include Marines by Navy Department's Order No. 223 of September 27, 1912, who are regularly detailed by the commanding officer of a vessel as gun captains, except at secondary battery guns, shall receive, in addition to the pay of their respective ratings, $5 per month. In the case of men holding certificates of graduation from the gun-captain class of the petty officers' school, this $5 shall include the $2 per month to which such certificate entitles them.

(2) No man shall be regularly detailed as gun captain in the above sense (that is, with extra pay) unless he has been examined and recommended by a board of three ordnance or division officers (exclusive of his own division officer, if practicable) appointed by the commanding officer to determine his fitness for the position, but the above shall not be construed as preventing the detail of any desirable member of a gun crew as acting gun captain, though such detail shall carry with it no extra pay. Such details are necessary in order that, prior to their examination, candidates may have had actual experience in their duties in this capacity.

(3) In order that he may draw his extra pay, a gun captain who has been recommended by a board, as above described, must be regularly detailed as captain of some individual gun of the main battery. If, however, the arrange-

ment of the ship's battery is such as to render necessary the detail of one gun captain to a group of guns, as for example, when a number of guns are more or less isolated and require a responsible person in charge, a man may be detailed as gun captain of the group of guns, permitting an acting gun captain to relieve him at his own gun. In no case will the number of men on board who draw extra pay as gun captain exceed the number of guns of the main battery on that vessel.

(4) The following headings are given as covering the subjects on which the candidates for appointment as gun captains shall be examined (in the report of examinations these subjects will be referred to by letter only):

A. Ability to station and drill the gun crew.

B. Thorough knowledge of the safety precautions to be observed in the service of the gun and of the method of procedure in case of a failure to fire.

C. Ability to bore sight the gun and adjust the telescope.

D. Familiarity with the telescope sights of the gun, including their care, the precautions to be observed in their use, and their most probable derangements.

E. Ability to shift and adjust the gas-check pad and breech mechanism.

F. A practical understanding of the general terms used in ordnance and gunnery.

G. A thorough familiarity with the mount, and ability to adjust such parts as require adjusting from time to time.

H. A ready knowledge of how properly to direct the changes to be made in the range and lateral compensation in order to make hits again after shots have begun to fall off the target.

I. A thorough knowledge of the firing circuit, with ability to detect and remedy local defects.

J. Knowledge of the method of receiving ranges and battle orders.

K. Ability to rig and adjust Morris-tube, dotter, and sub-caliber apparatus, and superintend the training at them.

(5) Reports of examination will be in the following form. No other report is required. These reports will be sent by the senior member of the board to the commanding officer of the ship to which the candidate belongs. The report will then be filed with the man's service record.

Report of examination.

Candidate's name, ______________________ Rate, __________

Attached to U. S. S. ______________________

Date of examination, ________________ ______, 191__

(Scale of marks: 5, excellent; 4, very good; 3, good; 2, fair; 1, indifferent; 0, bad.)

Subject.	Marks.	Subject.	Marks.	Subject.	Marks.
A.............	....	E.............	....	I.............	....
B.............	....	F.............	....	J.............	....
C.............	....	G.............	....	K.............	....
D.............	....	H.............	....		

We certify that we deem the candidate $^{\text{not}}_{\text{to be}}$ qualified for the duties of a gun captain.

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(Signature of members of the board.)

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