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LECTURE ON GUNNERY FOR WAR COLLEGE CLASS OF 1923.

DELIVERED BY

CAPTAIN W. C. WATTS, U. S. N.

AT THE

FLEET-WAR COLLEGE SESSIONS

7-19 August, 1922

Stenciled and printed
at the
Naval War College
Newport, R.I.
22 September, 1922.

CONFIDENTIAL

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LECTURE ON QUERENCY FOR WAR COLLEGE CLASS OF 1952.

DELIVERED BY

CAPTAIN W. G. WATTS, U. S. N.

AT THE

FLEET WAR GAMING SESSIONS

7-19 August, 1952

Recorded and Released
at the
Naval War College
Newport, R.I.
25 September, 1952.

C O N F I D E N T I A L

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DELIVERED 17 JULY, 1922.

INTRODUCTORY

Last February at the request of the War College, I prepared a paper on Gunnery for the Student class. On reporting here on 1 July, I was informed that it was desired that the paper be brought up to date and read to the present class. Unfortunately, much of the data of recent practices had not been completely analyzed when I left the Office of Gunnery Exercises, and even the figures then at hand are not available to me here. Consequently, it has been necessary to trust to my memory in some cases, and the paper should not be considered as taking fully into account the 1921-22 exercises. As will be appreciated by my fellow students, lack of time has also prevented a really thorough revision.

When first informed that a lecture on Gunnery was desired, I was furnished from the War College with a synopsis of the subjects which should be covered, and these remarks are arranged in accordance with that outline.

The subject of gunnery is given such serious consideration at the War College and the officers present are so familiar with it that general discussion is quite unnecessary, and my remarks will be limited to a few salient points. Although numerous figures and statistics are purposely avoided, as probably being uninteresting and which are available elsewhere, certain data will be mentioned that may be of value in connection with game board scoring methods.

There certainly has been decided improvement recently in the extent to which the prescribed exercises are conducted by all classes of vessels. More ships conduct all practices required for eligibility for the trophies, and gunnery interests thus are well served. On the occasion of quite frequent visits to the Fleet at target practice times, I have been favorably impressed with the less strained attitude toward these exercises. They are not now regarded as such strikingly special occasions as at one stage in our development, and the personnel seems to take it more calmly, though none the less zealously and earnestly. It is not due to greater experience, for such condition does not exist, but rather to the gradual absorption of the doctrine that a ship should always be substantially ready to shoot and that, after reasonable amount of final tuning up and adjusting, it should be all in the days work to go out on the range and fire.

I have also been still more favorably impressed with the much greater disregard of weather conditions that now prevails. So long as the wind and sea are not too high for the target, and the repair boat if required, or so long as the target is barely visible at the long range practices, ships are expected to fire and do so willingly and cheerfully under conditions that would never have been contemplated a few years ago. Likewise, I have witnessed practices when the visibility was very unfavorable, but there was no hesitancy about firing as soon as reasonable safety to the towing ship seemed assured. The destroyers also accept severe weather conditions for that type of craft. It is unfortunate that means cannot be devised

to compensate in the score for such conditions, for it is highly advantageous that our ships be trained to fire under unfavorable conditions.

In the cruiser and gunboat classess, the conditions under which these vessels of very varied characteristics hold their practices are often necessarily so different that it is difficult to devise entirely satisfactory exercises when it is realized that so often special types of rafts or towing vessels or means of taking observations would not be available. Nevertheless, the considerable number of personnel attached to these vessels must be encouraged to continue their gunnery interest and training, and in some respects it has been practicable to modify the rules so as to permit of more fair competition. The importance of the gunnery interests of these vessels, meaning primarily their personnel, is fully recognized and is not overlooked in consideration of the larger and more spectacular features of gunnery for the battleships and other vessels of more military characteristics. The auxiliary class of vessels are now required to hold only one form of gunnery exercise a year - short range battle practice - and, by thus simplifying the demands, it was hoped that the net result would be a greater total amount of gunnery work by this class of vessel.

It has been said that the personnel situation has recently affected adversely the gunnery efficiency of the Fleets. This condition commenced in most ships during the war, and has continued throughout the service up to the present time, in greater or less degree. The difficulty has lain both in the inexperience of the personnel in general and in the lack of permanency in assignment,

the term personnel including both officers and men. The abnormal conditions confronting the Bureau of Navigation both in the war and post war periods are fully recognized, and undoubtedly everything possible has been, and is being, done to correct the situation. Some ships have been very shorthanded, in order that a maximum number might be spared from the evils of going out of commission, so that the burden on the relatively few experienced officers and men in each ship was greatly increased and changes in these depleted allowances worked correspondingly greater hardship. However, the worst seems now to over and the policy has been adopted that all ships in commission shall have more nearly their full complements of personnel on board in time of peace, so that war training may be carried out to the best advantage.

Whereas the personnel situation has had a serious effect in all branches of gunnery, it is perhaps in torpedo training and exercises that it was felt the most acutely. The result is that torpedo firing was at a low ebb for a time and progress was negligible, except in a few isolated exercises and cases. However, torpedo practices were held more generally in 1920-21 and still more frequently and successfully in the year just completed. A revival of interest in the subject has flowed naturally from an improvement in the personnel situation and the resultant better condition of the material. The ready torpedo practices have now been resumed again, and the ready torpedo policy is more firmly established. A new practice of this character was adopted for destroyers which offers a problem much more similar to battle conditions, and the results of

the firing this year were in some cases very encouraging.

Torpedo practices form the greater part of the annual gunnery schedule for submarines, and these vessels have already advanced considerably in the various forms of simulated attacks. A Board of Officers was convened last fall to consider their forms of practices, and it is believed that the requirements for the present year are more evenly balanced and will lead to further progress. It is also the aim to bring the general principles on which the gunnery exercises for submarines are founded more closely similar to those for other classes of vessels, particularly in methods of scoring, etc.

The number of torpedoes lost from various causes during the year 1920-21 was great - some 110 in all, from all classes of vessels, representing a value of probably over $1,000,000 - and it is becoming a serious question how this loss can be reduced without restricting unduly the number and character of exercises considered necessary for war training. The form of target to be used is directly involved in this question, it being most desirable for various exercises to employ as point of aim a moderately high speed shallow draft surface vessel under which torpedoes may be set to run with a safe margin. This reduces the clearness of the torpedo wake and the facility of recovery, besides incurring a slight risk of striking the point of aim, but nevertheless these facts must be accepted as part of the risk connected with any form of gunnery exercise. More suitable torpedo water is prescribed; further efforts are being made to develop better methods of automatically

showing the position of torpedoes that have made erratic runs; and more attention in the form of recovery vessels is enjoined.

It was finally decided that instructions relating to torpedo fire, from the gunnery standpoint, should be issued from the Office of Gunnery Exercises, where the subject seems logically to lie. A Board of Officers had submitted a proposed Manual of Torpedo Fire for Destroyers, which accordingly was revised and published to the service. The so-called Tentative Manual of Torpedo Fire that was issued last year from the Office of Naval Operations was also brought up to date, re-edited under the title of General Principles of Torpedo Fire, and issued to all classes of vessels.

Mining exercises, consisting of day, night and battle mining practices, were held last year for the first time on a competitive basis, in accordance with prescribed rules. These practices, except the last named were tried experimentally by some mine layers the year before and certain details modified from this experience. Although in devising them there was not much on which to work and although they are no doubt susceptible of much improvement, it is felt that a valuable start has been made, and the results so far are encouraging. The proficiency thus far attained in these new exercises may be of interest and is indicated by the following best performances reported up to February last for the several practices, the practices of mine sweepers not being considered as they are required to lay only a small number of mines and do not hold battle mining practice. On day mining practice, one ship laid the required 24 mines of which 23 were effective, and on night mining practice

another ship got 22.25 effectives, of the 24 laid as required. The specifications for effectiveness of mines on these practices are rigid and the results are considered excellent. On battle mining practice, where the full allowance of mines is laid under less rigid requirements as to effectiveness, one ship laid the required 160 mines with 151 effectives, also a very good performance. It is believed that in at least one instance these records were improved later in the year, but the scores are not now available to me.

Depth charge practices were also prescribed last year for vessels so equipped, in accordance with the policy that every portion of a vessel's armament should be tested in the competitive practices on which her merit in gunnery for the year is determined. This supplementary to the more general policy that every vessel, of no matter what class, having any armament of any description on board, should be required to use it in conducting a definite gunnery schedule, even though it consist only of the single most elementary form of practice in the case of the least military vessels.

The gunnery of aircraft, both in gun firing and bomb dropping exercises, cannot be said to have advanced materially in 1920-21, though it is hoped that some improvement will be apparent when the final scores for the year just completed are fully analyzed and compared. It is believed that the element of competition may not have been very effective in the past, dut to the manner in which the scores and standings were determined. A Board of Officers,

assembled for the purpose, submitted very helpful suggestions for the 1922-23 practices for aircraft, and the rules were completely revised, not only to improve the requirements but also to provide for unit, division and squadron, in addition to individual, scores, along the same general lines as apply to the competition for ships. The comment thus far received regarding the new system is encouraging, and it is hoped that better and more concrete results will be obtained.

The War College is familiar with the results of the bombing exercises last summer, when the ex-German ships and the ex-IOWA were used as targets, and it seems unnecessary to dwell upon the sound conclusions of the Joint Board on the results thereof. Whereas these exercises were considered of an experimental character, it will be realized that, from the gunnery standpoint, there was little that could be learned that was not already fairly well established by the prescribed annual bombing practices for aircraft. The information which the exercises were designed to furnish was largely either of a material character, relating to the action of the bombs and the effects of their explosion on different types of vessels, or of a tactical nature in connection with the search problem feature of the ex-IOWA exercise.

We are looking forward with great interest to the aircraft torpedo practices which will shortly be held, as the torpedoes and suitable planes are promised for next month. After a more elementary form of practice, it is planned to hold an experimental practice against a moving battleship formation. The great possibilities

of this weapon are recognized, and we have been anxiously waiting for the time when the material would permit of making a start on its development in use, under the competitive system that has produced results with other forms of weapons.

Several important questions relating to the extent and character of gunnery exercises for the battleship class were sent out to the Atlantic and Pacific Fleets for study and comment by the experienced personnel. When the replies were received, a Board was appointed, consisting of officers from the Fleet, the Bureau of Ordnance and the Office of Gunnery Exercises, to study them and to submit their own conclusions, with this concensus of opinion from the Fleets as a most valuable guide. The various comments received were most interesting, and a number of excellent suggestions resulted. It was decided that the evidence was convincing that the schedule had grown gradually to an extent where some reduction was advisable, in order that all forms of exercise may be conducted in the course of a year, without overcrowding and with a maximum benefit both in training and from the practices themselves. Means were therefore recommended, by combining certain practices, whereby this may be accomplished, and it is hoped that the results will be acceptable.

The best manner in which awards for gunnery excellence should be made, whether by prize money alone or by combining with it a system of extra compensation similar to the gun pointer money, was also considered by the service. In this way, a general review of the whole gunnery situation was held, which is believed to be advisable from time to time, and the attention of many officers that

has thus been drawn to this taking count of stock in gunnery matters cannot fail to be of assistance in the long run.

The restrictions placed on the operations of the Fleets due to the lack of sufficient fuel procurable under last year's appropriation limited the amount of gunnery training that could be conducted underway, which is of course the most important means of developing efficiency. It is a matter of gratification that it was decided to be possible to conduct the required practices by the active units, but it can be stated with certainty that the inability of vessels to be at sea the desired amount throughout the year had a direct and harmful effect on gunnery efficiency. The gunnery activity of the destroyers operating with 50 percent complements, and of vessels in reserve was practically at a standstill because of the fuel situation.

EXPERIMENTAL FIRINGS.

A number of experimental exercises by several types of vessels have been carried out or are planned for the future. Falling under this category may be included modifications of some of the prescribed non-weighted practices that were authorized for the purpose of developing special points.

Prominent among these exercises are the experimental torpedo practices conducted in the last two years by the active destroyers in the Atlantic and Pacific. The form prescribed for this year was designed to simulate a supported and coordinated attack by a squadron of destroyers, using smoke, upon a formation of capital

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ships. Each destroyer, except the leader was allowed to fire three torpedoes, and a total of fifty four torpedoes would thus have been launched nearly simultaneously. Light forces were represented and the capital ships were free to maneuver within certain limits so as to avoid the torpedoes if possible. Gun fire between the opposing battle lines was to be simulated, and elaborate data and records required for the purpose of studying the tactical as well as the gunnery side of the question.

Unfortunately, due to lack of sufficient recovery vessels and for other reasons, it was deemed advisable in the Atlantic to fire torpedoes from only two divisions, whereas in the Pacific it is understood that only one division fired, as was the requirement in the preceding year. No report has yet been received from the Pacific Fleet, but the practice in the Atlantic brought out some interesting points. Although the destroyers proceeded to a position that in action would have subjected them to probably overwhelming gun fire, as the smoke screen used did not well mask them from the opposing battle line, the attack resulted in four hits on battleship hulls out of 33 torpedoes actually fired, in spite of the fact that the battleships turned away through 50°. Exercises of this nature are particularly valuable, and a great deal remains to be learned about the tactics and technique of such an attack and the best means of countering it.

As the next step following the squadron practice conducted by seven battleships of the Pacific Fleet in the spring of 1921, it was planned to hold a battleship force practice this winter, when

15 or 16 vessels would engage simultaneously a tow of 10 target rafts during the period when the Fleets were expected to unite in the Canal Zone. All preparations were made, a special towing hawser manufactured to permit of towing the large number of rafts, and it was a bitter disappointment when the shortage of fuel necessitated a change in the plans of the Fleets.

However, eleven battleships in the Pacific conducted a most valuable squadron practice this Spring, using eight targets, and with a change in fire distribution and a shift to pointer fire introduced during the firing. Unfortunately, as described later, aircraft observations of fall of shot were available to only about half the ships, but as this practice is fired with reduced charges and consequently at relatively short actual range this misfortune did not particularly affect the gunnery features, though the last chance for experience with the aircraft spotting doctrine is greatly regretted. Also the air planes designated for taking photographs of the fall of shot failed to arrive on the scene, so that the triangulation pictures from the towing ship were the only means of plotting the fall of shot, which are inadequate for so long a tow. Consequently the results could not be determined with the usual accuracy and at least 17 salvoes could not be plotted at all. From the salvoes plotted, it appears that there were 108 hits in the eight constructive targets, or approximately 12% of the 902 shots actually fired, As there may have been additional hits in the unplotted salvoes, it is considered that this result is very encouraging. As a particular feature of interest in this practice in-

volving concentration of fire and a shift of fire distribution, it is to be noted that the average shots per gun per minute for the whole squadron reached the quite high figure of 1.21, though of course the range was less than for the long range battle practices. In 1921, the average range on the corresponding practice was about 10,700 yards and it probably was about the same this year, though the exact figure is not available to me now.

Elaborate investigations, with numerous experimental firings, have been recently conducted in the Pacific Fleet to develop the best doctrine for the control of fire of illuminating projectiles, both for illumination of a target and for searching, and from both battleships and destroyers. Much valuable data has been collected and certain apparently very sound conclusions have been reached that fortunately lead to the strong belief that the problem is not as difficult in some respects as has been suspected in the past. It is felt that great progress has been made in this phase of gunnery and that a well established doctrine for control of fire of illuminating projectiles is clearly in sight. The results of the night battle practice by the Fleets are encouraging, and are believed to be due probably to more efficient illumination.

Also the Pacific Fleet has been engaged in much experimental firing, study, and investigation, in a determined effort to solve the still more troublesome and difficult problem of the control of anti-aircraft batteries. In this respect, little progress had heretofore been made, and - frankly - the lack of effectiveness of fire of these batteries is a source of grave concern. The fact that we have had no targets that can simulate to any satisfactory degree

the condition to be met in war has gone far to hold back development of this battery. This situation has been improved materially: a successful glider target has been developed; numerous parachutes have been made available; investigation and experimentation toward an automatic or radio controlled airplane target are in progress; and above all experiments have proved the practicability of towing by aircraft a sleeve as a target for gun fire of ships. The unavailability of an airship from which to launch the gliders, which cannot in safety be carried aloft by heavier-than-air-craft now available, has been an unfortunate handicap, but confidence is felt that important conclusions will soon be reached regarding the best method of controlling the fire of anti-aircraft batteries. The problem is regarded as one of the most serious now confronting the service and much effort is being concentrated on the subject. The inadequacy of the anti-aircraft batteries was recognized and the number of such guns on battleships has been increased to eight, while the development of the short 5-inch A A gun is being expedited.

The form of long range battle practice prescribed for at least one division of destroyers in each squadron, in which the system of massed fire was used, with observations from aircraft, if available, and with divisional control, was very instructive and gives promise of further useful development. The fire of all ships on one target was controlled by one ship, from which range and deflection was transmitted to the others, and the fire of the entire division was shifted to a second target during the exercise. The British came to much this same principle of fire control in their

destroyer division during the latter part of the war, and there is much to be said in its favor, but it is necessary to acquire additional data of exercises conducted in this manner before any sound conclusions could be established. The fact that many destroyers for a long time could not be equipped with the director system has held back the development of gun fire in destroyers, but the installations, as far as authorized, are now nearly completed and will proceed as fast as funds permit.

An experimental practice was conducted last summer by a destroyer to test the efficiency of a torpedo salvo plan designed to meet the condition of such a vessel coming suddenly upon an enemy reasonably close aboard, at night or in low visibility, when time would not permit of any tracking or estimate of enemy course and speed. This is one of the very important contingencies which destroyers must be prepared to meet. The exercise developed certain weaknesses in the salvo plan under test, a new one was prepared, and it will be tested on one of the advanced practices prescribed for destroyers this year.

A torpedo practice has been worked up for submarines for this year in which the firing vessel will resort wholly to the listening device equipment for obtaining necessary data for torpedo fire regarding the bearing, speed and course of target. Development of this form of attack is very important, and the elementary exercise laid out for this year will lead, it is hoped, to a more advanced practice with the torpedo launched from the submarine submerged to about sixty feet, if certain experiments to ensure that torpedoes

can be fired with sufficient reliability under such conditions prove satisfactory.

An interesting exercise was conducted last Spring by the Florida in which bombardment operations of unseen shore defenses were simulated. The ship steamed on radical zig zag courses, with an approximate countermarch at the end of the first leg, as would be necessary to reduce the effectiveness of shore fire or to avoid a submarine menace. It was intended to obscure the target entirely with a smoke screen, leaving visibile only a reference point, but suitable vessels for the purpose were not available. However, precautions were taken to ensure that no advantage was taken of the visibility of the target, and the practice was conducted wholly as if by indirect fire. It had been hoped that air craft would be available to report the estimated fall of shot but this was also not practicable, and their presence was simulated by the receipt of spots from observing vessels. The exercise was a severe test of the fire control equipment, particularly of the Ford range keeper. The results were entirely satisfactory and proved that the bearing of the target could be followed with very considerable accuracy by automatic means, even in spite of the radical changes of course and speed of the firing ship. With the improved equipment installed in later ships, the results would have been even more encouraging.

Advantage was taken of the availability as targets of nine submarines of the A and B classes at Cavite to conduct certain experimental practices by the Destroyer Squadron, Asiatic Fleet. An allowance of ammunition was obtained for the purpose, and certain

general requirements laid down, but the details of the exercises were left to the discretion of the Commander-in-Chief. All the submarines were sunk and the reports indicated that much valuable experience was thus gained.

The main purpose for which the ex-IOWA was converted to radio control was to furnish a large, self propelled, ship target for the gunfire of a capital ship. It is most unfortunate that these exercises have been repeatedly delayed by a succession of regretable incident, for valuable lessons are awaiting the service. However, it is hoped that they surely will be held during the present year.

These exercises as now laid down are divided into four phases. The first will exercise the secondary battery in engaging the ex-IOWA steaming at her best speed, with her course and that of the firing ship so regulated that the maximum rate of change of range may be obtained, consistent with keeping the guns of one broadside bearing. It is believed that more satisfactory conclusions regarding the zone control of fire will be established from this test of present methods, and a check will be obtained as to the flexibility of our fire control system and installations to meet a more difficult condition than has been possible with towed, anchored, or drifting targets.

The next phase will be main battery fire opened at maximum range and directed against the ex-IOWA, while the two vessels are steaming on courses to give a good rate of change and with the ex-IOWA maneuvering by radical changes of course, toward or away from the firing vessel, whenever straddled by gun fire. This will present a severe test of main battery control, and give needed data on

the reduction in effectiveness of fire that can be caused by radical maneuvers of target vessel. The third exercise is designed to test the ability to keep main battery fire on a vessel executing a countermarch, and is an extension of the second phase for much the same purposes. A liberal amount of ammunition is provided, and by using half or reduced salvoes it is believed that the fire can be continued on each portion for a sufficient length of time to lead to sound conclusions, thus eliminating the often expressed criticism of the inconclusiveness of target practice because of the limited ammunition allowance.

If the target survives these three tests, the final phase will consist of a night attack upon her under difficult conditions with the secondary battery of the firing ship. This is desirable not only to better visualize the problem of a night engagement of this battery, particularly in regard to the identification of hits on a large material target and the added difficulty of spotting when overs may not be seen, but also to test out the doctrine of control of illuminating projectiles recently the subject of investigation in the Pacific Fleet, when an actual ship under fire is the object to be illuminated.

It is problematic, of course, how long the ship may survive the damage to be expected from this considerable amount of gun fire, and derangement of her motive power or control gear is naturally a grave source of apprehension. Whereas of course it is hoped that a high degree of effectiveness of fire may be demonstrated; it also is equally as earnestly desired that the hits may be in lucky positions and that the exercises can be completed. They constitute by

far the most advanced form of experimental practice that have ever been attempted, and should be exceedingly interesting and instructive.

Four other forms of advanced practices for certain of the battleships have been prescribed for this year. In one of these, one of the 30° elevation ships will fire at extreme range, using aircraft observations. It is expected that an opening range of at least 33,000 yards will be used, at which the target will be invisible except from the tops, and it is hoped that some data may be forth coming as to when a naval engagement may advantageously be opened, though the conditions must necessarily be simple on this exercise.

In another, a division of ships will exercise their secondary battery control in coordinated fire against a target partially, or intermittently, obscured by smoke. A project has been started to obtain a radio controlled destroyer for use in enlarging this exercise to permit of a greater rate of change of range. The vital question of the ability of capital ships to stand off a determined destroyer attack still remains very unsettled, and these exercises will serve to clear it up to some extent.

The third exercise will test the new fire control equipment in the control of main battery fire during a countermarch of the firing ship, and the fourth one is designed to give information as to the results that may be expected from the fire of one group of turrets, controlled entirely from the high turret, with all electric power from external sources off in the firing turrets and with all external lines of communication considered cut, except to plotting room.

From these numerous experimental or advanced exercises, it will be noted that gunnery also is progressing in the scope and character of the prescribed practices. Much remains to be done, some problems as yet have hardly been started, but the prospects for the future are encoureging, and now, since the limitation of armament treaty, it is more than ever important to develop gunnery efficiency to the utmost.

FIRE CONTROL IN BATTLE.

With regard to fire control in battle it cannot be said that the past year brought forth any particular new developments, though considerable progress was made in coordinating observations from aircraft, the personnel became more familiar with the ships installations, minor improvements were constantly in progress, and work continued in the development of new devices such as the stable zenith, erosion correctors for 14-inch guns, tube directorscopes and follow-the-pointer system in train for torpedo tubes on destroyers, etc.

A great disadvantage in the director systems as now installed lies in the fact that they are not self-synchronous and that therefore shift cannot be made from one directorscope to another without incurring the loss of time of synchronizing the entire system by an elaborate system of checks, which at best would introduce a grave risk of inaccuracy in the stress of battle. The MARYLAND is now being fitted with the first delivery of the new General Electric director system which is automatically self-synchronous, much sim-

pler of adjustment and in many ways a great improvement over the former designs. This system is held highly confidential and is not to be discussed outside the service; it is to be installed on the two new battleships that are to be completed and on six scouts and twelve destroyers.

The MARYLAND will also have the target bearing transmitter system cross connected with the directorscope and spotter's telescope at each station where these instruments are located, which will relieve the directorscope operator and the spotter of the necessity of keeping their telescopes on in train, will be a triple check on the designated target, and will enable the director operator to hold the fire in cases where the target bearing transmitter operator is off in train. The TENNESSEE and CALIFORNIA are also so fitted, as will be all later ships. For the secondary battery, a directorscope is being designed with the Ford range keeper connected thereto, and on the TENNESSEE and later battleships the broadside directorscopes are located at the control stations, which have been raised to a position immediately under the tops - a much better arrangement and position. These and similar improvements will add greatly to the efficiency and simplicity of fire control, and it only is regretted that reduced appropriations have slowed up the work so materially.

The new Mark VIII directorscope for destroyers is being installed and a test of one of the first completed installations was recently held by the OSBORNE, which confirmed the value and necessity of this system for destroyers. It is a wonderfully ingenious

instrument, with Ford range-keeper direct connected, a gyroscopically stabilized sight, which may be used instead of a director pointer in the usual way, and a cross levelling device to overcome the error due to tilt of the gun trunnions that is produced by the violent motion of a destroyer in a seaway. Although the motion of a battleship is much less, it is considered necessary at long ranges to correct this error in their case also, and it is proposed to fit their director system with the cross leveling device.

Although the fire control system in a battleship today is a very complex one, there is nothing at all mysterious about it and comparatively little difficulty is encountered in ships having the necessary number of experienced officers and men to follow it up. On the other hand, the shifting of personnel that has sometimes been necessary, with resulting occasional shortage in the officer complement for important fire control details, has had a more serious effect on this feature of a ships organization than probably on any other, and a number of ships have had most discouraging experiences. The tendency however is to simplify rather than further complicate the fire control system, insofar as the duties of the personnel are concerned, and this is believed to be entirely sound and desirable. Whereas certain of the instruments are becoming more complicated in order to place less demand upon the human element, yet the improvement in their design and construction seems to have prevented their becoming any more difficult of upkeep or adjustment. It must be constantly kept in mind that the complete fire control system cannot be expected to remain effective, either

as to personnel or material, for any considerable period after a vessel begins to receive heavy hits in action, and for this reason it is most important to be able to continue effective fire control by secondary methods. During and since the war it has been felt up to this time that our personnel situation was so unsatisfactory that artificial casualties introduced into target practice would not be desirable, but it is planned to revert to this procedure in the near future, in order to better insure a high degree of training for maintaining the fire efficiently when various casualties to the fire control system are experienced.

AIRCRAFT SPOTTING.

The assistance to the control of fire derived from observations of the fall of shot from aircraft has become more and more recognized, and considerable progress has been made in eliminating the difficulties that were first experienced, particularly in the matter of communication with airplanes. It is of course recognized, and a matter of record, that estimation of the error of mean point of impact from aircraft is more accurate than can be made from aboard ship, other things being equal. For instance, on the two Long Range Spotting Practices held in the Pacific Fleet in the Spring of 1921, when the fall of shot was observed from airplanes as well as from the spotting ships, the average error of 34 spotters from various vessels of the Fleet, from heights of 100 feet or over on the spotting ships, was 264 yards, whereas for 27 spotters in airplanes the average error was but 137 yards. In the case of one of these practices, all airplane spotters stood higher than any observing spotter stationed on the spotting ship.

Two forms of aircraft are used for the assistance of fire control, kite balloons and airplanes. Considerable difficulty at times has been experienced in flying kite balloons from battleships and several fatal accidents occurred from their use in the winter of 1921, leading to an opinion on the part of a considerable number of officers that this procedure should be definitely abolished.

It is fully recognized that kite balloons have very definite limitations; that probably they could or should not be carried on capital ships on certain forms of long campaigns; that they may disclose prematurely the ships from which flown; that they cannot be used in some weather conditions; that they constitute a menace to ships in a certain degree, particularly until helium gas is available; that they are a great inconvenience to ships; that their present ceiling is so low as to cause too much shock during salvo fire; and that, if flown in unfavorable weather, they interfere with the maneuverability of ships. On the other hand, the accidents that have happened occurred under very adverse weather conditions and also are traceable partly to matters of design and material that can undoubtedly be improved, and the numerous possible advantages of kite balloons when used under suitable conditions cannot be overlooked.

The simplicity and reliability of direct telephone communication, free from interference, with an observer in a kite balloon certainly outweigh some of the bad features of that type of aircraft, when compared with the difficulties encountered when a number of ships are attempting to receive radio reports from spotting planes. This feature constitutes probably their greatest advantage,

for it is granted that observations in range from them cannot be made with as great accuracy as from a well placed plane, though deflection observations are more practicable. However, conditions might well arise, especially until airplane carriers are constructed, when spotting planes might not be available, and the great difficulty experienced by them in spotting for a large number of ships, unless concentration of fire is adopted, will be described later.

As to the possibility of premature disclosure of our own ships due to their flying kite balloons, it would seem that this would be comparatively remote if the Fleet was properly screened, for before the kite balloons could be sighted it is probable that contacts of surface vessels and aircraft would have quite accurately located our battle fleet. Its formation at that time would not be of great importance, as the battle formation would hardly yet have been taken. In any event, the risk of disclosing otherwise unobtainable information can be reduced by keeping the kite balloons partially hove down, and promising experiments have been made in transferring them from smaller ships to battleships. Thus it may be practicable on a long passage or campaign to carry such balloons deflated on a suitable carrier, with a view to their inflation and transfer by destroyers to the capital ships when distant contact has been made and when no handicap is accepted by flying them. There are other phases to the question, but after careful consideration of them all the Office of Naval Operations is of the opinion that it would be unwise at this time to abolish the use of kite balloons, but rather is encouraging their further improvement and

continued practice in flying them and in their transfer from ship to ship. The Orders for Gunnery Exercises do not, however, make mandatory their use under all conditions for the gunnery exercises for which they are authorized. The Bureau of Aeronautics, after investigations following the casualties last spring, has recently condemned, as unfit for Fleet use, all the kite balloons of the Navy except the new F type, of which only a very few have been delivered. Experiments had first to be conducted even with these, so the use of kite balloons in Fleet gunnery exercises was impracticable in the year just completed.

Real progress has been made in the cooperation of airplanes with firing ships during gunnery exercises recently, although on at least one occasion in 1921 the ships were firing when the wind was blowing too hard for the planes to stay up. In the Pacific, special spotting practice was provided for the aircraft spotters by use of a battery of 3-inch guns installed ashore for this purpose, and long practice between the ships and planes greatly improved the radio transmission of spots. As a result of these tests it was decided to equip nine ships of the Pacific Fleet with a special installation of multiple receiving sets designed to receive simultaneously reports from as many as four airplanes, and also to supply the planes with improved transmitting sets, so that still better results were realized in the practices this year.

In addition to the difficulty of maintaining certain communication, another great problem for the airplane spotter is to determine and keep under observation the target at which his ship is firing, when a considerable number of ships are engaged. In

fact, no satisfactory solution has thus far been devised by which any reasonable chance of success under many conditions of battle is offered. The whole subject was most carefully studied in the Pacific Fleet last winter, and it was decided that the difficulty of distinguishing the proper target of each plane would be so great as practically to preclude the possibility of furnishing airplane spots in a ship- for ship action, when more than eight ships are engaged each at its own target.

Therefore it was felt by them that airplane spotting might not be available with larger numbers of ships engaged, unless concentration of fire to produce not more than eight targets was arranged. The inadvisability of thus restricting the manner of fire distribution of the battle line was recognized, but it was realized that when, because of great range or poor visibility, spotting could not be done from the ships or from kite balloons, it might be wise to adopt the necessary concentration, in order to make airplane spotting practicable and thus to gain an initial advantage. A very comprehensive scheme was worked out by which the one target under fire by a number of ships would be indicated to the spotting planes by the continuous evidence of salvoes landing in the same general vicinity, thus establishing so called "salvo zones" which could be counted off from right or left to a total of four in each direction, thus providing for a battle line of eight divisions, if each division should concentrate on one target. Each plane assigned to a zone would report the fall of each salvo from the ships concentrating on that target, and each ship would determine her own salvo by

use of the time of flight clock. The scheme is based on vessels firing in rotation at predetermined intervals, although, when all ships were straddling, independent rapid fire by salvoes presumably could be taken up until the growing errors of mean point of impact could necessitate a return to the rotational fire.

The great objection to this scheme lies of course in the restriction to a certain form of fire distribution and in the reduction of volume of fire that results from concentration and from rotational fire. However, there as yet seems to be no other solution, and the tentative doctrine submitted by the Pacific Fleet is now being reviewed finally by the Department and will probably shortly be approved. It is emphasized that under normal conditions the use of aircraft to assist in the control of fire is not contemplated except when, due to extreme range, poor visibility, intervening smoke screen, or for some other reason, the ships spotter or kite balloon spotter is unable to see the target with sufficient clearness to permit of reasonably accurate control of fire.

It had been hoped that the doctrine could be tested on the force practice that was planned for the combined fleet, when 15 or 16 battleships would have fired together. It is in this subject that the greatest loss comes from the abandonment of this exercise, for until a considerable number of ships can fire together it can never be known to what extent reliance can be placed on aircraft spotting in a fleet engagement.

For the Squadron Practice held in the Pacific, with 11 ships engaging 8 targets, elaborate plans for the participation of aircraft for spotting and photographic purposes were made. Unfortun-

ately, on the scheduled day for the exercise, low visibility necessitated a delay, and, when it was finally decided to fire, the planes in many instances failed to find the targets or found the clouds too low for their mission. As a result, only one flight of spotting planes took part, covering about half of the targets with their observations. It is greatly regretted that a more satisfactory test of the spotting doctrine was thus prevented, but, as far as those that participated is concerned, it appeared to be satisfactory. At least, the incident emphasized that complete reliance cannot be placed on the availability of aircraft at the time and place required, under all conditions of weather.

The incorrect expression - "control of fire by aircraft" - is sometimes heard and has led to some misconception of the true function of aircraft in assisting the control of a ship's fire. It is the duty of a spotter in an aircraft to estimate the distance of the mean point of impact over or short of the target and to transmit this information instantly to the firing ship. He should take no account of external circumstances or apparent variations of the mean point of impact, nor report "no change" merely because of a salvo being one of successive straddles, but should in each case report his estimate of the error of that particular mean point of impact, leaving to the control spotter the consideration of the other features. He should, under most circumstances, be required to report also his estimate of deflection errors, and if communication is sufficiently easy and reliable he might be expected to report changes of enemy course, etc. Obviously, however, the duty

of determining what correction shall be applied to the guns, in other words, the control of the fire in that respect, must lie with some individual in the firing ship, cognizant also of the observations of the ship's spotters, any errors of gun layers or of director or gun pointers, the part of the roll on which the last salvo was fired, changes in indices or temperatures of powder, and the numerous other factors that should enter into a proper determination of the correction to be applied to the guns, usually called the "control spot". It is thus apparent that the airplane spotter should not be regarded in any sense as controlling the fire, although his estimate, when it gets through correctly to the ship, is usually of more assistance than anything else to the officer determining the control spot.

Particularly when there is only one ship firing and communication with aircraft is thus made simple, the temptation to rely almost wholly on the airplane spot for determining the control spot is very great, and of course is very dangerous. The service has been warned from time to time not to neglect the training of ships' spotters nor to permit the importance of their responsibility to be overlooked, and this year a casualty was introduced into the long range battle practice of battleships by which communication with aircraft was interrupted at a certain stage of the firing, prescribed for each ship in sealed instructions.

LONG RANGE FIRING, DISPERSION, AND PERCENTAGE OF BATTLE HITS.

These three subjects are so interwoven that it may be simpler to consider them together. Aside from the regular prescribed

practices, there has been only very little long range firing and our present information, except from theoretical estimates, regarding dispersion and percentage of hits does not go much beyond what is established by the regular practices. Unfortunately, incomplete or erroneous data prevented plotting with sufficient accuracy most of the calibration firing of the TENNESSEE and CALIFORNIA so that the results are quite inconclusive.

The MARYLAND, whose battery will be tested soon in connection with calibration tests in much the same manner as the former two ships, will have shell with the new type of rotating band, and her sixteen inch forty five caliber guns are so closely similar in rifling to the latest design being developed that but little sacrifice or accuracy need be considered on that account. These tests are anxiously awaited, and confidence is felt that the results will be gratifying. Calibration tests by the NEVADA, at present being re-gunned, are also scheduled.

The California and Tennessee held long range battle practice this Spring at average ranges of about 25,000 yards with very satisfactory results. In the case of the Tennessee particularly, the performance was such as to show without doubt that an engagement could be opened with good effect at such a range, with air craft observations available. Even without the assistance of aircraft, it was reported that a ship's spotter, under the visibility conditions then obtaining, could have controlled the fire with very fair success. Certain features of the Tennessee's performance may be of interest:-

Average range. 25,087

Shots fired. 75

Hits on constructive target. 8

Percentage of hits. 10.67

Time for 7 salvoes. . . . . 4 Min.58 Sec.

Shots per gun per minute. 1.2834

Hits per gun per minute. 0.1369

Number of salvo first to get on target. . . .First

Number of straddles. . . . . .6 out of 7

Average error of M.P.I. . . . . .112 yards

Average pattern. . . . . .823 yards

Average true range dispersion. . . . . .315 yards

Final merit for practice. 89.298

Standing in class. . . . . 3.

Coming now to the actual performances on target practice, we find that, in the battleship class, the average ranges for the long range turret fire increased gradually up to the Spring of 1919 when, under the favorable visibility conditions off Guantanamo for all ships, it was 19,193 yards. In 1920, the practices were held largely under such poor visibility conditions that it was necessary to close in considerably in order to fire with safety, and the average range for that year was 15,774 yards. In 1921, the average range came up again to 18,096 yards, while in 1922 it was 19,253 yards.

The subject of hitting power at various ranges and the effect of range upon pattern size, dispersion in salvoes, and error of

mean point of impact has always been carefully studied, both from an analysis of actual practices and from the theoretical standpoint. By the former method, it must be said that the data are as yet too scanty to admit of precise answers, and the figures, when combined in different ways, do not always lead to the same conclusions. Inferences, or estimates, are about all that can be deduced at this time. Although long range practices have been held for many years, it must be remembered that the present fire control equipment has been reasonably complete only in recent years, and results of practices of previous years cannot therefore be averaged with recent ones . The lack of conclusiveness in these investigations is largely due to the relatively small ammunition allowance that is available for target practice, and of course to the varying conditions of weather, state of training, and personnel that exist in the several ships from year to year.

However, a complete tabulation of every 12-inch and 14-inch turret gun salvo fire on the 1919, 1920 and 1921 long range battle practices - some 264 in all - has been made, showing all the characteristics of each salvo. The number of salvoes from each separate caliber and length of guns is not great enough for averaging purposes, and it is felt that better results are obtained by considering together all 12-inch and 14-inch guns, particularly as theoretical investigations lead to the conclusion that there is very slight difference in the accuracy of these guns at any particular range. Averaging the results of the performances of all these guns, therefore, we arrive at information as indicated in the fol-

lowing table, the hits being as plotted on a target 30 feet high, 90 feet in beam, and 600 feet long, and with shots striking within 30 yards short of the target and on in deflection being considered also as hits:-

TABLE A.

Year	Average Range	Shots per salvo	% of hits	H.P.G. P.M.	Pattern	Mean Dispersion	Error of Mean Point or of impact.
1919	19193	9.2	8.9	0.0754	1051	259	456
1920	15774	9.6	11.2	0.1000	684	170	302
1921	18096	10	12.8	0.1016	747	190	332
(1922	19253	9.53	11.13	0.1081	818	223	359)

Whatever else this may show, it confirms previous statements that gunnery has been improving, remembering in the analysis of it that the 1920 practice was fired at considerably shorter range, and with the added information that the hits per gun per minute for 1922 is nearly 7% greater than 1921, at a range greater by over a 1000 yards.

Then all the salvoes upon which the above is based were further divided into four groups, according to the range at which fired, and those in each group averaged for their various elements, leading to the following tabulation:-

TABLE B.

Range Limits	No. shots	Hits:	% of hits	No. Salvoes	Average range	Pattern	Mean dispersion	Error M.P.I.
11000 15000	441	66	15.0	46	13,612	572	135	175

TABLE B. (Contd.)

Range Limits	No. shots	Hits	% of hits	No. Salvoes	Average range	Pattern	Mean dispersion	Error M.P.I.
15000	319	32	10.0	39	16,461	795	191	401
17000								
17000	1010	101	10.0	88	18,072	851	223	349
19000								
19000	732	71	9.7	91	20,455	1019	256	513
23000								

A consideration of these tables shows how difficult it is to arrive at anything but the most general comparative conclusions, which have always been obvious, but which are verified only in comparison of the shortest with the greatest ranges, for the results in accuracy of the firing at the mid ranges are apparently inconsistent. In other words, by these figures it is impossible to establish the rate at which the percentage of hits will fall as range increases, although it is known of course that such takes place, other things being equal. The rate of increase of error of mean point of impact, which bears a direct ratio to the percentage of hits, is likewise not susceptible of determination from these data. On the other hand, the increase with range of pattern size and mean dispersion is fairly regular, and it is interesting to note that the rate of the latter is considerably greater than that at which the theoretical curves mentioned later show the mean range error to increase; the individual amounts are also much greater. (See Table C). The fact that these elements come out more consistently is due of course to their being uninfluenced by fire

control errors and are not dependent so much upon the state of training of the personnel, except in gun laying and communications. New standards have been adopted for range dispersion, which heretofore had been considered constant for all ranges.

Insofar as percentage of hits is concerned, it is believed that the average for the three years as shown in the first table gives the only figure upon which even fair reliance can be placed, and that for the present the rate at which the percentage would change with range had best be deduced from theoretical considerations. This average figure is 11% of hits at a range of 17,688, or say 17,700 yards.

As has been mentioned, a new type of rotating band has been developed by the Bureau of Ordnance to prevent the present fringing tendency, and an improved style of rifling with uniform twist has been designed with a view to truer flight of shell. The proper balancing of shell for the same purpose is also under investigation and as a result of these measures it is expected that considerable reduction of dispersion will result, which within certain limits should increase the percentage of hits.

Shells with the new type band were supplied for the night battle practices and long range battle practices recently completed. The results of the former seemed to confirm the unquestionable improvement in dispersion demonstrated by the proving ground tests. On the latter, however, the figures were discouraging and showed no improvement in this respect. The conclusion seems reasonable that other elements, such as more frequent gun laying errors, must

have accounted for this fact as there can be no doubt that the new type of band results in truer flight.

As ships are regunned, they receive guns with the new type of rifling, and in every manner the Bureau of Ordnance is making strenuous effort to reduce dispersion.

No reference has as yet been made to the performances of the secondary batteries of battleships or of the batteries of other types of vessels, and indeed for them the data are still more incomplete and misleading than in the case of the turret guns, so that no venture will be made to discuss the varying percentages of hits or dispersions for different ranges. It is presumed however, that all guns would follow the same general laws as do the turret guns. This past year is the first one when hits for the secondary battery of battleships on day torpedo defense practice are plotted and assigned on a constructive target, and when the score is calculated from several factors as in long range battle practice. It is believed that data susceptible of much clearer analysis will gradually thus be accumulated now for this battery, with resulting more rapid improvement in efficiency.

Coming now the theoretical investigation of the subject of accuracy of fire, some very interesting curves of probable mean range errors and percentages of hits for various ranges for 12, 14 and 16 inch guns of 45 and 50 calibers were prepared by the Special Board on Naval Ordnance, when headed by Rear Admiral Chase. Such calculations must of course be based on various assumptions, which were set forth in the descriptive letter. Without going into too

much detail, it may be said that the mean range error of a gun, when fired in salvo, is regarded as made up of the elementary range errors due to the following causes:-

(a) Variation in muzzle velocity,
(b) Variation in angles of departure, and
(c) Variations due to inaccuracy of flight.

To each of these causes was assigned an assumed amount, based on all available data, the resulting errors calculated and plotted, and the combination thereof determined by computing graphically the square root of the sum of the squares of these errors, the result being plotted as a curve of mean range errors for each of the guns. These curves are very nearly identical, and the following table being based on the average of all of them, may be considered reasonably applicable to any of these guns:-

TABLE C.

Range in yards	Mean range error in yards.
12000	78.3
13000	80.4
14000	83.2
15000	86.4
16000	90.2
17000	94.1
18000	98.3
19000	102.7
20000	107.8
21000	112.9
22000	118.8
23000	123.1
24000	129.1
25000	134.8
26000	140.4
27000	146.2
28000	152.
29000	157.7
30000	163.6

Actually, the mean range errors shown above are not realized in practice. For example, during the dispersion tests of the NEW MEXICO, the actual mean range error derived from six twelve-gun salvoes fired very carefully and deliberately at 18,000 yards, was 284 yards, whereas the curve shows about 98 yards for that gun at that range. Carrying this comparison farther, a mean range error of 98 yards would lead to the expectation of an average spread in range, or pattern, of 12-gun salvoes of about 427 yards, whereas actually in the case of the NEW MEXICO it was 1084 yards. The mean dispersions shown in actual practices are also much greater, as previously noted.

With the theoretical mean range errors thus determined, a fire control error of one half of one percent of the range was then assumed, and with these two errors the percentage of hits were then calculated, assuming a target 9 feet high joining a horizontal deck 102 feet wide, this representing very closely the above water side armor and protective deck of the latest design of battleship. No length of target was considered, as deflection errors are disregarded. Again, these curves proved to be very similar and the following table, based on the average of all, is very nearly correct for any of these guns, in theory:-

TABLE D.

Range in yards	Percentage of hits.
12,000	19.46
13,000	17.63
14,000	15.91
15,000	14.51
16,000	13.34

TAPLE D. (contd).

Range in yards	Percentage of hits.
17,000	12.27
18,000	11.29
19,000	10.52
20,000	9.82
21,000	9.18
22,000	8.63
23,000	8.10
24,000	7.67
25,000	7.27
26,000	6.90
27,000	6.59
28,000	6.30
29,000	6.01
30,000	5.73

The percentage of hits curves showed also the percentages of hits on the vertical and on the horizontal armor, it being noted that at about 11,000 yards they are equal, each being about 11%, while at greater ranges the percentage of hits on the vertical armor decreases rapidly, being only about 2% at 21,000 yards, at which range the percentage of hits on the horizontal armor is about 7%.

The Bureau of Ordnance stated that the percentages of hits shown on the various curves could not be expected to be realized in practice at this time, and that, due to lateral misses and other causes, it would be best to reduce the percentages by one half.

As soon as all the reports of the long range battle practice of battleships in the spring of 1921 were received and plotted, the number of hits was also determined for each ship upon a target identical with that used by the Special Board in calculating their percentage of hits curves, deflection errors being also disregarded in these determinations. In the cases of guns of various calibers

and lengths, the comparison between curve and actual percentages of hits showed quite different results, so that even an approximately fair comparison can only be made by averaging the performance of all guns, which shows an actual percentage of hits of 6.4 at mean range of 18,149 yards, for 1002 shots, or about 57 1/2% of the average curve figure from Table D for the same average range. It will be remembered that the fire control error was assumed by the Special Board as being 1/2 of 1% of the range, in other words the average mean points of impact of salvoes are assumed to be 1/2% of the range distant from the center of the target. In the actual practice of 1921, this error was approximately 1.8% of the range, and this variation between assumed and actual figures would account for a considerable portion of the discrepancy in percentage of hits. Nevertheless, there is nothing to show that the shape of the theoretical curve of percentage of hits is not substantially correct, and in the absence of any conclusions from actual practices, as previously noted, it seems that the form of this curve is the best available means of estimating how the percentage of hits on any given target at a certain range will vary for other ranges. The constructive target for target practices is a ship 600 feet long, 90 feet beam and 30 feet high, with shots striking within 30 yards short of the target and on in deflection counting as hits.

It will be noted that this target is much larger than the target on which the theoretical curves were computed. For instance, with the 14-inch 45 caliber gun, at 17,000 yards the virtual horizontal target for the curves is about 132 feet, whereas

for gunnery exercises hits are allowed under these conditions on a virtual horizontal target of about 285 feet. However, deflection errors enter into the determination of hits on the regular target practice, but it should be noted that when salvoes are on in range a comparatively small number of shots fall in deflection outside the limits of the 600 feet long target. As previously stated, the average percentage of hits for three long range battle practices of the battleships was 11.0 at an average range of 17,700 yards. For this range, at a target approximately one half in virtual horizontal width, the curves from Table D show an average theoretical percentage of hits of 11.6. The smaller target used for the curves therefore about neutralizes the fact that these theoretical percentages were considered by the Bureau as about 50% too high, with the result that they, the curves, show a theoretical percentage of hits for the average range of these three practices not far different from the average percentage of hits actually obtained on the larger target for those practices. Therefore, it is not an unreasonable assumption that these curves, or the table previously given, would show values at all ranges approximately equal to the percentage of hits at target practices in recent years. The percentage of hits by the California at about 25,000 yards agrees almost exactly with the table, but the excellent performance of the Tennessee at that range, as previously noted, is considerably better.

The average hits per turret gun per minute on the standard battle ship target have also been shown for the past three years,

which introduces the other important factor of rate of fire. This average of 0.1016 hits per gun per minute at an average range of 18096 yards for 1921 is susceptible of considerable improvement under target practice conditions. The eleven ships of the Pacific Fleet averaged 0.1283 hits per gun per minute this past year at an average range of 19235 yards - a very material advance over the 1921 figures, but it must never be overlooked that target practice performances can never be expected in battle.

Since the foregoing was written, a copy of the new method of scoring gunfire at the War College came to my attention, and I was much interested in the exhaustive method by which the percentage of hits on different sized targets under certain assumed battle conditions at various ranges was derived. Many of the conclusions reached by the author of that pamphlet coincide with the principle adopted by the Office of Gunnery Exercises, and in my opinion it is a very great improvement over the method in use previously.

Some of the assumptions and statements are of course open to argument, but by the nature of the case this is unavoidable. For instance, the conclusion that probably dispersion is greater with director than with pointer fire is not sustained by the comparison of the results of these two systems of fire, under similar conditions, by numerous vessels, on two different forms of practice last year.

For purposes of comparison with the foregoing Table D, there is quoted the following table of percentage of hits from the War College pamphlet for the 14" 50 caliber gun, the target being con-

sidered as a ship 600 feet long, 99 feet beam, and 30 feet high; and the percentages shown being the average of those deduced for target angles zero and 90°.

TABLE E.

RANGE	Percentage of Hits		
	Top Spot	Kite Spot	Plane Spot
12,000	12.3	12.8	----
14,000	8.9	9.7	----
16,000	6.2	7.2	----
18,000	4.2	5.4	----
20,000	2.6	4.0	4.3
22,000	1.5	3.0	3.4
24,000	0.7	2.2	2.7
26,000	0.1	1.6	2.2
28,000	---	1.2	1.8
30,000	---	0.8	1.5

It will be noted that the rate of decrease of percentage of hits with range is much more rapid in the War College pamphlet - too rapid indeed, in my opinion. It will also be noted that the percentages of hits allowed by the pamphlet (Table E) are materially less than those indicated in this paper (Table D). This however is natural and is probably caused by the difference in target size, and, by some allowance, not stated in the text, for the assumed battle condition. How much the effectiveness of a ship's fire is impaired by all the conditions of battle is impossible to determine with accuracy, but certainly it will suffer very considerably and we must guard carefully against over-confident expectations in regard to battle gunnery, drawn from target practice results.

I have available here the complete results of all battleship practices for the year just completed, and the corresponding figures of Gunnery merit for the year. Also the scores of the leading battleships in the engineering competition, subject to check, and the tentative figures of battle efficiency merit for the leaders. I would be glad to give the figures for any ships in which anyone may be interested.

(Revised 14 July, 1922)
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