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CRUISERS AND DESTROYERS

IN

THE GENERAL ACTION

Captain R. B. Coffey, U.S.N

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NAVAL WAR COLLEGE
Newport, R.I.
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IN

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by

Captain R. B. Coffey, U.S.N.

Naval War College
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CRUISERS AND DESTROYERS IN THE GENERAL ACTION.

Chapter I.

INTRODUCTION.

(a) Cruisers, Destroyers and the Battle Line. In a previous paper, entitled "The Fire Action of the Battle Line" (W.C. No. 2721/5-23-32), you had a discussion of the major element in a modern naval general action. The present paper follows as a sequel to the previous one. In it an attempt will be made to analyze the part played by the cruisers and destroyers in company with the Battle Line. Like the previous paper, this paper is in no sense a tactical manual, but a discussion of the elements of tactical action.

The fire action of the Battle Line, by reason of its power and continuity, dominates. In general the cruisers and destroyers take their cue from the Battle Line, and operate in support of, or in elaboration of, its plan. The role of the cruisers and destroyers, though subordinate, is nevertheless important and may be decisive.

While the moral factor in battle is predominant, particularly so in cruiser and destroyer actions, we will confine our point of view in this paper to the intellectual factor, in the same manner as we did for the Battle Line.

(b) The Fundamental Principle. As with the Battle Line, so with the cruisers and destroyers, the underlying and master principle of tactics is concentration. But in their subordinate role, this may not mean concentration within the restricted sphere of cruisers and destroyers alone, but concentration for the battle line, or for the fleet, as a whole. The application of the principle of concentration by the fleet as a whole, may often lead correctly to cruiser and destroyer actions against superior forces. The stopping of a torpedo attack, the clearing away of light forces from the Battle Line's path, the maintenance of freedom of maneuver for own Battle Line, the covering of a re-

treat, may require correctly the expenditure of cruisers and destroyers against superior force. The principle of concentration may not be violated thereby, but applied for the fleet as a whole. To recognize such situations and act on them requires a nicety of judgment on the part of commanders of cruisers and destroyers. A thorough understanding of the general plan of the O.T.C. and a coup d'oeil are imperative.

But aside from these cases, the most usual situations permit the employment of the principle of concentration within the sphere of cruiser and destroyer action itself. Concentration is the creation of superior momentum at the right place and at the right time. Superior force against a portion of the enemy line. Superiority of force at the point of contact. And not inapplicable for the cruisers and destroyers are the precepts of John Clerk (Plate 30).

Among the apothegms, or contributory principles, that are particularly useful for the commanders of cruisers and destroyers are the following:-

(1) Coordination of effort and unity of action, especially with reference to the Battle Line.

(2) The offensive spirit.

(3) Simplicity of conception and execution.

(4) The initiative.

(5) Timeliness.

(6) Singleness of purpose.

(7) The selection of proper objective.

(8) Surprise.

(9) Security.

(10) Mutual support.

Chapter II.

THE GUNFIRE ACTION OF CRUISERS AND DESTROYERS.

With concentration, in the sphere of the cruisers and destroyers, as our theme, let us investigate the gunfire action of these types of ships.

(a) Fire Factors.

At the outset it must be said that the most potent factor for concentration is superiority of numbers. Fighting strengths are proportional to the squares of the respective numbers - not to the first powers. "Only numbers can annihilate." But in this day of numbers limited by treaty, superiority in numbers may be difficult to attain. We are constrained, therefore, to investigate all factors of fire. In this way we may find means of making numbers. The modern factors of fire action, which are available to us for this purpose, are the same as those for the Battle Line (Plate 31).

(b) Basis of Examination.

The basis of examination will be the same as used for the Battle Line; i.e., we will use the War College rules, and will assume, except where specified otherwise, that the accuracy and rapidity of fire on both sides are normally equal for the same calibre and kind of gun and type of ship; that the direct method, director lay of fire control and top spot are used; that the main batteries only are in use; that the range has been established; that there is no surprise fire; that the rate of change of range is small; that no guns are masked; and that the damage control on both sides is equally efficient.

Omitting those factors which are entirely out of our hands to control, we will consider:

First: Those factors which are partially in our hands to control.

Second: Those factors which are wholly in our hands to control.

(c) Factors only partially under one's control.

(1) Kind of Spot. Plane spot is available to all cruisers carrying planes. All CAs carry planes. All BLUE CLs and a few RED CLs carry planes. Most of the RED CL and all of the ORANGE CL do not carry planes. No destroyers carry planes. With the CA's 8" guns plane spot begins to be superior to top spot at about 16,000 yards; top spot becomes ineffective totally at about 26,000 yards. With the CL's 6" guns plane spot begins to be superior to top spot at about 12,000 yards; top spot becomes ineffective totally at about 22,000, the maximum range of the guns. Within these bands plane spot gives an advantage over top spot, which increases decidedly in the upper ranges. In some cases local control may have to be resorted to. Local control reduces the accuracy of fire below that of top spot and plane spot.

(2) Smoke, gas, and spray. Cruisers and destroyers are affected by smoke, gas and spray in their fire effect under the same conditions, and to the same extent, as the Battle Line. Turret guns are not affected by spray when director fire is used. Spray is worse than gas, but is less likely to occur. Smoke is worst of all.

(3) Roll, pitch and yaw. Cruisers and destroyers are affected by unusual roll, pitch and yaw in their fire effects under the same conditions as the Battle Line. As the weather gets worse the fire effects get less. Cruisers and destroyers, however, are affected to a greater degree than the Battle Line. In some cases the CA will have twice the penalty and the CL and DD three times the penalty that the Battle Line will have under the same weather conditions and on the same course. Yaw is worse than pitch or roll. Pitch and roll are about the same when using director lay. When pointer lay is used the roll is worse than the pitch.

(4) Silhouette and sunglare. The accuracy of fire of cruisers and destroyers is affected by sunglare and silhouette under the same conditions and to the same extent as the Battle Line.

To illustrate the foregoing factors let us consider them in combination. On Plate I, Case I, we have 2 BLUE ASTORIAS and 2 BLUE HOUSTONS versus 4 ORANGE MAYAS at 19,000 yards, using plane spot. These are CAs. There are no penalties on either side. The ratio of fire effect for the first 3 minutes of fire is BLUE to ORANGE 131%. Now in Case II the conditions are the same, except the wind is force 4 on BLUE's port beam, raising a moderate sea, and ORANGE goes ships left 30°. By this turn ORANGE avoids all penalties. BLUE continues and has roll and gas interference. By going ships left 30°, ORANGE has reduced BLUE's advantage from 131% to 93%. If now this action occurred between sunrise and two hours afterwards, or between sunset and two hours before, and ORANGE bore from BLUE within 15° of the sun with a clear sky, BLUE suffers the additional penalty of sunglare. BLUE's fire effect is now only 82% of ORANGE's. If now BLUE's planes shoot down ORANGE's spotting planes, BLUE's fire effect is increased to 97% of ORANGE. BLUE has about evened matters.

Let us consider a battle between CAs and DLs. This is Case III. 2 BLUE ASTORIAS and 2 BLUE HOUSTONS versus 12 ORANGE OBORAS at 6,000 yards. Wind force 4 raising a moderate sea dead ahead of both forces. In this case BLUE suffers from pitch, from the use of local control of his turrets and from being under minor fire. He uses his 8" guns only. The battery interference, as well as the other penalties, makes the effect of his secondary battery of 5"/25 high angle guns negligible. ORANGE suffers from spray, pitch and over concentration. BLUE's fire effect in the first three minutes of fire is 91% of ORANGE.

The 12 DL are more than equal to BLUE's four CA. Suppose this battle occurred in a rough sea, other things the same as before, then the destroyer leaders will suffer more from pitch than the CAs will. The CA fire effect will then be 98%, or almost equal to that of the DL. The CA can fight better in a rough sea than the DLs.

(5) Priority of effective fire. This is a factor of importance. Its advantages are self evident. They occur in the same manner and under the same conditions as for the Battle Line. In cruisers and destroyers priority of effective fire probably will fall to the side which can employ plane spot when the other cannot, which has the greater flexibility in fire control to meet surprise conditions and multiplicity of targets, and which can be brought into action more nearly simultaneously and with more nearly full effect.

(6) Enfilade. Enfilade is a condition that will often arise in the action of cruisers and destroyers. To be subject to damage by enfilade, a vessel must be within about 100 yards of the line of fire and within about 1200 yards of the target. On Plate 2 we have one BLUE OMAHA versus 3 ORANGE OBORAS, which are standing in to make a torpedo attack on a Battle Line to the left of the OMAHA, range 6000 yards, rate of change of range 3000 yards in 3 minutes, both sides using local control. OBORAS are using bow fire and suffering from over concentration. OMAHA is presenting 90° target obliquity. In Case I the OBORAS are disposed to avoid enfilade. In this case BLUE fire effect is 111% of ORANGE in the first 3 minutes of fire. If, now, in Case II all conditions are the same, except the OBORAS are in a line of bearing such that they are suffering enfilade, this per cent becomes BLUE 304% of ORANGE. ORANGE suffers a great increase of damage through enfilade.

(7) Surprise Fire. This factor occurs often in cruiser and destroyer fire actions. On Plate 2, Case I, we saw that BLUE's fire effect during the first 3 minutes of fire was 111% of ORANGE, under the conditions assumed. In this case no surprise was involved, because the OMAHA had seen the OBORAS in ample time previously to get her battery on in train, get her sights set and establish her fire. In Case III the conditions are the same, except the 3 OBORAS suddenly appear at the beginning of the move out of a smoke screen or fog, with the OMAHA's guns not on, her sights not set, and her fire not established. The OBORAS, however, were ready, but their fire was not established. In Case III BLUE's fire effect during the first three minutes of fire is now only 81% of ORANGE - a drop of 30%. This is due to the surprise factor.

(8) Rate of change of range. This factor often applies in cruiser and destroyer actions - particularly during torpedo attacks. On Plate 3 we have 1 BLUE OMAHA opposed to 3 ORANGE OBORAS. BLUE is using broadside fire, and is under normal fire. ORANGE has bow fire, with over concentration, and is under less than normal fire. Both sides are using local control. In Case I the rate of change of range is about zero. In Case II it is 1600 yards per minute. This large rate of change of range causes BLUE's fire effect in the first three minutes of fire to drop from 1.18 to .73, or 38%, and ORANGE's from .48 to .27, or 44%. Both sides lose greatly in fire effect. ORANGE can get much closer before he is stopped by gunfire, when the rate of change of range is great. The penalties for large rates of change of range not only increase as the rates increase, but increase as the range increases. This is one of the reasons why cruisers and destroyers at high speed and at long ranges can avoid damage.

(9) Range Bands and Ammunition Supply. In cruiser and destroyer firing there are favorable range bands as with Battle Lines and for the same reasons. A series of typical fighting strength comparison curves of modern BLUE, ORANGE and RED cruisers and destroyers is shown on Plates 4 to 13. These curves are useful in comparing the ships concerned, provided the assumptions upon which they are based are not lost sight of. These assumptions are listed in the legends. These curves show that there are favorable and unfavorable range bands. But in cases where speeds are nearly equal the attaining of a predetermined range band may be difficult.

On each of the plates is shown the maximum range at which the ammunition supply of the winner is just sufficient to damage the loser 80%. If the fight is begun and continued above this range, there will not be sufficient ammunition to gain a decision. Obviously fights, designed to obtain a decision, must be fought on the whole at ranges below this maximum. The quicker the decision is desired - the shorter the range must be. Attention is invited to the fact that the assumptions, upon which the curves are based, are optimistic. In practice, therefore, this maximum probably will be less than shown.

It is interesting to compare the different types of ships. The ships selected are the best of their types, now existing in the BLUE, RED and ORANGE navies. You will note the following under the conditions assumed:-

(a) The BLUE ASTORIAS and HOUSTONS are generally better fighting ships, when operating about 1/2 ASTORIAS and 1/2 HOUSTONS, than the RED LONDONS at all ranges (Plate 4), except between 20,000 and 23,000 where they are about equal. The superiority is not great unless the BLUE ships can present a target obliquity of less than 90°. Target obliquity is of no assistance to RED because he has no side armor. Decisive engagements must

be fought at less than 20,000 yards on account of ammunition supply.

(b) The BLUE ASTORIAS and HOUSTONS, when operating about 1/2 ASTORIAS and 1/2 HOUSTONS, are generally inferior to the ORANGE MAYAS (Plate 5) below 15,000 yards. Between 15,000 and 21,000 BLUE is superior. Above 21,000 they are about equal. Target obliquity plays an important part, but is more in BLUE's favor than ORANGE's except in the small band 14,000 to 17,000 yards. Decisive engagements must be fought at less than 21,000 yards on account of ammunition supply.

(c) The BLUE OMAHAS are better fighting ships than the best RED light cruisers (CL) and the best ORANGE light cruisers (CL), (Plate 6), except above 18,000 yards. The superiority is decidedly in favor of the BLUE ships. Target obliquity is useful for all of these ships. Decisive engagements must be fought at less than 20,000 yards on account of ammunition supply.

(d) 12 of the latest ORANGE DL are more than a match for 2 ASTORIAS and 2 HOUSTONS at all ranges below 9000 yards (Plate 8). Above 9000 yards BLUE has some advantage, but not much. Target obliquity helps BLUE. Perhaps roughly speaking the 4 CA would about match 9 DL. For decisive engagements BLUE must fight below 11,500 yards and ORANGE below 8500 yards on account of ammunition supply.

(e) These same 12 ORANGE DL are still more superior to 4 BLUE OMAHAS (Plate 9). They are superior at all ranges and at all target obliquities. Roughly speaking the 4 OMAHAS would about match 6 OBORAS (DL). For decisive engagements the ORANGE DL must fight below 9000 yards on account of ammunition supply, if our estimate of this supply is correct.

(f) The present BLUE destroyers are ship for ship decidely inferior to the latest ORANGE DL (Plate 10) and the latest RED DD (Plate 11). Roughly speaking 4 BLUE DD are about a match for

2 ORANGE DL and 3 RED DD. For decisive engagements the ORANGE DL must fight at less than 11,000 yards and the RED DD at less than 7000 yards, on account of ammunition supply.

(g) Coming to the theoretical BLUE 10,000 ton 6" cruisers (Plate 7), we see that they are somewhat superior to the ORANGE MAYAS (CA), except at ranges 13,000 to 17,000. Target obliquity plays an important part for both types of ships. For decisive engagements ORANGE CA must fight below 16,000 yards and BLUE CL below 23,000 yards, on account of ammunition supply.

(h) The ORANGE battleship ISE is more than a match for 4 of the newest BLUE CA at all ranges above 10,000 yards (Plate 12). If the ISE can present a target obliquity of 60° or 45° she is superior at all ranges. Should the CA be lucky enough to begin and end the battle at 9000 yards or less, with the ISE presenting 90° target obliquity, there is ample 8" ammunition on the CA to damage the ISE 80%. This comparison is interesting because CAs sometimes find themselves fighting BB.

(i) The latest ORANGE battlecruiser is slightly superior in fighting strength to four of the newest BLUE CA at ranges above 16,000 yards, but decidedly inferior below 16,000 yards, at all target obliquities (Plate 13). For decisive action ORANGE CC must fight below 21,000 yards and BLUE CA below 16,000 yards on account of ammunition supply.

(10) Night Firing. There are a number of factors entering into night firing that are worth considering. Some of them enter into day firing also, but may not rise to such importance as at night. Some are peculiar to night alone. Of the former may be listed the following:-

The number of guns firing, which varies constantly;

Local control;

The frequent shifting of targets;

Surprise fire;

Battery interference on the same ship;

Masking of fire by another ship;

Over-concentration;

Frequent re-establishment of fire;

Ship and target changing course frequently;

Rate of change of range and bearing often great;

Danger of firing into own ships.

In the War College rules these factors act as penalties generally on normal fire. Sometimes the penalties become so great that the fire effect amounts to zero. Chance plays constantly and often decisively. There is little that one can do to control these factors at night to one's advantage beyond gunnery expertness and attempting to be superior in actual numbers at the points of contact.

Visibility and illumination are factors that occur principally at night and are more under one's control. The range of visibility at night, unaided by artificial illumination, varies according to height of observer, the number and efficiency of lookouts, the character of the object observed, the clearness of the atmosphere, and the amount of natural light existing. At the War College three conditions of natural night visibility are used: night-high, where moonlight, clear sky and clear atmosphere obtain and the horizon is visible; night-normal, where clear sky, clear atmosphere and no moon obtain but the horizon is visible; and night-low, where an overcast sky and a moist atmosphere obtain and no horizon is visible. These conditions are diagrammed on Plate 14 in the case where the observer is on the bridge of a large or intermediate size ship. They will be different on smaller ships where the bridge is lower. Generally when the bridge is lower and the horizon is visible, the range of visibility is greater.

These natural conditions are affected by artificial illumination in the War College rules as follows:-

(a) For night conditions, other than fog, searchlights give ranges of visibility to the ship using the searchlight equal to night high visibility as seen from a large ship, when the natural visibility is night-high or night-normal, i.e., up to 6000 yards when illuminating a large or intermediate size ship. When the natural visibility is night-low searchlights give ranges of visibility equal to night-normal visibility, i.e., up to 3000 yards when illuminating a large or intermediate size ship. For ship not using searchlights and offset to one side of the searchlight rays of another ship, the ranges of visibility are considered to be 50% greater than these. In natural night-high or normal visibility searchlight beams are considered to be 6000 yards long, in night-low visibility 3000 yards long. Against these beams vessels may be silhouetted, in which cases visibility for gunfire and recognition purposes reaches as high as 9000 yards. Under night conditions, without fog, searchlights themselves are seen 30 miles in night-high and night-normal visibility and 15 miles in night-low visibility. Under like conditions gun flashes are visible 10 and 5 miles respectively. These conditions are diagrammed on Plates 15-A and 15-B. For gunfire purposes searchlight illumination can be used up to the limit of visibility, but the fire effect is reduced considerably over that for daylight conditions.

(b) Star shells and parachute flares illuminate a circular area of water beneath them, the diameter of which varies from 1/4 to 1/2 mile, at a maximum horizontal range for star shells from 6000 to 17,000 yards. The duration of each illumination varies from 1/4 to 1 minute for star shells to 5 minutes for a flare. Continuous illumination requires bursts from 1 to 8 per minute at moderate speed of target. The above variations are due to different calibers and ballistics of the star shell and the gun firing them. These effects are diagrammed on Plate 16.

For gunfire or recogniation purposes the burst should be beyond and within 8000 yards of the target and cross the line of sight. Bursts short of the target obscures it. Objects, other than the target, may be illuminated or obscured accidentally or by design. In night-high or night-normal visibility star shells and flares will give an extreme visibility as high as 15,000 yards for large ships; in night-low visibility as high as 6000 yards. Gunfire may be used up to these ranges, but the fire effect is reduced considerably over daylight conditions. Star shells and flares are visible 30 miles in night-high or normal visibility, 15 miles in night-low visibility. These effects are diagramed on Plate 17.

From the above it is seen that there are great restrictions on the efficiency of artificial illumination for gunfire purposes. A high degree of gunnery expertness is required to use artificial illumination to one's advantage. It is very liable to be a disadvantage, by reason of the fact that own ship, by using a searchlight, which is visible 15 to 30 miles, or by silhouetting own ship or ships by star shells or flares, may disclose one's position, or turn one's unseen ship into a very good target for an unseen enemy.

The reasons for the following instructions in the "Tactical Employment, Destroyers, U.S.Fleet, 1932", are now apparent:-

> "2501. The necessity of not illuminating our own capital ships and other important units and of not disclosing our own position prematurely or unnecessarily must be remembered at all times.
>
> "2502. Every effort must be made to - - - - have all guns and torpedo tubes ready and on the target before using searchlights or star shells and before opening fire.

"2503. Searchlights are the primary means of illumination when the range is less than 3000 yards until illumination by star shells is established. Star shells are the primary means of illumination when the range is over 3000 yards. Star shells will, if the circumstances permit, be used in conjunction with searchlights.

"2504. Under no circumstances will searchlights be used for searching or sweeping prior to opening fire. If a search is necessary star shells will be used.

"2507. Each ship is responsible for the illumination of its own target. Should the illumination provided by another ship be sufficient, a ship is not required to illuminate its own target - - - .

"2508. When searchlights or star shells are being used, care must be taken that an undetected enemy is not on the unengaged side or on a bearing different from that of the target which is under illumination."

In this connection the following extracts from "Tentative Cruiser Tactics and Doctrine, U.S. Navy, December, 1931", are interesting:-

"96. Night Illumination of Targets. - - - - In general, cruisers shall,

(a) Not illuminate a target if it is sufficiently illuminated by other sources.

(b) Use illuminating projectiles as a primary means of illuminating targets.

(c) Use searchlights if the target is not or cannot be illuminated by using other means and it is necessary to fire at the target. - - - Use searchlights to blind an enemy who is already employing searchlights."

(d) Factors Under One's Control.

These factors are listed on Plate 31. They can be grouped under two heads:-

(1) Fire;

(2) Formations and Maneuvers.

Under Fire we will discuss distribution of fire, selection of targets, and ammunition expenditure; under Formations and Maneuvers, lines of bearing, distance and interval, target obliquity, and changes of course and speed.

In the "Fire Action of the Battle Line" all of these factors were analyzed and discussed in detail. Such a complete treatment will not be repeated here for cruisers and destroyers. But an attempt will be made to show differences between capital ships and light craft wherever they appear to exist.

In the following discussion we will consider that top spot is in use on both sides, that there is no spray, no smoke or gas interference, no sunglare, no silhouette, that visibility is good for the ranges considered, and that roll, pitch or yaw is not excessive.

(1) Fire.

Distribution of Fire. Natural concentrations are obviously advantageous, provided they do not result in excessive penalties for over concentration. The penalties for over concentration are more severe for light craft, except CA, than for the Battle Line. This is due to the reduced ability to distinguish own splashes, the greater rapidity of fire, and the less accuracy of fire control in smaller types. Heavy 8" cruisers are considered fully as capable as ships of the Battle Line for concentration purposes. Normally 3 BB, or 3 CC, or 3 CA, may concentrate on the same target without penalty, but 3 CL, 3 DL, or 3 DD, are each penalized. Above 3 ships concentrating, all types are penalized the same. At ranges below 4000 yards by direct method there is no penalty for over concentration.

Due to the inability of CL, DL and DD to concentrate without penalty, artificial concentration for these types is undesirable. One case will be enough to show this. On Plate 18 we have 4 OMAHAS versus 4 OMAHAS at 10,000 yards, with a target obliquity of 90°, speed 28 knots, on parallel courses abeam of each other, in column, distance 500. Side penetration occurs at this range. In Case I both sides use ship for ship fire. In Case II BLUE uses the artificial concentration shown, and

RED uses ship for ship fire. The curves show the relative fighting strength, BLUE to RED, for 12 minutes of firing. In Case II, as compared with Case I, BLUE starts inferior and gets decidedly inferior by 12 minutes when the battle is about over. The relative fighting strength is getting worse and worse for him. At the end of 12 minutes BLUE's total damage and the damage on individual ships is greater than RED. There are no features that would improve the general effect for BLUE at other ranges, except at very short ranges under 4000 yards. This same general result will occur for DL and DD, when fighting each other. This is due to the penalties of over concentration, which CL, DL and DD suffer when concentrating even the minimum amount - 2 ships against 1.

This considers artificial concentration by itself, i.e., when all other factors are equal. However, for CL, DL and DD, when a decided less mean range can be obtained, artificial concentration is often advantageous. In Plate 19 we have 4 OMAHAS vs 4 OMAHAS. In Case I both sides are using ship for ship fire. In Case II BLUE is employing the same artificial concentration as on Plate 18 with a mean range of 10,250 yards, while RED is employing ship for ship fire at a mean range of 11,250 yards. Whereas in Plate 18 the artificial concentration was very disadvantageous to BLUE, in Plate 19 the same artificial concentration is advantageous. This is due to the less mean range which BLUE obtains. The gain resulting from this less mean range overbalances the penalties of BLUE's over-concentration.

CAs are like battleships and battle cruisers in their ability to concentrate without penalty. Artificial concentration for them is advantageous - particularly if there are mixed targets giving hard and soft ships, or a less mean range is available.

With both natural and artificial concentrations there is

a limit to the number of ships that can concentrate effectively on one target. For CAs this limit is three. According to the rules for CL, DL and DD, 9 ships on 1 give an effect about equal to one ship on 1. The maximum effect for concentration of these types occurs when about 5 ships concentrate on 1.

n equals number of ships (CL, DL or DD) concentrating on 1,

a equals fire effect of each ship,

$n(a - \frac{n}{10} a)$ equals fire effect of n ships on 1,

$n(a - \frac{n}{10} a)$ is a maximum, when n equals 5. If the return fire of the one ship is considered, n can equal 8, but practical consideration would reduce this. When we consider a fight between a number of ships on each side probably 3 is the maximum practicable number. Although one might say from 3 to 5 is practicable.

Selection of Targets. The same conclusions, relative to the selection of targets, apply to cruisers and destroyers as to the Battle Line. The formula Rt equals $\frac{FEt \times FEo}{Lt}$ is useful in selecting targets.

In this connection the effect of shifting fire is interesting. This is shown on Plate 20. In Case I the fire distribution of 4 OBORAS versus 8 DECATURS is as shown. BLUE's fire effect is 38.4% of ORANGE during the first three minutes of fire. In Case II, during the first three munites, ORANGE is engaged in shifting fire to remove the cross fire and to fire at the nearest ships. In this case the act of shifting increases BLUE's percent from 38.4% to 45.2%. In Case III ORANGE makes the same shift of fire, but the targets to which he shifts bear more than 15^{o} from the original targets. This necessitates ORANGE re-establishing fire. During this 3 minutes BLUE's percent of ORANGE rises temporarily to 53.6% - an increase of 15.2%. Once fire has been established, it is disadvantageous, other things being equal, to shift fire to another target, if the new

target is not adjacent, or a large change of range or bearing is involved, or the new target is on a materially different course and speed from the old.

Allied to the subject of selection of targets, comes the effect of multiplicity of targets. Where the number of targets greatly exceeds the number of firing ships, or the number of available controlled groups of guns, some of the targets may not receive damage before they have accomplished their task, provided they do not get into an enfilade from some target under fire. This, of course, is due to the restrictions on all ships to efficient divided fire beyond a set limit, to the penalties of shifting fire, to the shortage of guns, and to the complexity of fire distribution. Capital ships and cruisers have duplicate fire control systems for their main batteries and can fire at two targets at once without loss of efficiency. The secondary batteries of capital ships may be divided into four groups, each group having separate control and director fire. This permits firing with the secondary battery at two targets on each side simultaneously. All ships, other than capital ships and cruisers, have only one primary system of fire control. So, to fire at more than two targets at once with capital ships and cruisers, or at more than one target with other types of ships, will require resorting to local control; or, in the case of capital ships, to simultaneous fire of turrets and secondary batteries. These give serious penalties to normal fire effect. It is generally better to bring the targets under fire successively than to try to fire at all simultaneously, if thereby local control must be resorted to. This, of course, requires that the maximum rate of destruction should be established as early as possible, shifting to new targets successively as old targets drop out. Effective fire should be established as early as possible in order to des-

troy the last targets before they can accomplish their tasks. For the Battle Line alone to knock out an attack of many destroyers is, for these reasons, very difficult in a general action. Cruisers, which can be so disposed as to establish a rapid rate of destruction in time, are necessary to stop an attack on the Battle Line of many destroyers.

The instructions now current for destroyers, as given in "Tactical Employment, Destroyers, U.S. Fleet, 1932", are now interesting. The following are extracts:-

"2400. Training must be directed with a view to the delivery of an accurate and rapid fire at the earliest possible moment on a target which may appear suddenly, be visible but a brief time and be changing its range and bearing with great rapidity.

"2402. Ships will not divide their fire.

"2403. Fire will be shifted rather than crossed.

"2404. The more dangerous targets should be fired at in preference to those less dangerous; the nearer targets in preference to those more distant, unless the latter are more dangerous.

"2405. All important targets within effective range should be kept under fire, subject to the above.

"2406. Fire must be shifted without delay from a target which is drawing out of effective range, or which is seen to be seriously damaged, to a more dangerous or nearer target.

"2410. Ships normally will concentrate from the head of the column.

"2411. When the rate of change of bearing is high and targets are drawing aft, leading ships will as a general rule open fire on targets first encountered. When new targets ahead draw within effective range vanward ships shift to targets ahead, leaving targets drawing aft to own ships astern.

"2412. When concentrating, destroyers cannot use a method requiring ships to fire in rotation without too great a reduction in volume of fire. When the Section Leader opens fire and the doctrine requires concentration other ships shall open fire as soon as possible and obtain maximum volume of fire. If salvos cannot be identified by any ship that vessel shall suspend fire temporarily to note the effect of such suspension on the M.P.I. As soon as the point of fall of own salvos is thus established by a process of elimination, she shall again take up a rapid rate of fire. - - - - - .

"2413. Fire distribution and concentration signals will not be made unless the situation manifestly requires it.

"2414. The requirement that the more dangerous or nearer targets be fired upon may produce an artificial concentration and ships should act promptly to accomplish this without waiting for signals. Thus, a cruiser, if in dangerous proximity, should be concentrated on though less dangerous targets may be nearer.

"2415. As a general rule, concentrations should not exceed the following:-

(a) Not more than two ships on one destroyer or smaller target.

(b) Not more than one division on a light cruiser."

Ammunition Expenditure. The rounds per gun on cruisers and destroyers are as follows:

8"	-	100
6", 5"5, 5"1, 5" (except DD & SS)	-	200
4"7 (except DD & SS)	-	225
4", 5", 4"7, 5"1 (on DD & DL)	-	90
5", 4"7, 4" A.A.	-	400
3" A.A.	-	600

Plates 4 to 13 show the maximum ranges below which decisions may be obtained, under the conditions assumed, with the ammunition allowance. Generally speaking when cruisers fight cruisers ranges below 20,000 should be used to obtain a decision. When cruisers fight DL or DD, or DD fight DL or DD, ranges below 10,000 and in some cases below 7000 must be used. Decisive battles cannot be fought at long or extreme ranges with cruisers and destroyers, not only on account of small fire effect but on account of shortage of ammunition allowance.

The times for cruisers or destroyers to damage each other 80% at the maximum range at which the ammunition will just last, under the conditions assumed (Plates 4 to 13), is roughly as follows:-

Cruisers versus cruisers, about one hour;
Cruisers versus DL or DD, about 25 minutes;
DD versus DL, about 20 minutes.

Even at these maximum ranges the time is short; events happen rapidly; there is little or no time for changing dispositions or adjustments once decisive range bands are entered. Light force actions are fast and furious, if they are decisive.

(2) Formations and Maneuvers.

Lines of Bearing. The side, which maintains its own line of bearing more nearly normal to the bearing of the enemy than the enemy does, has the advantage of a less mean range; providing he realizes on it by concentrating fire on the nearest enemy ships, and, if artificial concentration is required, divides fire or neglects fire on the furthest enemy ships, other target qualities equal. This applies to cruisers and destroyers as well as capital ships. It also applies to ships in no regular formation, if we will define their line of bearing as the alignment upon which the individual ships of the group or mass can form up the soonest. Plate 21, Case I, shows this. Both sides have similar

formations but their lines of bearing are not normal to enemy bearing. BLUE's line of bearing is closer to normal to enemy bearing. Both sides are concentrating fire on nearest ship and dividing on furtherest. BLUE has the less mean range.

Distance and Interval. The force of cruisers or destroyers which maintains the shorter distance, or is more compact, obtains an advantage of less mean range in the same manner and for the same reasons as battleships. From too great a distance to isolation of units is but one of degree. The advantage of a more compact formation still holds. Compact formations also provide for mutual support and more ready maneuvering. In Plate 21, Case II, BLUE and RED have their lines of bearing normal to bearing of enemy, and are disposed similarly, except BLUE's group has one-half the distance between ships. Both sides are concentrating fire on the nearest enemy ship and dividing on the furtherest. BLUE has the less mean range.

Target Obliquity. The factor of target obliquity comes into effect only on ships carrying side armor. Unarmored ships can gain no advantage by changing their target obliquity. This eliminates destroyers from consideration under this head. Of the cruisers, armor is carried as follows:

	No. of Ships	Side	Deck
BLUE	8 CA	3"	1"
	2 CA	3"	2"
	6 CA	5"	2".25
	4 CL	5"	2".25
	10 CL	3"	1".5
RED	9 CA	0"	3"
	6 CA	0"	4"
	20 CL	3"	1"
	1 CL	3"	2"
	8 CL	0"	3"

ORANGE	8 CA	4"	1".25
	4 CA	1".5	1".5
	12 CL	2".5	0"
	1 CL	2"	0"

Generally speaking BLUE cruisers carry more side armor than either RED or ORANGE, more deck armor than ORANGE, and less deck armor than RED. RED cruisers as a rule go in for more deck armor than side armor; while ORANGE seems undecided. These different policies result in making target obliquity of varying importance to the cruisers of the different nations. As a rule BLUE and ORANGE can obtain advantages by a judicious presentation of side armor, whereas RED can obtain no such advantages except with his CL. When cruisers fight capital ships there is practically no advantage to be gained by the cruiser in target obliquity. This is shown on plates 12 and 13. The heavy guns of capital ships will pierce any cruiser armor at any obliquity and at most any effective range. Altho at ranges above 23,000 BLUE CAs can get some advantage by presenting 45° target obliquity when fighting ORANGE or RED capital ships. When BLUE cruisers fight RED or ORANGE cruisers, or destroyers, BLUE can obtain advantages from the target obliquities. When BLUE cruisers fight CA this advantage is available below about 23,000 yards roughly; when fighting CLs, below 12,000 yards; when fighting DL or DD, below 10,000 yards. ORANGE has about the same advantages. RED has none except for his CL, which are about the same as BLUE's. This is roughly speaking.

Changes of Course and Speed. What is the effect of a firing cruiser or destroyer, or a target cruiser or destroyer, changing course while firing or under fire, other things being equal?

Plate 22 shows calculations for one OMAHA versus one OMAHA. Ship B maintains course and speed 28 knots. Ship A maintains 28 knots, but changes course as shown. Other things are equal.

This is done at 11,000 yards where side penetration occurs, and at 16,000 yards where it does not occur. A uses director lay and then pointer lay. At 16,000 yards, where target obliquity does not enter, with A using director lay, the ratio of A's fire effect to B's is practically not altered by any change of A's course of 90° or less, which is completed in three minutes. However, if A uses pointer lay, the ratio will suffer considerably as a result of changes of A's course of 90° or less. For larger changes of course, over 90°, A suffers in an increasing amount, until he changes 180° with pointer fire when his fire effect is zero. If A zigzags 30° right and 30° left in 3 minutes he suffers. But if he had made a long zigzag of, say, 30° to 90° right in the first 3 minutes and 30° to 90° left in the next 3 minutes, he would not suffer in relative fire effect. When A is in a range band where side penetration occurs the effect of target obliquity due to the change of course has more effect than the change of course by itself when using director lay. This may improve matters for A, or make them worse, depending on the target obliquity at the beginning and the amount of turn. In the case considered on Plate 22 at 11,000 yards, A actually improved his relative fire effect by changing course 90° to 30°, when using director lay. When using pointer lay he did not.

Cruisers and destroyers, operating at high speed, pass through their changes of course relatively quick, thus reducing the penalty on the firing ship, if she is the one turning, because she steadies on the new course sooner and her fire control is adjusted sooner. If the target ship is the one turning, the penalty on the firing ship is increased as the speed of the target increases and as the range increases. Long zigzags up to 90°, in cruiser or destroyer targets, when operating at high speed, can reduce the fire effect on them considerably. This is

in addition to any reduction due to large rate of change of range. This was done in the Battle of Jutland by cruisers "chasing splashes". When pointer fire is resorted to by a turning ship, which occurs frequently on cruisers and destroyers, the penalty on that ship is more for changing course than when using director fire.

What is the effect of changes of speed, other things equal?

Plate 22 also shows calculations for one OMAHA versus one OMAHA for changes of speed. Ship B maintains course 0° and speed 24. Ship A maintains course 0° and varies speed as shown. Other factors are equal. If A increases or decreases speed 6 knots voluntarily in 3 minutes and B continues at 24 knots, other factors equal, there is no change in the relative fire effects, unless the range is below 5000 yards when B gains in relative fire effect. Above 5000 yards the effect of voluntary speed changes are independent of the range. A cruiser or destroyer may change speed voluntarily in 3 minutes 8 to 10 knots. But the size of the increment will not affect the relative fire effect, except below 5000 yards. Below 5000 yards the ship changing speed will always lose in relative fire effect. If A loses 6 knots due to damage from 24 knots in 3 minutes, the ratio of fire effect is 70% for all ranges. In this case A suffers relatively about the same for all ranges.

In other words, generally speaking, a voluntary change of speed of firing cruiser or destroyer will not affect the relative fire effect at ranges above 5,000 yards; but will reduce the relative fire effect of the changing ship at ranges below 5000 yards and when the change of speed is due to damage at any range. A change of speed of less than 2 knots will not affect fire. If the change of speed were transmitted to the plotting room in time, it is probable that no change in relative fire would occur in any case.

(e) Summary of Ways and Means.

We may summarize the ways and means of attaining concentration by the fire action of cruisers and destroyers as follows:-

(1) Superiority of numbers of ships is the most potent factor in attaining superiority of fire. The following are ways and means of making numbers:-

I. Ways and Means Only Partially Under One's Own Control. These are important, but whether or not we can apply them will often depend on chance and on the fickleness of nature. The coup d'oeil of the commander is required to seize on them if possible.

(2) When in ranges above 16,000 yards for CA and 12,000 yards for CL, the CA and CL that can maintain own plane spot and deny plane spot to the enemy, will reap an advantage. The ship that can avoid local control of gun fire has an advantage over one that cannot.

(3) Considering fire action only, the cruisers and destroyers, which have the leeward position, are generally in a position of advantage.

NOTE: When under fire of heavy calibre guns, whose splashes come aboard, the leeward position may not be so advantageous, particularly if a strong wind is blowing.

(4) The cruisers and destroyers that can steer a course to avoid unusual roll, pitch or yaw, will improve their fire effect. Yaw is worse than roll or pitch. Roll and pitch are about equal in effect with director lay. With pointer lay roll is worse than pitch. The smaller the ship the worse the effect in these particulars.

(5) The cruisers and destroyers that can maneuver to silhouette the enemy, or place the sun in his eyes, has an advantage. Of the two sunglare will occur oftener.

(6) All ships should be brought into action simultaneously and with full effect at the earliest effective moment. Priority of effective fire is to be sought.

(7) Cruisers and destroyers should avoid the penalties of enfilade, and whenever possible, those of surprise fire.

(8) Rates of change of range, over about 700 yards a minute, reduce the fire effect of a firing ship. This reduction increases as the rate increases and as the range increases.

(9) There are favorable range bands to seek and unfavorable range bands to avoid. These can be determined by constructing "Fighting Strength Comparison Curves". But we must beware of the limitation of these curves. Favorable range bands result not only from relative fighting strengths but from available ammunition supply.

(10) In night firing chance plays constantly and often decisively. Gunnery expertness and attempting to be superior in numbers at the points of contact are about the only means within one's control to gain concentration in fire action. Artificial illumination for gun fire purposes is difficult to obtain, restricted in effectiveness, and may react against one.

II. Ways and Means Under One's Control.

These are available for the use of the commander of cruisers and destroyers at will.

(11) Concentration of fire by cruisers and destroyers is often useful to accelerate the rate of destruction of the enemy's fire effect. Natural concentration is advantageous, provided over concentration does not result. Over concentration probably can not occur below 4000 yards. Above 4000 yards over concentration probably will result when more than 3 ships concentrate on one. Artificial concentration by heavy 8" cruisers, if natural concentration is not available, will be advantageous - particularly if there are hard and soft targets, or a less mean range is available. Artificial concentration is generally inad-

visable for light cruisers, destroyer leaders and destroyers, unless a decided less mean range can be employed. When concentrating, either natural or artificial, fire should be concentrated on those ships where the rate of destruction of the enemy fire effect will be the greatest. The rate of destruction of the enemy's fire effect generally will be greatest, other things equal, when we concentrate fire on the defensively weakest ship, and/or the nearest ship, and/or the ship having the most enemy ships behind it in formation, and/or the ship that is doing us the most harm. When artificial concentration is employed, too many divided fires, or too many enemy ships in effective range not under fire, are to be avoided.

(12) In concentration of fire more than 3 ships on one target is to be avoided.

(13) If possible, no cruiser should divide fire on more than two ships. The best ships on which to divide fire or neglect, other things equal, will be the furthest enemy ships, and/or the ships having the fewest enemy ships behind them in formation, and/or the ships that are doing us the least harm. Destroyers should not divide fire.

(14) The formula, Rt equals $\frac{FEt \times FEo}{Lt}$, is useful in selecting targets on which to concentrate, or to divide fire, or to neglect.

(15) Once fire has been established, it is disadvantageous, other things equal, to shift fire to another target, if the new target is not adjacent, or a large change of range or bearing is involved, or the new target is on a materially different course and speed from the old.

(16) Cruisers and destroyers that can present a multiplicity of targets, i.e., more targets than enemy can fire at simultaneously without resorting to local control and more targets than the enemy can knock out in the time available , will

often accomplish their task where otherwise they would not. Ships confronted with a multiplicity of targets should establish the maximum rate of destruction as early as possible avoiding local control.

(17) With other things equal and with about equal forces engaged, it is probable that the amounts of ammunition carried will require cruisers to fight cruisers below 20,000 yards, and cruisers to fight destroyers and destroyers to fight destroyers under 10,000 yards, if decisions are sought. Cruiser and destroyer actions are fast and furious if they are decisive.

(18) Cruisers and destroyers, which have their formation line of bearing more nearly normal to the bearing of the enemy than the enemy has and present a more compact formation, have the advantage of a less mean range; provided they realize on it by concentrating fire on the nearest enemy ships and, if artificial concentration is required, divide fire or neglect fire on the furtherest enemy ships, other target qualities equal.

(19) Other things equal, it is advantageous for cruisers and destroyers to avoid isolation and dispersion.

(20) Cruisers, which present the more favorable target obliquity, have great advantages when fighting heavy 8" cruisers below 23,000 yards, light cruisers below 12,000 yards, and destroyers below 10,000 yards. RED heavy cruisers have no such advantages.

(21) (a) A steady course and speed is best for own fire effect, as well as for the enemy's.

(b) Neglecting the masking of guns, at ranges where side penetration does not occur, the relative fire effect of a cruiser or destroyer operating at high speed is probably not changed to any degree by change of course under about 90° when using director lay. When using pointer lay the relative fire effect is reduced steadily as the turn becomes greater.

When the turn is over 90° in either case the relative fire effect of turning ship is reduced materially. At ranges where side penetration occurs the target obliquity will have more effect than the turn per se when using director lay; when using pointer lay the turn probably will have more effect to penalize the turning ship. Long zigzags reduce the damage on target ships - the more so as the speed and range increase.

(c) Neglecting the masking of guns, for aggregate turns of 30° or less by the firing ship, when using director lay, or 10° or less when using pointer lay, and for net turns of 30° or less by the target, the relative fire effects will not be changed, except in ranges where side penetration occurs when it will depend on the target obliquity.

(d) Generally speaking, a voluntary change of speed by a firing cruiser or destroyer will not affect the relative fire effect above 5000 yards. But all speed losses of more than 2 knots due to damage, or any speed change of more than 2 knots below 5000 yards, will reduce the relative fire effect of the changing ship.

(f) Relative Importance of the Ways and Means. Nearly all fire factors increase in effect and the time for their application decreases, as the range decreases. When you fight at extreme ranges you have more time to think and act than when you fight at close ranges. Decisive cruiser and destroyer actions are fast and furious. You must be able to think and act fast. The fire action of cruisers and destroyers is complicated by the demands of torpedo fire. Adding the various factors of torpedo fire, which we will discuss in the next chapter, to those of gunfire, we find that the complexity of a tactical situation for cruisers and destroyers is greater than for the Battle Line. Even more so, each tactical situation of cruisers and destroyers merits its own solution.

However, by keeping these facts in mind, and considering only the factors of gun fire, we may attempt to arrange the ways and means of gun fire for creating concentration in an order of importance, in the same manner as we did for the Battle Line. This may be used as a rough guide in determining their application.

First - Relative numbers.

Second - Target obliquity for cruisers below 23,000 yards when fighting CA, below 12,000 yards when fighting CL, and below 10,000 yards when fighting DL or DD.

Third - Range bands and ammunition expenditure.

Fourth - Lines of bearing, compactness, and enfilade.

Fifth - Distribution of fire, selection of targets, shifting fire and multiplicity of targets.

Sixth - Roll, pitch and yaw.

Seventh - Plane spot above 16,000 yards for CA and 12,000 yards for CL; top spot, local control and priority of effective fire.

Eighth - Changes of course and speed and rate of change of range.

Ninth - Surprise fire.

Tenth - Sunglare and silhouette.

Eleventh - Weather and leeward positions.

Of the above the First and Third should always have an important place in every battle plan. The Second, Fourth, Fifth and Eighth are largely under one's control and should enter into every battle plan. The Sixth, Seventh, Ninth, Tenth and Eleventh, while not always under one's control, should nevertheless be utilized to one's advantage whenever possible. They should enter into a battle plan, depending on the situation.

CHAPTER III

THE TORPEDO FIRE OF CRUISERS AND DESTROYERS.

(a) Torpedo Armaments.

The following are the general characteristics of the torpedoes now carried on cruisers and destroyers:-

Type	Speed	Range
A	26 kts.	17,000 yds.
B	28 "	16,400 "
C	27 "	13,500 "
G	(27 " (34 " (46 "	15,000 " 10,000 " 6,000 "

Type A is carried on all BLUE light cruisers (CL) and on practically all RED cruisers, destroyer leaders and destroyers. Type B is carried on ORANGE cruisers. Type C is carried on all BLUE and ORANGE destroyers now built. Type G is carried on BLUE heavy cruisers (CA), on all ORANGE destroyer leaders, and on all BLUE and ORANGE destroyers projected. The RED and ORANGE cruisers carry from 8 to 12 tubes. RED carries no reloads, ORANGE two. BLUE's cruisers carry 6 tubes with 1 reload. Almost half of BLUE's heavy cruisers (CA) carry no torpedoes. In the destroyer type RED carries 8 tubes with no reloads; ORANGE destroyer leaders 9 tubes with a reload for about 1/3 of the tubes, ORANGE destroyers 6 tubes and 1 reload; BLUE destroyers 12 tubes and no reloads. Practically all tubes on cruisers and destroyers are deck tubes. On practically all cruisers, tubes are not on the center line, but equally divided on the sides. On RED and ORANGE destroyer leaders and destroyers all tubes are on the center line. On BLUE destroyers all tubes are divided equally on the sides, except on the few projected ones which are to have center line tubes.

The above information is the best available, but is not certain. If we accept it, it appears that RED and ORANGE cruisers can deliver more torpedoes in a salvo than BLUE cruisers can. ORANGE cruisers carry more than twice as many torpedoes as BLUE or RED. BLUE destroyers can deliver about 50% more torpedoes in a salvo than RED or ORANGE destroyer leaders or destroyers can. As to the quality of torpedoes on the basis of speed and range in a general action, ORANGE cruisers seem to be better armed than either RED or BLUE cruisers, and the RED cruisers probably better than the BLUE cruisers; in destroyers RED is better armed than either ORANGE or BLUE, ORANGE and BLUE are about alike.

The torpedo is often spoken of as the primary weapon of the destroyer. This is true when the destroyer is engaged in an attack on the enemy Battle Line. When it is defending own Battle Line against a destroyer attack the gun is undoubtedly the primary weapon. Normally the torpedo is the secondary weapon of the cruiser, coming after the gun. However, there will be occasions when the reverse is true. A cruiser force, which has cleared the way for a destroyer attack on the enemy Battle Line, may have favorable conditions for joining its torpedo fire with that of the destroyers. At such times no cruiser weapon could be more important than the torpedo. But whether of primary importance or not, successful torpedo gunnery is ruled by the same factors on cruisers as on destroyers.

In the following discussion we will deal with the types of torpedoes <u>now</u> provided on cruisers and destroyers.

(b) Factors of Torpedo Fire.

(1) The Torpedo and the Gun. Plate 24 shows the triangle of torpedo fire. This triangle is the basis of calculation, upon which all torpedo fire is directed. The torpedo director is merely an instrument for quickly solving the triangle of torpedo fire. The known elements of the triangle are the line of sight, the firing range and the speed and range of torpedo. The unknown elements are the course and speed of the target. Gunfire has a similar triangle, but with the side TH, or run of Target Ship, much less. This is shown by a comparison of the figures given on Plate 24. A further comparison is interesting. The time of flight of a torpedo with a run of 12,000 yards is 12.9 minutes for a 28 knot torpedo and 13.8 minutes for a 26 knot torpedo. During this period a target can go 7,740 yards and 8,280 yards respectively at 18 knots on a straight course, or can make a radical change of course and speed and be over 12,500 yards from the point of intercept. Even when the target ship does not avoid the torpedoes by such a great distance, the torpedoes' comparatively slow speed, limited range and small number often permit the target ship to avoid them even when they are sighted fairly close, or to run away from them when they approach from abaft the beam. A BLUE 14"/45 gun has a time of flight of 37½ seconds, at a mean velocity of about 1,220 knots per hour, at an effective range of 23,000 yards; as compared with the best torpedo's 12.9 minutes at 28 knots per hour at a run of 12,000 yards. The gun has an extreme range of 33,000 yards as compared to 17,000 yards for the best torpedo. Add to this the gun's ability to fire a number of ranging shots and be spotted on and still fire 75 to 90 shots thereafter, as compared with no opportunity or practicability for ranging shots or spotting and only 1 shot per tube for the torpedo. One battleship can fire from 800 to 1200

heavy calibre shots in many successive salvos; a destroyer or cruiser 6 to 12 torpedoes in one or two salvos, or a division of destroyers or cruisers 24 to 48 torpedoes, or a squadron of destroyers only 153 torpedoes. From all of this it is seen that, in regard to accuracy and rapidity of fire and ability for continuous hitting to a decision, the torpedo as a weapon is far inferior to the gun. The comparative gunnery problems are not unlike two enemies on horseback - one armed with one hand grenade and the other with a rifle and a hundred cartridges.

To combat these inherent deficiencies is the problem of modern torpedo control. A great deal of analysis, experimentation, and material improvement have been made in torpedo control in the last ten years. As a result we may say briefly that it is now believed that the best results are obtained in torpedo fire by the use of salvo firing of maximum volume with dispersion from favorable firing positions. Let us discuss these various factors.

(2) Volume of Fire. Obviously, the chances of hitting will occur in direct proportion to the number of torpedoes fired in a salvo, other factors being equal. In view of this, rarely will a cruiser or destroyer be justified in firing at any one time, when a decisive issue is joined, any less than the whole number of tubes on board. It has been said, and I think justly, that rarely will a destroyer unit be justified, when a decisive issue is joined, in engaging in any other than one determined, fierce assault with all torpedoes, actuated by the utmost perseverance in enemy destruction. Feints, threats and secondary attacks, designed to influence the enemy's mind and action adversely and involving the firing of a few torpedoes and a retirement, violate the best torpedo gunnery practice and may be counted on to result in no hits. If a feint or threat is ever attempted, just as good results probably will result by firing no torpedoes and depending on the cruiser's or destroyer's position and action outside of gun range to affect the enemy in this way.

However, the conduct of war cannot be governed by set rules. Opportunities will be met of injuring the enemy by the fire of one or two torpedoes without jeopardizing the success of the General Plan - such as the appearance of an enemy submarine, light craft, or a ship of inferior military value close aboard. Whether such an expenditure of torpedoes will be justified or not will depend on the trained judgment of the officer concerned, the necessity of furthering the General Plan, and the importance of injuring the enemy to the utmost. The primary mission of the destroyer, and often of the cruiser, is to join its offensive power with that of its own Battle Line in the decisive issue in time. If this issue is imminent or probable, torpedoes should be reserved for that occasion.

(3) Firing Positions. Firing positions are located by the target angle and the firing range.

A target angle will serve best torpedo fire when it is such as to:-

(a) best permit the torpedoes of a salvo to make as many actual hits as possible,

(b) best permit the torpedoes of a salvo to reach as large a percentage of the entire length of the target selected as possible, and

(c) best permit the greatest errors in assumed enemy course and speed, or the greatest changes in enemy course and speed after torpedoes are fired, and still permit them to reach and hit the target when fired in a salvo.

The target angle which probably will make the most actual hits, if the torpedoes will reach and the enemy does not maneuver, is where a closed target is presented. This will depend on the enemy's formation and will be a different target angle for each

different formation. The target angle where the torpedoes will reach the best is 0°, or dead ahead. The target angle which will reach and hit the best, in spite of errors in sight bar course and speed or of enemy maneuvers, is somewhere near where the track angle is 90°. It may be stated, without important inaccuracies, with reference to any target - single ship or any formation or group of ships, that the single target angle which best meets all of the above conditions is the angle whose tangent is the torpedo speed divided by the enemy speed, or which gives a track angle of 90°. This is for a single salvo. When a number of destroyers or cruisers in formation are firing approximately simultaneously, this will be fulfilled practically when the middle firing ship is on the bow of the middle ship of the target an angle = $\tan^{-1} \frac{St.}{Se}$. This target angle is shown on Plate 25.

Firing Range. The distinction between Firing Range, Effective Range and Range of Torpedo should be remembered. The Firing Range is the distance from the firing ship to the target ship at the instant of firing. The Effective Range of a torpedo, when fired at a particular target ship on any particular target angle, is the maximum firing range at which that torpedo can be fired and just reach the target ship if the target ship continues at its initial course and speed. The Range of Torpedo is the total distance a torpedo runs, at not less than its designed speed. These are the practical definitions. They are illustrated on Plate 24. With target angles so that the target ship is continually approaching the firing position, the Effective Ranges are greater than the Range of the Torpedo. With other target angles the Effective Ranges are less than the Range of the Torpedo. For example, when the target ship is heading directly for the firing position the Effective Range is greatest, and when heading directly away the Effective Range is least.

The Effective Range depends on the target angle, the Range of the Torpedo, the speed of the torpedo and the speed of the target ship. Plate 26 shows the Effective Ranges at all target angles, with the target ship at speed 18, for all types of torpedoes carried by cruisers and destroyers.

It is, therefore, apparent that the Firing Range should never exceed the Effective Range. For practical purposes it should be considerably less than the Effective Range, in order to allow for errors in sight bar enemy course and speed and changes therein after firing. The shorter the range the less the run of torpedo and, consequently, the less opportunity the enemy has to maneuver to avoid the torpedo, and the denser the salvo in many cases. The Firing Range should be as short as possible. How short this is, is difficult to say when approaching under gunfire. Just how far, for example, a destroyer can go in and not get sunk before firing its torpedoes cannot be determined by fixed rules. One guide for destroyers sometimes is advocated of continuing the approach until the enemy shells are falling regularly and his fire is beginning to be effective.

We may summarize by saying that the best firing position, other things equal, is where the middle ship of a firing unit is at the target angle = $\tan^{-1}\frac{St}{Se}$ on the middle ship of the target, i.e., where the track angle is 90°, and at the shortest practicable firing range within effective range. However, the accomplishment of a timely, concentrated and coordinated attack on the right target with many torpedoes in salvo at the shortest practicable firing range within effective range is more important than the attainment of an ideal firing position.

(4) Enemy Course and Speed. The accuracy of the solution of the problem of torpedo fire depends on the accuracy of the determination of the enemy course and speed. This is a problem

not only in torpedo fire, but also in gunfire. But in torpedo fire the great time of flight makes it of greater importance.

No satisfactory means for determining enemy course and speed within destroyers and cruisers for purposes of torpedo fire has yet been devised. Larger ships are much better fitted for this purpose, and isolated ships and aircraft may have good opportunities of observing and reporting such data. A flow of important information of the enemy throughout a general action is of utmost importance to all types of ships. Good tactical scouting often may remedy this defect in torpedo control.

It is believed that errors in the assumed enemy course and speed can best be corrected by intelligent methods of salvo firing with dispersion. The efficacy of a single salvo of given dispersion in minimizing the errors of sight bar course and speed will depend on the firing position attained, both as regards target angle and firing range. The nearer to the best target angle and the shorter the range the more efficient the salvo will be in this respect.

It is believed that the best sight bar course and speed to set on a director, or to use on the maneuver board, will generally be the best estimate that can be obtained of the enemy course and speed at the instant of firing. By this means we leave to the salvo dispersion the enemy's changes of course and speed.

(5) Salvo Firing. Firing by salvo, which involves the firing of a number of torpedoes from a single firing ship approximately simultaneously, should be the normal method of torpedo fire. An ideal salvo:-

(a) will permit as many torpedoes as possible to hit,

(b) will permit as many ships of the target selected as possible to be hit, and

(c) will permit as many torpedoes as possible to hit as many ships as possible, irrespective of the target's maneuver to avoid them or errors in sight bar course and speed.

For as many torpedoes as possible to hit, the salvo must be dense. For many ships of the target to be hit the salvo must be wide as well as dense. To hit, irrespective of the target's maneuver or errors in sight bar course and speed, the salvo must be wide.

The elements of width and density are incompatible. No single salvo, embodying ideal width and ideal density at the same time, can be designed. The problem is not susceptible of mathematical solution. A compromise between width and density is required. When we remember that target angle, firing range, volume of fire, length and character of target formation and number of firing units - all conspire to complicate the problem, we readily can see that this is the case. We might attempt a compromise by saying that if the target is free to maneuver, a wide dispersion is desirable. This would be the case in an unsupported attack. If the target is not free to maneuver, a dense salvo is preferable. This would be the case when the target is under fire of own battle line and we give the enemy the choice between the harmful effects of maneuver and certain heavy damage from torpedoes. But such a rule is difficult to apply. Another method of compromise is to select a single dispersion angle and use it on all occasions. This will be required, if our mechanical gear precludes easily shifting the dispersion angle. The tendency now in the fleet is to use a standard dispersion angle for all occasions. This angle is 20° to 22° for a single firing ship.

While these are the difficulties in a single salvo, it is readily seen that ideal width and density is approached by the simultaneous fire of a number of salvos from many firing units from widely different directions at the same target. Matters

are improved also if a point of aim toward the center of the enemy formation is selected, as enemy ships, other than those aimed at, may then be struck if a turn is executed by the enemy.

To illustrate width and density, let us examine two salvos - one leaning more to density and the other to width.

On Plate 27 we have the simplest way of firing salvos, where 4 destroyers in formation fire 6 Type C torpedoes each on one broadside, each destroyer directing all 6 of his torpedoes at one particular target ship, without the application of spread. The 4 destroyers fire at 4 adjacent target ships - destroyer speed 30 knots, target speed 18, firing period 30 seconds. With the target angle and firing range shown, the dispersion (or width) will be 1800 yards at 7000 yards run and 2100 yards at 13,000 yards run. This will give an average density of 1 every 163 yards at 7000 yards run and 1 every 190 yards at 13,000 yards run. With target ships 200 yards long, many ships within the limits of the pattern at any run of torpedo will be hit unless they maneuver individually. If they maneuver in concert to avoid the salvo entirely, they must turn at least 80° toward, or 50° away. These results, of course, change as the target angle and firing range changes. On Plate 27 the target angle is close to the ideal. As the firing range decreases the density gets better. But there is not much difference as the dispersion angle is only 3°. This salvo is strong on density, but suffers in width.

On Plate 28 we have the same 4 destroyers firing in the same relative position, but they are using a recently proposed method of salvo firing. This method uses curved fire ahead (or virtual straight fire), each ship selecting individual target ships in the leading half of the enemy formation. Gyros are set to give a dispersion angle of about 4° between torpedoes when one broadside is fired and 2° when both broadsides

are fired simultaneously. This gives a salvo dispersion angle from each destroyer of 20° or 22°. The salvos are bodily offset toward the target's rear an angle varying with the target angle. In this case it is 10°. This is predetermined and given in a table. If the target angle is abaft the beam of the target, or is 0°, no such offset is used. Using this method under the conditions shown on Plate 28, we notice that the dispersion at 7000 yards run is 5200 yards as compared with 1800 yards by the previous method, and 8900 yards at 13,000 yards run as compared with 2100 yards by the previous method. The resulting density is 1 every 473 yards at 7000 yards and one every 809 yards at 13,000 yards, as compared with 163 yards and 190 yards respectively. Ships 200 yards long may steam through such a salvo and may be missed completely, particularly if they can see the torpedo wakes in time for individual maneuver. If they maneuver in concert to avoid the salvo completely, they will have to turn toward at least 120° or away 60°, as compared with 80° and 50° respectively in the previous method. As the firing range decreases, the density by this method gets better. To obtain as good a density as the first method the torpedo run must be no more than 2000 yards. This salvo catches much greater errors in sight bar enemy course and speed and much wider changes of enemy course and speed than the previous one. It is weak on density, but strong on width.

In both cases the density, as well as the width, is improved as the number of firing units increases and the target angles are more numerous and more varied, providing all salvos are directed at the same target at about the same time. This also tends to give a criss-cross pattern which is hard to avoid once the salvo area is entered. Plates 29 and 32 show a squadron using these two methods. It is seen that the density and width are improved in both cases.

These two cases are shown not to prove one method better than the other, but merely to illustrate width and density and the difficulty of embodying both requirements in one salvo.

The only conclusion that seems justified is that rarely should a dispersion angle in excess of 20° be used from any one firing ship and one much smaller is often better. It is believed that a dispersion angle of 10° is a good average for all conditions, when measured from the firing ship as the apex and all torpedoes are fired.

Plate 33 shows the largest and best controlled destroyer torpedo attack made during the World War. 31 torpedoes were fired at the British Battle Line by 13 German destroyers in two salvos. These two salvos were fired almost simultaneously, from good target angles and at firing ranges within effective range. The dispersion angles, as measured from a single firing destroyer, were about 13½° in one case and 9° in the other. About 42% of the torpedoes fired passed through the target formation, but unfortunately the density was not enough. It averaged about 1 torpedo to 500 yds. in one salvo and 1 to 200 yds. in the other. All target ships maneuvered clear by individual action. No hits were made.

(6) Selection of Target. Considering the general action, it is obvious that the best target for cruisers and destroyers to select is the same target that the Battle Line has, viz. the enemy Battle Line. This naturally results from the principle of concentration - the creation of superior momentum at one vital place in time. The time generally will be during the battle line action, preferably early other things equal.

(c) Summary.

We may summarize the ways and means of attaining concentration by means of torpedo fire by cruisers and destroyers as follows:-

(1) In the general action the target of torpedo fire for cruisers and destroyers generally should be in the enemy Battle Line - preferably in the same part at the same time, in coordination with own Battle Line.

(2) The volume of fire usually should be all torpedoes, fired as nearly simultaneously as possible.

(3) The ideal firing position is where the middle ship of a firing unit is on the bow of the middle ship of the target an angle = $\tan^{-1} \frac{\text{Torpedo Speed}}{\text{Target Speed}}$, i.e., where the track angle is 90°; and where the firing range is the shortest possible within effective range. However, the accomplishment of a timely, concentrated and coordinated attack on the enemy Battle Line with many torpedoes in salvos at the shortest practicable range within effective range is more important than the attainment of an ideal firing position.

(4) The best sight bar enemy course and speed is generally the best assumed course and speed that the enemy is on at the instant of firing. Errors in sight bar course and speed and maneuvers of the target after firing are allowed for best by salvo firing with dispersion.

(5) Both width and density should be considered in designing a salvo of torpedoes - width to cover errors of sight bar course and speed and target maneuvers, density to insure hits when the enemy enters the salvo pattern. A dispersion angle for a single firing ship greater than 20° is seldom justified - one much less is often better. 10° is probably a good average for all conditions when firing all torpedoes. The dispersion angle in these cases is considered as measured from an apex at the firing ship. An approach to the ideal in salvo firing

will be made by the simultaneous fire of a number of salvos from many firing units from widely different directions. A point of aim toward the center of the enemy formation, or group, or an offset to accomplish the same result is nearly always advantageous.

Aim to hit and thicken the salvo.

CHAPTER IV.

CRUISERS AND DESTROYERS IN DEFENSE OF THE BATTLE LINE.

If the Battle Line could conduct its action with the enemy Battle Line free from the threat of torpedo attack, a great gain in liberty of decision and action would result. Such liberty of decision and action in the Battle Line might well be decisive. Let us investigate the possibilities of guaranteeing to the Battle Line this liberty of action.

(a) Battle Line Defending Itself against Surface Torpedo Attack.

In the first place, what can the Battle Line itself do in this respect? Granted that it does not wish to maneuver, what can the Battle Line guns do toward defeating a destroyer attack?

Plate 34 shows the effect of BLUE Battle Line guns against 12 ORANGE destroyers (DD) approaching the Battle Line on collision courses on various target angles. BL speed 18 kts. DD speed 30 kts. The approximately concentric curves are the loci for the different percentages of damage resulting from approaching on different target angles. The single elliptical curve is the locus of all points where the torpedo firing range will give a 25% over-run. A firing range greater than this probably would be ineffective in practice. The torpedoes are Type G-- 27 knots, 15,000 yards range. If we assume that a destroyer attack is defeated when the destroyers are damaged 75%, or 50% if we choose, it is readily seen to what extent an approach by 12 DD will be successful coming in on the various target angles. According to the War College Rules a ship damaged 70% from gun fire loses all its deck tubes; 50% it loses one-half its deck tubes. An ORANGE destroyer damaged 50% can have only from 1½ to 2 torpedoes run. In Figure A,

where the main batteries of 3 BBs are firing, it will be seen that in approaches forward of target angles of 75° and 84° the main battery guns of 3 BB cannot damage the destroyers 50% and 75% respectively before they can fire at firing ranges that will permit the torpedoes to reach. Abaft these target angles the main batteries can defeat the attack in time. The fire of only 3 BBs against only one squadron and only one combination of speeds (18 and 30) were considered. It seems a fair assumption that rarely can more than 3 BLUE BBs direct their main battery fire at destroyers, without compromising their action with the enemy Battle Line. It, therefore, is conservative to say that, except for approaches abaft a target angle of about 80°,* the available main battery of the Battle Line in a general action cannot stop a destroyer attack in time. If more than one destroyer squadron is approaching, the situation for the BBs is still worse.

Using the same method in Figure B, where the entire secondary battery of 9 BBs is employed on one destroyer squadron while the main batteries are engaging the enemy otherwise, it is seen that, except for approaches abaft a target angle of about 130°* the entire secondary battery is unable to stop one destroyer squadron in time.

In these diagrams the destroyers were assumed to close on a collision course with the target. For practical purposes this is the quickest way for cruisers or destroyers to reach effective range from any given point. This applies equally when the destroyers plan to close to the shortest practicable range, or to a predetermined range within effective range. A collision course also gives, for all practical purposes the greatest rate of change of range and the least time under fire from the Battle Line or a ship interposed.

*This considers all practicable combinations of speed.

From the above we may safely conclude that the Battle Line guns by themselves cannot be relied on to stop a destroyer attack in time in a general engagement. Let us see now what cruisers and destroyers can do in this respect.

(b) Defense by Cruisers and Destroyers against Surface Torpedo Attack.

(1) Light Cruisers defending against destroyer leaders or destroyers. In Plate 35 we have a Battle Line of 4 BLUE BB, standing on course West at 18 knots, engaging the enemy Battle Line. An attacking force of 1 ORANGE CL and 12 ORANGE Oboros (DL) approach from any point at 30 knots on a collision course with the Battle Line. The curve A B C D E F is the locus of all points having a torpedo firing range which will give a 25% over-run. If the DL can be stopped before they reach this curve, their attack is defeated. The beetle shaped curve N G H I J K L M O P is the locus of all points upon which interposing cruisers can be stationed and just damage the attacking force 70% by the time it reaches the curve A B C D E F, if it is brought under fire initially at about 15,000 yds. The attacking force, approaching between target angles 0° and 60° and between 120° and 180°, if they steer a collision course, can only bring their bow guns into action against the interposing cruisers. As the attacking force is assumed to use one of the BLUE compact squadron formations, only the CL and 2/3 of the DL can fire. The cruisers are assumed to have broadside fire in all cases. When the approach is made between 60° and 120° target angles, the attacking force can bring the broadsides of the CL and 2/3 of the DL against the interposing cruisers. In the arc 0° to 60° 4 Omahas are required to stop the attack in time; in the arc 60° to 120° 6 Omahas are required; and in the arc 120°

to 180° 3 Omahas are required. It is seen that the arc 60° to 120° requires the most ships to defend; the arc 0° to 60° requires fewer ships but they must be stationed at much greater distances from the Battle Line; and the arc 120° to 180° requires the fewest ships and they can be close to the Battle Line.

On Plate 35 for practical purposes, we can connect the points N and M and H and K. This changes our "beetle" to a shape like an "apple". There will be a different shaped "apple" for the different types of torpedoes; for different speeds, formations and numbers of ships of the Battle Line; and for different kinds and speeds of attacking destroyers and different kinds of defending cruisers. If we will assume, as constants, that the Battle Line will always be in some formation in which the battleship divisions each consist of 4 battleships in column, which is approximately the case in all our standard battle formations, that the defending cruisers are Omahas, and the attacking force are ORANGE destroyer leaders approaching at 30 knots, we can reduce the variables to types of torpedoes and speeds of the Battle Line. Plate 36 shows "apples" for different speeds of Battle Line, consisting of 4 BBs in column, where the attacking force uses Type G torpedoes. Plate 37 shows "apples" for 4 BBs in column at a constant speed of 18 knots, but with the four different types of torpedoes carried by BLUE, RED and ORANGE cruisers and destroyers. By fairing out the curves as shown on Plate 37 in dotted lines and by placing a Battle Line speed scale as shown, we can construct a template which readily will permit us to lay off quickly on the mooring board the best positions for interposing Omahas to defend a Battle Line of any number of ships, in any standard battle formation, at any speed, and against any torpedo carried by cruisers and destroyers. Such

a template is shown on Plate 38. For reference it might be called an "apple card". The practical use of the "apple card" is explained thereon.

If the speed of the DLs varies from 30 kts. the only practical effect on the "apple card" will be to increase or decrease the arc within which the DLs can use their broadside guns while approaching on a collision course. For any B.L. speed less than one-half of the DL speed, the DLs cannot obtain broadside fire on a collision course. As the B.L. and DL speeds approach each other above the ratio $\frac{1}{2}$, the arc where the DLs can have broadside fire widens, until the two speeds are equal when the arc is 30° to 180°. Therefore the "apple card" still applies for practical purposes providing we change the ratio table so that 6 Omahas are required to stop 13 DLs between target angles 30° to 120°. If the DLs, to obtain broadside fire, do not close on a collision course, the "apple card" and "ratio table" still hold for practical purposes, because the DL must take longer to close to firing ranges and therefore give the cruisers longer to stop them.

If the Omahas, by interposing on a station, indicated by the "apple card", can stop the attack of the DLs, the Battle Line has freedom of action in all respects, except for a turn toward the attacking DLs. In this case the defending cruisers will be too close in to stop the attack in time. This is particularly so if the turn leads toward the enemy Battle Line, where the cruisers may be thrown under fire of the enemy Battle Line in attempting to keep the destroyers off in time. Except for a change of course toward the attacking destroyers, the Battle Line may perform any battle maneuver, such as re-deployment, or change of battle formation by division columns right or left, without fear. If the Battle Line or any part, should change course toward the attacking destroyers, the defending

cruisers must as a rule get out further. This is readily shown by the use of the mooring board and the "apple"card . This is illustrated on Plate 39. On this plate a Battle Line of 12 BB, originally in Battle Formation Zero changes to Battle Formation 30° toward enemy Battle Line. If the interposed cruisers are on the original "apple" at a target angle of 17°, they need not change their station when the Battle Line changes to Battle Formation 30° right. If they are interposed to the left of this point on the original "apple", they may fall back to the segment NML. If they are to the right of a target angle of 17°, they must go out further from the original "apple" to the segment H I J K. If the enemy Battle Line is 25,000 yards from own Battle Line at points Q, R or S, the nearest distances the cruisers may be to the points Q, R and S on the original "apple" are 14,000, 16,000, and 19,000 yards respectively. If they must go to the new "apple", these distances become 9400, 11400 and 15000 yards respectively - about 4500 yards nearer. When the Battle Line is heading directly for the attacking destroyers the distance the cruisers should be out from the leading battleship is O B, or O'H, which are equal. This distance is always the greatest distance in the "apple". All other distances get smaller as the target angle increases toward the stern. So, any change of Battle Line course, or any change in formation that throws any part of the Battle Line, toward the destroyers requires the cruisers to go further out. In many cases, however, this may not be so much as to prohibit the maneuver, as the cruisers may have time to gain their new station. The use of the mooring board and the "apple card" will answer readily such questions.

(2) Light or heavy cruisers defending against light or heavy cruisers respectively. Enemy CL or CA standing in toward our Battle Line probably have one, or all, of three tasks; viz., to attack our Battle Line with torpedoes, or to clear away our cruisers which are opposed to the enemy destroyer attack, or to stop our torpedo attack. To defend against the latter will be considered under Covering Operations in Chapter V, where it will be seen that cruisers interposing between enemy cruisers and our Battle Line are initially in the best position to cover our destroyer attack. After that the cruisers must decide which to cover - the battle line or the DD. If our destroyers attack from near our Battle Line, which is believed to be best, our own cruisers interposing between them and the enemy cruisers, will in most cases also cover the Battle Line.

In the other two cases it is believed that our cruisers can best defeat a cruiser torpedo attack on our Battle Line and an attack on our other cruisers, by keeping interposed between the enemy cruisers and the head of our Battle Line. In covering a DD attack the distance for the cruisers to go out will depend on how far out it is necessary to go to interpose. The attacking destroyers will often go beyond the "apple". If so, there the covering cruisers must go also. But in defending against cruiser attack on our Battle Line, or on our other cruisers, our own cruisers need not go beyond the "apple" more than 2000 to 4000 yards.

If we will draw an "apple" about 4000 yards beyond the "apple" of the type of torpedo carried by enemy cruisers, we will have a locus for our cruisers opposed to them. If our cruisers will keep on this locus and keep interposed between enemy cruisers and the head of our Battle Line, they should be able to bring the enemy cruisers under sufficient fire to

prevent them reaching effective torpedo range, or interfering with our other cruisers which are opposed to the enemy DL or DD. This, of course, will require equal or superior force on the part of our cruisers.

(3) The aggregate effect of cruisers and destroyers in defense against surface torpedo attack. In the basic calculations for the curves given previously, we have dealt only with 12 Oboras (12 DL) led by 1 ORANGE CL. It took 6 Omahas to stop this force in time when the Oboras approached in a BLUE standard attack formation with a target angle between 30° and 120°, where they had broadside fire. Using this as a yard stick we can approximate the number of Omahas (or their equivalent) necessary to stop any size attack, providing the Omahas(or their equivalent) follow the rule of always keeping interposed between the attacking force and own Battle Line and occupy a position on the "apple". For example: BLUE has 16 CA, 10 CL and about 95 DD built or building which would be available, and can build 2 - 10,000 ton 8" cruisers and 7 - 10,000 ton 6" cruisers. This is the BLUE treaty fleet minus some destroyers which are not considered available. ORANGE has 12 CA, 13 CL, 24 DL and 53 DD built or building and can build 4 - 9000 ton 6" cruisers. This is the ORANGE treaty fleet. For defeating 1 ORANGE CL and 12 DL, 6 Omahas, or 3 - 10,000 ton 6" cruisers, are required. On this basis and using other equivalents where required, BLUE can defeat the 6 CL, 24 DL and 53 DD of the ORANGE destroyer force with the following BLUE units:-

BLUE	ORANGE
10 Omahas	: 2 CL, 20 DL
7 CL(10,000T)	: 4 CL, 4 DL, 25 DD
1 CA	: 5 DD
28 DD	: 19 DD
	6 CL, 24 DL, 49 DD

With 4 ORANGE DD acting as plane guards this accounts for all of the destroyer force. This could be interpreted to mean that BLUE's 10 Omahas, 7-10000 ton 6" cruisers, 1 heavy cruiser, and 28 destroyers can insure freedom of maneuver of the BLUE Battle Line, except for turns toward the attacking force, against all ORANGE DL and DD and their CL leaders. This leaves 17 BLUE CA to take care of 12 ORANGE CA and 11 ORANGE CL - a big job, but not impossible if conditions are favorable for BLUE. BLUE still has left 67 BLUE DD for attack or other desirable purposes. In like manner, we can estimate the possibilities of defense for any combination of cruisers and destroyers.

(c) Defense by Destroyers against Submarine Attack.

90% of RED and 70% of ORANGE submarines are armed with Type G variable speed torpedoes. The remainder are armed with Type F (35 kt. - 3500 yard) torpedoes. The Type G torpedo can be adjusted quickly to a range of 15,000 yards at 27 knots, or 10,000 yards at 34 knots, or 6000 yards at 46 knots. As the submarines cannot fire more than 4 to 8 torpedoes in a salvo, the resulting density is so thin that rarely will a submarine use any other than the highest speed - shortest range setting. On Plate 40 are shown the effective range minus 25% loci for the Type G high speed and the Type F torpedo, when fired to hit a column of four battleships, steaming at 12 knots to 19 knots. Submarines must get within these loci in order to reach with their torpedoes with a 25% overrun. Assuming that a submarine will submerge rather than permit itself to be sighted on the surface, we can draw a circle with radius equal to visibility range, from the battleships, or from the A.S. screen, or from the light forces on the flanks or in the center, within which circle all hostile submarines will be submerged. The range at which a submarine on the surface can be recognized as such is assumed to be 7 miles from a large or intermediate

sized vessel, or 6 miles from a light cruiser or destroyer. A submerged submarine cannot make more than 10 knots to 10.5 knots submerged. In one hour this speed will run its battery down to such an extent that it will have to use a much less speed from then on. For a submarine, attempting an attack on a Battle Line, 7 knots submerged speed is a good average. With Battle Line speeds of advance ranging from 12 knots to 19 knots, there is a large arc of bearings from which the submarine cannot reach a firing position. The limiting bearing between the areas, where a submarine can reach firing position and where it cannot, is that target angle from which there is only one collision course. That course is at right angles to the bearing of the target from the submarine; or sin θ (target angle) equals $\frac{\text{sub. speed}}{\text{target speed}}$.

For a submarine speed of 7 knots and a target speed of 12,15, 17 and 19 knots, this value of the limiting target angle is 35½°, 28°, 24° and 22° respectively. If we will use the outside and inside limits of 35½° and 22° and draw them tangent to the effective range loci, we will have the diagram shown on Plate 40.

This means that a submerged submarine, in order to be able to attack the target (T), which maintains a steady course north at speeds between 12 and 19 knots, must be in the acute angle between lines AD and CD. This area is about the maximum. It will be smaller as the target speed increases, and also if the submarine uses a Type F instead of a Type G torpedo. Of course, a submarine, armed with a Type G torpedo, finding itself outside of this area, might use a slower speed setting on its torpedoes. It could use as low as 27 knots, which would give 15,000 yards range and permit the submarine to fire within the effective range locus of a destroyer. This would give about 3 times the effective range. However this would not increase much the dangerous area outside of the effective range locus; and the chance of hitting would not be great due to low density of salvo.

As the division column of three or four battleships is the unit of maneuver and formation, it is easy to lay off quickly on the mooring board a diagram, showing dangerous submarine areas for any standard formation, if we have a basic diagram similar to Plate 40. Plate 23 is such a basic diagram. On Plate 41 we have done this for Battle Line Cruising Formation No. 3 of 13 battleships on course North, speed 19 knots.

Let us now consider the defense of a Battle Line against submarine attack. The most dangerous area is in immediate proximity to the battle line, within the effective range locus. If we had enough destroyers, arranged so that every spot inside the effective range locus was within 1300 yards of a destroyer with A.S. lookouts, the submarine probably would be seen. But she might get her shots off even then, if she had prepared her firing data outside the effective range locus, and then taken one look and fired immediately when within range. How accurate such shooting would be is problematical. Any way with destroyers so arranged, we have probably done all we can.

Plate 41 shows an inner and outer A.S. screen, used with Battle Line Cruising Formation No. 3, arranged in accordance with "General Tactical Instructions 1924". Three destroyer squadrons (39 destroyers) have been used. It will be noted that so far as Type F torpedoes are concerned, the screen is probably effective. But for Type G torpedoes the screen is not effective. Most of the RED and ORANGE submarines carry Type G torpedoes. The increase in the range of submarine torpedoes from the F to the G type has made our standard A.S. screens in the "General Tactical Instructions" out of date. The only known effective remedy in this area within the effective range locus is to increase the number of destroyers in the screen. Aircraft might be considered were it not for their inability to frustrate the firing of torpedoes, even if they should sight the submarine inside this area. The demand for more destroyers for this purpose, combined with the decreasing number of de-

stroyers in the fleet presents a problem. How can a large number of destroyers - perhaps as many as four squadrons - be assigned to the A.S. screen during an approach without unduly sacrificing the essential offensive quality of the destroyer for attacking the enemy Battle Line when the battle joins?

It is believed that this problem can be solved, if we will accept as a fact that effective approaches for destroyer attacks on the enemy Battle Line can and should be begun much nearer to our own Battle Line than has been the practice heretofore. If this is accepted, then we will not only gain more destroyers for the A.S. screen, but we will enhance their offensive power. By stationing destroyers near the Battle Line, both in the approach and in battle, we will also give to them much greater ease and flexibility of maneuver in retaining assigned positions with reference to the maneuvering Battle Line. Shifts of axis, re-deployments, changes of fleet course, will be easier for the destroyers, if they are near the center of movement. Such a disposition will also give to the O.T.C. a better control of the destroyers. In the next chapter an analysis will arrive at the conclusion that the best target angles, from which to start an approach to attack the enemy Battle Line, lie between 50° and 80°. This being so, all destroyers in the A.S. screen are habitually near suitable positions from which to launch attacks - much nearer than positions 15,000 to 20,000 yards in the van and some other widely extended positions that have been proposed and used heretofore. As a matter of fact, it is believed that, except for those destroyers which are sent to strengthen defensive cruiser operations forward of the beam, all destroyers should be kept near the Battle Line both in the approach and after the deployment prior to destroyer attack. This, ordinarily, will give ample destroyer strength for the A.S. screen as well as maximum attack power in a good position of readiness.

Such being the case another destroyer squadron should be placed further out still in Plate 41; and perhaps, the distances between individual destroyers increased. In Plate 41 the outer A.S. screen is about 2000 yards beyond the inner screen. This could probably be increased to 2500 yards without loss of practical efficiency. Another squadron 2500 yards beyond the outer screen would reach to the Type G locus. This would give a total of four squadrons in the A.S. screen. All of this would force any submarine, that is in a position to hit, to fire in the midst of destroyers, which would be from close aboard to 1300 yards away. It would be a gamble for the submarine to enter such a screen.

On Plate 42 a four squadron A.S. screen for the approach is shown. The Battle Line is steaming at 19 knots. On signal to deploy the O.T.C. can send any number of these four squadrons into the attack position, retaining the remainder in the A. S. screen. It is now believed that, while the Battle Line is firing, it is not good to have destroyers in the line of fire - not only because of the danger to them but also on account of their smoke and gas. In Plate 42 two attack squadrons are ordered to the van and 2 squadrons to the A. S. screen. The diagram on the right shows the disposition ordered. The two attack squadron (I & II) can assemble ready for approach in the position shown in 25 minutes at 30 kts. This is the time for the last destroyer to join up. A good sized attack force will be ready much sooner. The entire disposition can be completed in 45 minutes if the advanced 1/2 Desron III goes to its position via the unengaged side. All destroyers after the deployment are still within the effective Type G torpedo range locus for A.S. purposes, and the attack squadrons are approximately in the best

approach position for attack on the enemy Battle Line. Of course the enemy Battle Line may not be on a course exactly parallel to own Battle Line course, so that target angles may not be as shown. But with good tactics the line of bearing of the enemy Battle Line will be kept normal to bearing of own Battle Line. So the target angles as shown are probably as close as they can be anticipated. The two attack squadrons are 6000 yards ahead of the leading battleship. They can, of course, work forward as much as 18000 yards and still be in a favorable approach area. This would take about 30 minutes longer at 30 kts. They can also be worked out toward the enemy.

If the attack squadrons are not in the A.S. screen during the approach, but in a position say 20,000 yards in the van (position A), it will require them about 16 minutes longer at 30 kts to get into the favorable attack position (position B) upon the deployment shown, and much longer if a deployment on course away from the enemy is ordered.. They may be driven to the other flank which might not be desired. This is an important point. For there are some approach positions for destroyers from which it is almost impracticable for them to obtain deployment stations that are at a distance from the B.L. The time from positions A to B in Plate 42 at 30 kts., with BL making 19 kts, is 41 minutes; to position 20000 yds. in the van on a deployment 90° to right, is 1 hour - an almost prohibitive time.

In these particular discussions a Battle Line maximum speed of 19 kts was assumed in order to illustrate the most difficult conditions for the destroyers. Many factors will tend to reduce the Battle Line speed below 19 kts. Often such a high speed of the Battle Line is not only unattainable but disadvantageous. A deliberate slowing of the Battle Line is sometimes advantageous to permit the re-allignment of the cruisers and destroyers both in the approach and battle. Any Battle Line

speed below 19 kts will shorten the times given previously in this discussion.

This arrangement of destroyers, or something similar, is probably the best we can do in the most dangerous area, - i.e., inside the effective range locus. For the dangerous area outside (Plate 41), the best probably that can be done is to endeavor to locate the submarines and warn the Battle Line so that it can maneuver clear. With our destroyers used up, aircraft suggest themselves. They are more efficient than destroyers in locating submerged submarines. Their effectiveness, however, will depend on the depth and clarity of the water, the nature of the bottom, the condition of the surface, the light effect and the altitude and relative position of the plane. Aircraft should be out far enough to enable the Battle Line to get the warning in time to maneuver clear of the approaching submarine. This means that an area out to 20,000 yards should be covered. The "dangerous area" hatched on Plate 41 is useful only so long as the battle line maintains course and speed. In avoiding a submarine, reported in the hatched area, the Battle Line need only turn enough to throw the sub out of the hatched area. But in so doing it may draw other submarines into the hatched area. For this reason the aircraft should extend their patrol beyond the hatched area to cover locations that the hatched area may occupy, resulting from probable changes of Battle Line course. This means an air patrol will be required almost completely around the Battle Line, but with attention concentrated in the current dangerous area.

(d) Defense by Destroyers against Aircraft Torpedo Attack.

Aircraft torpedo attacks differ from other forms of torpedo attack on the Battle Line by being quickly and equally effective from any direction. While the torpedo itself must be launched within the effective range locus, yet the relative

speed of the aircraft makes this possible by an approach from any direction. A torpedo plane going 100 knots and a Battle Line going 19 knots gives a maximum rate of approach of 119 kts. and a minimum rate of 81 knots. If we assume 15,000 yards as the maximum range at which the airplane can be brought under fire, in the first case it will be under fire only 3 minutes and in the latter case 5 minutes. This difference is not sufficient to influence greatly the direction from which the airplane will approach. Therefore, there is little a Battle Line can do by maneuver to avoid torpedoes being launched at it from the air. However, the aircraft must launch its torpedo within the effective range locus; and after it is launched it performs the same as any other torpedo.

If the launching of the torpedo can be frustrated with its effective range locus the attack can be defeated. For this purpose the A.S. screen described before is well placed to defeat any type of torpedo which is believed to be carried now by aircraft. Four squadrons in an A.S. screen cover about 2500 yards beyond the effective range locus of a Type F torpedo, which is the type RED and ORANGE aircraft carry. Torpedo planes must fly low to fire. They must get close to the water in the midst of the A.S. screen. If the screen is armed with .50 calibre machine guns, it should be difficult for torpedo planes to launch their torpedoes successfully.

Torpedo planes not only are required to fly low when firing but also during the last portion of the approach. Any destroyer or cruiser outside the effective range locus may also be in position to attack the planes; but the destroyers and cruisers are too few in number, the rate of approach is too high and the selected directions of approach can be from too many di-

rections, to permit specially stationing surface craft for this purpose.

How to insure or assist effectively, by means of cruisers and destroyers, the defeat of bombing attacks on the battle line from the air is not known - particularly dive bombing attacks. So far as our present knowledge goes A.A. guns on all such craft are undoubtedly advisable. Smoke is sometimes suggested, but so far as our experience goes to date, it is thought not to be particularly effective. Perhaps more experience with smoke is needed.

(e) Special Defensive Type of Vessel.

Under the Treaty of London the following special types of combatant surface naval vessels are exempt from limitation:-

(a) Any of 600 tons and under.

(b) Any exceeding 600 tons, but not exceeding 2000 tons, provided they have none of the following characteristics:-

(1) Mount a gun above 6.1 inch.

(2) Mount more than four guns above 3 inch.

(3) Are designed or fitted to launch torpedoes.

(4) Are designed for a speed greater than 20 kts.

Within these limitations types of ships can be designed and built which can be capable of relieving destroyers of many anti-submarine and anti-air defensive duties. The General Board is considering the design of such ships.

(f) Summary.

We may summarize what we have said of cruisers and destroyers in defense of the Battle Line, as follows:-

(1) It is not safe to rely on the Battle Line guns alone to stop a destroyer attack in time when the Battle Line is engaged with the enemy battle line. Battle Line guns are most effective when used against destroyer attacks abaft the beam - available main battery guns are not effective generally forward of a target angle of 80° and secondary batteries forward of about 130°.

(2) Omahas (or their equivalent) can stop (inflict 70% damage) ORANGE Obora (DL) attacks (or their gunfire equivalent) before they can fire torpedoes to reach the Omahas' Battle Line, if they will interpose between the Battle Line and the attacking Oboras at a minimum distance from the leader of the Battle Line as shown on the "apple card" and open fire at not less than 15000 yds; and the Omahas are in the ratio of 4 Omahas to 13 Oboras in target angles 0° to 30°, or 6 Omahas to 13 Oboras in target angles 30° to 120°, or 3 Omahas to 13 Oboras in target angles 120° to 180°. The safe rule is 6 Omahas to 13 Oboras in target angles forward of 120°, and 3 Omahas to 13 Oboras in target angles abaft 120°.

(3) Other CL or CA, in equal or superior strength, can best defeat the enemy's CL or CA, whether they intend to fire torpedoes at the Battle Line or to clear the way for their own destroyer attacks, by interposing between the Battle Line and the attacking CL or CA at a distance from the Battle Line as shown by the "apple" for the type of torpedo carried by the attacking CL or CA plus 2000 to 4000 yards.

(4) No submerged submarine can attack effectively a Battle Line unless it is within the danger area, constructed similarly to that on Plate 41. Conversely, a Battle Line which maneuvers to place submerged submarines outside of this

area, is practically immune from attack. To warn the Battle Line of the presence of submerged submarines, an air patrol completely around and out as far as 20,000 yards may be useful.

(5) Destroyers, armed with depth charges and so disposed that they cover the area within the effective range locus of the 46 knot 6000 yard torpedo with a 25% overrun and are within about 1300 yards of every spot therein, and patrol their stations 400 yards each side, will probably frustrate a submarine attack. To do this will require four squadrons (52 DD) for a three or four division Battle Line. Destroyers so assigned can be made available in a short time for attack on the enemy Battle Line from the most favorable positions from which to approach.

(6) An effective A.S. screen of destroyers if properly armed also probably will be effective against air torpedo attack. It probably will not be advisable as a general rule, in the approach or battle, to especially station additional surface craft to deny other air attack. But all cruisers and destroyers should be armed with A.A. guns to fire on all enemy air craft.

(7) During the approach and battle prior to attack on enemy Battle Line, when cruiser strength is ample to stop enemy cruiser and destroyer attacks, it is probable that all destroyers should be kept near the Battle Line, not only for A.S. and A.A. defense but also to conserve their maximum attack power in the best position of readiness.

(8) With a defense as indicated in (2) and (3) above, the Battle Line may make any maneuver it chooses without fear of torpedo hits from surface craft, as long as it does not head more nearly toward the attacking torpedo craft nor places any part of Battle Line nearer to the torpedo craft. The "apple card" and mooring board will show the possibilities in this respect.

(9) A Battle Line protected by an A.S. screen and air patrol as described in (4), (5) and (6) above, may be considered free to maneuver in the approach or in battle.

Cruisers and destroyers, defending against surface torpedo attack, keep interposed and at a distance from Battle Line not less and very little more than shown by "Apple Card".

CHAPTER V

CRUISERS AND DESTROYERS ATTACKING ENEMY BATTLE LINE.

We have now discussed the elements of cruiser and destroyer action in a general engagement, as regards gunfire, torpedo fire and defensive dispositions. We come now to the subject of cruisers and destroyers in the attack on the enemy Battle Line. When should they attack? What should be their line of approach? What formations should they use? What should be the action of the covering forces?

(a) The time to Attack.

The timeliness of a destroyer attack on the enemy Battle Line in a general engagement is an element of prime importance. It is probably true that effective coordination of a destroyer attack in point of time with the action of the Battle Line is more important than isolated effectiveness. For in a general engagement torpedoes hitting when the Battle Line guns are also hitting gives a greater impetus to the accumulating momentum, which is the essence of concentration, than a similar or somewhat greater number hitting at some other time. A man can stand a number of blows, each ten minutes apart, better than the same or a fewer number of blows hitting simultaneously.

The time of attack is a matter of proper coordination with the Battle Line. The officer in most cases best fitted to determine this is the O.T.C. He should provide for this in his battle plan, or by direct order. The O.T.C. will be influenced in this respect by the type of action he intends to fight, by the necessity of adequate Battle Line support for his attacking destroyers which probably cannot occur at Battle Line ranges much over 21,000 yards, and by the relative strength of his Battle Line and his cruisers and destroyers. Often his Battle Line will be superior to that of the enemy, when the role of the cruisers and destroyers may be defensive

primarily, in order to insure liberty of action of the superior Battle Line. At other times the Battle Line may be inferior, or the enemy's light forces may be inferior, so that the O.T.C. may choose an offensive role for his cruisers and destroyers primarily. In the former case the O.T.C. may reserve for his own volition the time of the destroyer attack. In the latter case he may direct the commander of the cruisers and destroyers to attack when adequate Battle Line support is seen to exist or a favorable opportunity arises. If the time of attack is left to the destroyer commander, this officer should be influenced by the same considerations that would influence the O.T.C., i.e., how best to coordinate the destroyer attack with the Battle Line.

In any case, the time of the attack in a general action will always be determined properly by the relations existing between the Battle Line and the destroyers, rather than by conditions within the destroyers themselves. For this reason, ideal approach directions, ideal firing positions, ideal destroyer formations and other theoretically best conditions for the destroyers themselves must give way to the needs of coordination with the Battle Line. When the order to attack arrives on your destroyer it means to attack at once from wherever you are.

(b) The Line of Approach.

(1) Course. To attack at once from wherever you are means to get to torpedo effective range as soon as possible. The mooring board will show that, for practical purposes, the quickest way for cruisers and destroyers to reach torpedo effective range, or a multiple of it, from any given point is to close the target on a collision course. This applies equally for closing to the shortest practicable firing range, or to any predetermined firing range within effective range. A collision course also gives, for all practical purposes, the greatest rate of change of range, the least time under fire from the enemy Battle Line or enemy light

forces interposed, and it holds any favorable target angle attained. The disadvantage of a collision course lies in the fact that it perpetuates an initially poor target angle. But this, as a rule, cannot be improved without reverting to courses that may prevent closing to the shortest possible firing range, or may increase the time under fire prohibitively. Theoretically, there are courses that permit closing to predetermined ranges and to predetermined positions quicker than a collision course, but their defect lies in the fact that enemy action may prohibit attaining such theoretical positions and for practical purposes the gain in time is not great. See Plate 43. If we seek a general rule, we may say that generally a collision course is the best go get to torpedo effective range the quickest, and should be followed if possible.

(2) Target Angle from which to begin Approach. Of course, there are favorable and unfavorable target angles from which to approach. These can be determined by consideration of the destroyer's task and the obstacles in his way. His task is to place the maximum number of torpedoes into the enemy Battle Line as soon as possible after the order to attack. The obstacles in his way are the effect of the target's course and speed and the enemy's defensive measures.

The effect of the target's course and speed and the fire action of the target itself, which is always present in some degree, make approaches in target angles abaft the target's beam always unfavorable. Forward of the target's beam sufficient fire effect of the target itself practically disappears as the bow is approached (Plate 34) and the efficacy of the target's course and speed in defense is reduced. Were these the only obstacles to consider, i.e., there were no light force defensive present, an approach from dead ahead would bring the destroyers to effective firing range, or a multiple of it, or

to any predetermined firing range, in the quickest time. See Plate 43.

If a predetermined firing position, i.e., a predetermined firing target angle and firing range, were sought, the best target angle (θ') from which to approach to arrive in the quickest time is that given by the following formula, where θ is the target angle and r is the range at which it is desired to fire, m is the range from the target where the approach is begun, and n is the ratio of destroyer speed over target speed.

$$\tan \alpha = \frac{\tan \frac{\theta}{2} \left(1 - \frac{m - nr}{m + nr}\right)}{1 + \frac{m - nr}{m + nr} \tan^2 \frac{\theta}{2}} \quad - - - - (1)$$

$$\sin (\theta' - \alpha) = \frac{\sin \alpha}{n} \quad - - - - - - - - - (2)$$

For $\theta = \tan^{-1} \frac{St}{Se} \left(\frac{27}{Se}\right)$, which we have learned in Chapter III is the best value of θ in which to fire, and with a firing range of 6000 yards (r), the values of θ', where m is 20,000 yards and 30,000 yards and n is $\frac{30}{20}$, $\frac{30}{15}$, $\frac{25}{20}$ and $\frac{25}{15}$, are as follows:-

	m	
n	20,000	30,000
$\frac{30}{20}$	$26\frac{1}{2}^\circ$	19°
$\frac{30}{15}$	33°	$24\frac{1}{2}^\circ$
$\frac{25}{20}$	$24\frac{1}{2}^\circ$	18°
$\frac{25}{15}$	31°	$22\frac{1}{2}^\circ$

If the best firing position, i.e., the best target angle combined with the shortest firing range which can be attained, is desired, then the approach should begin at this target angle and it should be held by a collision course. From Chapter III we found that the best firing position is where the track angle is about 90° at the shortest possible range. This will result when the target angle is $\tan^{-1} \frac{\text{Torpedo speed}}{\text{Target speed}}$. The following table shows the value of this angle when met in practice.

Torpedo speed	Target speed 12	15	18	21
26 k.	65°	60°	55°	51°
27 k.	66°	61°	56°	52°
28 k.	67°	62°	57°	53°

So we must agree that, granted there are no light forces to interfere, the best target angles from which to begin an approach lie between 0° and about 70°. The approaches begun at 0° and near that have the decided disadvantage of making it difficult to obtain a favorable firing target angle, even though desired firing ranges may be attained quicker. Favorable firing positions, which combine favorable target angle with favorable firing range, can be attained quicker by approaches begun further aft, i.e., somewhere between 20° and 70°.

When the enemy light forces come into the picture the situation changes. Approaches begun sharp on the enemy bow are practically eliminated, because of the great initial distance out, to which the destroyers are forced, to keep out of gun range until time to attack. This great distance makes impossible proper coordination with own Battle Line, as well as requiring difficult positions to attain. Let us assume that the enemy light forces will keep interposed between their Battle Line and our destroyers and at a distance out from their Battle Line as shown by the "apple card". This is believed to be the best defensive disposition that they can use.

In Plate 34 we saw that the Battle Line itself, using available turret guns, can defeat a destroyer squadron, before it can reach a practicable firing range, whenever the destroyers approach on target angles abaft 80° and when using secondary battery abaft 130°. In Plate 35 we saw that only 3 OMAHAS are needed to stop 13 OBORAS, without aid from the Battle Line, when the OBORAS approach in target angles abaft 120°. When they approach in target angles 0° to 120°, the conditions for the ap-

proach are much more favorable for the destroyers, so far as being stopped by cruisers before they reach effective range is concerned. When approaching between 30° and 120°, it takes the most number of cruisers to stop the destroyers in time. This is because the destroyers as they approach can use broadside fire on the cruisers more often. The most favorable part of this arc for the destroyers is from 30° to 80°, where the most cruisers must come out the furtherest and the enemy Battle Line is ineffective. In the arc 0° to 30° the destroyers cannot use broadside fire and a collision course too; nor any other course without difficulty when in the more forward portions of this arc.

What is the most favorable part of the arc 30° to 80°? The nearer 80° is approached the greater the chance that broadside fire may be used. If the Battle Line speed gets less than 1/2 the destroyer speed, broadside fire cannot be used at all and the collision course maintained. But the nearer the destroyers come to 80° the less the turn off from the collision course to bring their broadsides to bear. With the usual destroyer speeds of 25 to 30 knots and the usual Battle Line speeds of 15 to 20 knots, the arc 60° to 80° gives broadside fire for all combinations. In this arc the nearer 60° is approached the further out the cruisers must come and therefore the less chance of their being there, and the less chance of the DD interfering with their own Battle Line fire. Also the arc 60° to 80° tends to force interposing cruisers into the area between the Battle Lines and to within range of the destroyers' Battle Line.

Combining all we have deduced, it is fair to say that the most favorable target angle, from which to approach for a destroyer attack in a general action, lies in the arc 50° to 80°. This takes into consideration also the difficulty destroyers have of gaining definite positions with reference to their own Battle Line. The nearer their assigned positions are to their

own Battle Line, the greater is the chance that they will be there.

It is necessary, of course, that the highest practicable speed be used in the approach.

(c) Formations for Approach.

The formations of destroyers for the approach have been a matter of much thought and experiment. The latest publication on this subject is "Formations and Maneuvers of Destroyers, U.S.Fleet, 1932". This paper will not attempt to elaborate on that publication. But attention is invited to the need for developing maximum gunfire by destroyers while making an approach. Often the destroyers' gunfire in maximum volume will be needed to get the attack through. A flexibility in the standard formations, either to extend them into squadron column or an approximation thereto, to allow full gunfire of the squadron, is imperative.

(d) Action of Covering Forces.

The covering forces are the cruisers and destroyers, detailed to keep the way cleared for the approach and firing of the attack destroyers. Their weapons are the gun, the torpedo, and the ram. Their objective is the enemy's cruisers and destroyers which may interfere with the attack. If such covering forces take the action, suggested in Chapter IV for defending the Battle Line against surface torpedo attack, and their attack destroyers approach from the arc approximately 50° to 80° or from near their own Battle Line, the covering force, as a rule, will be in the best initial position for covering the approach of the attack squadrons.

Once the destroyer attack is seen to go in, the covering force has to decide between covering the Battle Line and covering the attack destroyers. The best position always will be to interpose between the object to be covered and the threatening enemy. As long as the bearings of the Battle Line and the attack

squadrons, from the interposed covering force, differ little, both the Battle Line and attack destroyers can be kept covered simultaneously without difficulty. This will occur oftener when the attack squadrons begin their attack from near the Battle Line and approach on a collision course, or from near their covering forces. The attack squadrons will be near their covering forces, as a rule, only when they are not approaching in the best target angles - 50° to 80°. When it is difficult to cover both, the covering force must follow the apparent intentions of the enemy and interpose between him and the more threatened object.

Quick effect is required as the tendency will be for the enemy cruisers, one's own covering force and the attack destroyers to close the same area. A melee often will result in this fight for torpedo water. As a rule the covering forces must close the range and keep in the van of the attack destroyers. To make a destroyer attack effective, covering forces must close to short range and fight the interfering force to a decision. If the O.T.C. orders a destroyer attack on the enemy Battle Line, it must be assumed that he intends for it to be of maximum effectiveness.

Plate 44 shows two opposing Battle Lines at 20,000 yards. It will be difficult to provide sufficient Battle Line support for a destroyer attack at ranges much in excess of this. Three BLUE attack squadrons at A, B & C at zero minute are starting their approach. At this instant A & B are approaching from favorable target angles - 50° to 80°. C has been in the van with the cruisers at D. There are three BLUE cruiser divisions at D, E & F, interposed just beyond the "apple" between their own Battle Line and three enemy cruiser divisions at G, H & I respectively. The BLUE cruisers have been in these positions ever since the deployment, keeping interposed between the Battle Line and the enemy cruisers. If the destroyers have been near

the Battle Line in the preliminary stages, the cruisers have been covering them also. The cruisers receive orders to cover the attack of these three squadrons, or they see them begin the approach. They also see their opposing cruisers stand to intercept the attack destroyers. The BLUE cruisers decide to cover the attack. They move to keep interposed between the enemy cruisers and their own destroyers and to close the range. At the end of 12 minutes all forces are in the positions shown. All BLUE cruisers have covered the attack destroyers, and their own Battle Line as well. They were able to do this by means of their initial interposing positions and by closing the range on the enemy cruisers. In a chase tails action, as illustrated to the right, the BLUE cruisers, abaft BLUE Battle Line beam, performed in the same manner.

The covering operations, performed in this way, will be successful if they are in sufficient force and adhere to gunfire requirements. If the covering force is not in sufficient strength, either the O.T.C. will not order the attack, or the disparity of strength must be accepted. There is no point in saving cruisers in a general action for something better, when a major destroyer attack is ordered.

(e) Smoke Screens.

Smoke screens in the general action will not be dwelt on exhaustively, for their characteristics are well known. They require special weather conditions to insure lying. Strong wind, low barometer, and misty or rainy weather are considered favorable. If they will lie, they can be laid down wind, up wind, and across wind, provided sufficient angle between course of layers and direction of wind is obtained to give breadth to the screen. If one's own fleet is to windward, smoke will drift toward the enemy and will cover forces between which it intervenes. Destroyer attacks can cover themselves when approaching from

windward. If one's own fleet is to leeward, smoke will drift away from the enemy and not cover forces to windward, but it may cover the splashes of overs or set a background that makes difficult the distinguishing of units. Smoke will not help destroyer attacks so well as when begun from to windward. If both fleets are heading approximately into the wind, or away from the wind, both sides probably will have about equal advantages in the use of smoke. In the former case there is greater chance of covering their own attacks with smoke.

One characteristic of smoke screens should be emphasized. A smoke screen laid nearer to one's own fleet than to the enemy's restricts one's own view and freedom of maneuver more than it does the enemy's. But the smokers are safer and the smoke is more easily controlled. Two cases will show how this characteristic may be turned to one's own advantage. Plate 45 illustrates Case I, in which BLUE is engaged with RED. Smoke Screen A is nearer BLUE than RED. In this case only 7 out of the 12 BLUE ships can see any of RED, whereas all 12 of the RED ships can see 6 BLUE ships - and some of them 7. RED has a distinct gunfire advantage. If the screen were half way between the two Battle Lines, as at B, then each side would see the same number of enemy ships and there would be no gunfire advantage on either side. If the screen were nearer RED, as at C, the conditions would be reversed in favor of BLUE. When the screen is near one Battle Line, that Battle Line is restricted in its maneuvers, by having its range of vision limited. If Screen A covered the BLUE O.T.C.'s flagship, he would hesitate to turn toward the nearby screen for fear of what may be just beyond it. The tendency will be for him to move away from the screen. On the other hand, RED's range of vision is not greatly affected. The Screen A appears to him just a bank of smoke on the horizon, subtending a small azimuth arc. In view of this and the difficulty of light

surface forces laying a smoke screen near the enemy, the airplane smoke curtain, which can be laid where wanted in much quicker time, is gaining favor. Plate 50 illustrates Case II. In this case BLUE is between two ORANGE forces with which he is engaged. He decides to block off Force A with smoke while concentrating on Force B. The BLUE smoke layers at S and the BLUE Battle Line smoke. S keeps to leeward of the leader of the Battle Line and not far from it. BLUE in this case does not care how restricted his view or his freedom of maneuver toward Force A is. He neither wants to maneuver in that direction nor be seen from there. He only wants to be sure that he is well covered so that A cannot see him and that his smoke is well under control. A position of the BLUE smokers near the BLUE Battle Line assures this.

Smoke laid by cruisers and destroyers has been suggested for various uses in a general action. Among them are, to protect cruisers and destroyers in attack or when under heavy fire, to mask a maneuver, to cover a disadvantageous disposition, to cover forces when in unfavorable range bands, and to isolate portions of the enemy. The situations are numerous.

The disadvantage of smoke is the danger of interfering with effective gunfire of the Battle Line and in covering those forces which it is disadvantageous to cover. This arises from the loss of control of the smoke once it is laid, the difficulty of anticipating how far it will go and how long it will lie, and the lack of information of what the O.T.C. may plan to do with the Battle Line. Smoke laid by light forces is a two-edged sword that may cut both ways. To compromise satisfactorily between its disadvantages and advantages by a single rule is difficult. Sometimes it is the style to keep exclusively the laying of smoke screens in the hands of the O.T.C.; at other times the light forces have discretionary powers. Both methods will be right in

certain circumstances. Each tactical situation merits its own solution. Trained judgment of the officer on the spot can never be dispensed with. It probably will be a safe plan for the O.T.C. to retain control of all smoke screens in areas adjacent to the Battle Line and to windward of it; and to grant discretion in the more remote areas with the understanding that Battle Line operations and plans must not be interfered with.

(f) Summary.

(1) The coordination of a destroyer attack, in point of time, with its own Battle Line is more important than the attainment of ideal attack perfection within the destroyers themselves. Destroyers, when ordered to attack, should approach and attack at once from wherever they are.

(2) For surface torpedo craft a collision course with the target is the best to get to torpedo effective range in the quickest time from any given position. This course should be followed, as nearly as practicable, at the highest practicable speed.

(3) For surface torpedo craft the most favorable target angle, from which to begin the approach to the firing position in a general action, lies between 50° and 80°.

(4) Often the attacking destroyers' gunfire in maximum volume will be needed to get the attack in. A flexibility of formation and maneuver is important for this purpose.

(5) As a rule the best initial position for cruisers to occupy, not only for defending other defensive forces and own Battle Line, but also for covering the attack of destroyers, is to keep interposed between the head of own Battle Line and the threatening force on, or 2000 to 4000 yards beyond, the "apple". After the destroyer attack starts to approach, the covering force may have to interpose between the attack and the threatening enemy, instead of the Battle Line and the enemy. Often the two bearings will differ little.

(6) Cruisers, covering a destroyer attack, should close as quickly as possible the threatening enemy, consistent with keeping interposed; and fight to a quick decision.

(7) Smoke screens can be used advantageously in a variety of situations, but they are two-edged swords that cut both ways. The nicest judgment is required in their use. Normally the O.T.C. should retain control of smoke screens in the areas adjacent to his Battle Line, and to windward of it; and grant discretion in remote areas with the understanding that Battle Line operations must not be interferred with. Interposing smoke screens nearer one's own Battle Line than the enemy's are often more dangerous than helpful.

CHAPTER VI

THE SYNTHESIS OF ATTACK AND DEFENSE BY CRUISERS AND DESTROYERS.

We have now separated by analysis the leading factors in the tactics of cruisers and destroyers in the general action. Let us see if we can improve the picture by assembling these factors by synthesis. Each tactical situation merits its own solution. For illustration purposes, let us assume three specific situations embodying:-

(a) The Approach;

(b) The Battle, where BLUE is superior in Cruisers and Destroyers;

(c) The Battle, where BLUE is inferior in Cruisers and Destroyers.

(a) The Approach.

Plate 46 shows the synthesis of the approach. In the situation assumed for Plate 46 the visibility is day normal; the enemy is not in sight of surface forces; BLUE is seeking action with a superior BLUE Battle Line, upon which he primarily depends. His cruisers are superior in gun fighting strength to the enemy's cruisers and destroyers combined and their task is defensive to insure freedom of maneuver for own Battle Line; the direction of the enemy Battle Line is known within 10°; and the enemy battle cruisers are in his Battle Line. Otherwise nothing is known, but BLUE aircraft are scouting. If it were impracticable for BLUE aircraft to scout, one cruiser division would have to be spread on a scouting line further in the van. The strength of BLUE cruisers makes unnecessary the assignment of destroyers to them. If it were found that the cruisers needed reenforcement, destroyers as required would join them from the destroyer area near the Battle Line. If the enemy Battle cruisers were not in their Battle line, or were unlocated, two or three BLUE battleships could be sent to support the cruisers.

With this information BLUE takes the disposition shown. His fleet axis is pointed in the direction of the enemy Battle Line, which is also his course at present, with fleet speed 19 knots. The destroyers, assumed to be five squadrons, remain within the hatched area marked "Destroyer Area". Within this area four squadrons dispose themselves into the A.S. soreen, described in Chapter IV. The fifth squadron is assembled either at D, A, B or C, as desired. The destroyers, therefore, are in position of readiness for defense against submarines and torpedo planes, to reenforce cruisers, and to attack enemy Battle Line when ordered, as described in previous chapters. They are near the center of maneuver of the fleet.

The cruisers are disposed as shown. The "apples" for the Type G torpedo, which is assumed to be the longest range torpedo that the enemy light forces carry, are shown for BLUE speed of 19 knots for present course and for deployments 45° to right and left of present course and 90° to right and left of present course. The cruisers are in position of readiness to occupy any of these "apples". The cruisers need not extend beyond 40° each side of the fleet axis, because it is improbable that the enemy light forces will be separated so far from their Battle Line that they will be found outside of these bearings. This arc (40° each side of fleet axis) allows for the maximum extention of enemy light forces from their Battle Line, as illustrated in Fleet Dispositions and Battle Plans. It is not possible for the enemy to extend any further without danger of light forces becoming isolated. These limiting bearings also allow for a 10° error in direction of enemy Battle Line. The BLUE cruisers are out about 22,000 yards which should permit ample warning to the O.T.C. of the enemy approach. Visual signalling is also practicable in all directions with all forces.

The cruisers in the area shown are sufficiently concentrated to interpose in time superior forces between their own Battle Line and the enemy light forces, whether the enemy light forces are massed in his center, or disposed on the flanks and center, or in any other combination. The heavy cruisers are ahead of the light cruisers, because of their longer range guns and because their station in deployment is 2000 to 4000 yards outside the "apple", whereas the light cruisers are on the "apple".

Plate 47 shows this same approach disposition when the fleet axis is 45° to the right of the fleet course.

(b) The Battle, where BLUE is Superior in Cruisers & Destroyers.

Plate 48 shows the battle, with the Battle Line range at 25,000 yards. It flows from the approach disposition shown on Plates 46 or 47. It is a still picture of a great deal of motion.

When the deployment signal is made out, the destroyers move, as described in Chapter IV and illustrated on Plate 42. In Plate 48 the destroyer squadron (V), which is in excess of the A.S. screen, goes to the rear. Squadrons I & II move out toward the enemy, and, when ordered, stand in on collision course to attack. They will pass about 5000 yards astern of the 5 OMAHAS, if the OMAHAS maintain present course and speed. All destroyers stay generally within or near the hatched area, marked "Destroyer Area", until ordered to attack. Those not assembled for attack form as A.S. and A.A. screen.

As soon as the enemy light forces are sighted during the approach and without waiting for fleet deployment or any other orders, the BLUE cruisers match off equal force to equal force and interpose on the "apples" shown on Plate 46. They steer a course at the speed required to hold this interposition on or near the "apples". As the enemy light force strength and dispostion is made out, reenforcements are sent in where required

until superior force is interposed against all enemy light forces - the CA against CA and the CL against destroyers if practicable. If the enemy light forces come in to fight, BLUE engages; but he does not pursue much beyond the "apples", unless the BLUE Battle Line is not uncovered thereby and a decided advantage is to be gained. By this means the BLUE cruisers insure freedom of maneuver for their own Battle Line during the approach.

As soon as the deployment is ordered, the BLUE cruisers draw in the "apples" shown on Plate 48 - one for the deployment course, one for the Battleships' Battle Formation 45° left and one for a change of course by the Battle Line to division columns left 150°; all for Battle Line speed of 19 knots, the maximum formation speed. These "apples" will cover all probable maneuvers of the Battle Line. They do not differ much from those used in the approach, except the one in the original van in the approach comes in closer to the Battle Line by about 5000 yards. The BLUE cruisers, which by now are interposed against all the enemy's cruisers and attack destroyers, hold their positions on or near the "apples" so drawn. If the enemy desires to push in a destroyer attack, he must break down the BLUE cruiser opposition. The enemy cannot find an open space for an attack, for the BLUE cruisers are on interior lines and are always interposed.

There is an area, however, where BLUE cruisers may have difficulty in interposing. That will be the area covered by the enemy Battle Line secondary battery. This battery, in Plate 48, can inflict about 3% damage on the BLUE OMAHAS at 15,000 yards and about 7% at 12,000 yards in 3 minutes. This area cuts in on the maneuvering water of the BLUE cruisers more and more as the Battle Line range decreases. The BLUE cruisers may hesitate to enter it. But may have to do so to stop a destroyer attack. How effective the secondary battery of the enemy Battle Line will be, while under fire at effective ranges from

the BLUE Battle Line, is problematical. The best area for the enemy destroyer attack will be through this area, as was shown in Chapter V. The enemy in Plate 48 has taken the battle disposition illustrated in Fleet Dispositions and Battle Plans. His rear flank forces, however, have been unable to reach the station recommended therein, on account of BLUE opposition.

It is believed that as long as the BLUE cruisers remain interposed in superior strength in the hatched areas, marked "Cruiser Area", the BLUE Battle Line will have practical liberty of decision and action. The enemy has to overcome superior cruiser strength in order to deprive BLUE of this.

(c) The Battle, where BLUE is Inferior in Cruisers & Destroyers.

In this case it is assumed that BLUE has the superior Battle Line, but inferior cruisers and destroyers. He is seeking decisive action, relying primarily on his Battle Line, with his light forces on the defensive to insure freedom of maneuver so far as possible. The enemy will probably use his superior light forces on the offensive to endeavor to make up his inferiority in the Battle Line. BLUE cannot be strong everywhere as in Plate 48. If he attempts to match the enemy's light forces in every direction, he will probably be weaker in every direction, and thereby lose all freedom of maneuver. We will assume that BLUE will endeavor to overcome this, by deliberately being weak on one flank in order to be overwhelmingly superior on the other. By this means he will surrender freedom of maneuver in one direction in order to gain it in the other. BLUE will, therefore, select a Battle Line course that will place the greater part of the enemy's light forces abaft the beam of his Battle Line, in order to minimize their torpedo effectiveness; and concentrate the greater part of his own light forces on the other flank to keep his van clear. We will assume that this will result in a "chase tails" action.

To illustrate the operations of the cruisers and destroyers under these conditions, in conformity with the suggestions of this paper, Plate 49 has been prepared. The situation shown is diagramed from the actual situation that existed on the maneuver board at 1648 in Tactical Problem IV, 1933-Sr. The only discrepancy is that the BLUE Battle Line is shown in Battle Formation 15° right, on course 105°, instead of turning to course about SW as he actually did. BLUE Desrons I & II, consisting of 20 DD, had just been wiped out by the RED light forces A and B. There was a smoke pall in this locality from the melee and burning ships. It is difficult for BLUE O.T.C. to make out what is happening in this area. The Battle Lines were just on the edge of visibility. When last seen the RED light forces at B were heading at high speed for the melee, the result of which was yet unknown. RED light forces at C also were heading for the melee at high speed. The RED cruisers at D had been under Battle Line and light force fire for some time. They were known to be crippled. The RED destroyers at C were known to be fresh, as well as RED's A.S. screen at E. The BLUE light forces at X, Y & Z were in good condition. The RED destroyers, ship for ship, are superior to BLUE's.

The "apples" for BLUE Battle Line courses 105°, 135°, 235° and 270° are shown. If BLUE turns his Battle Line to SW, the smoke, where the enemy light forces are, will be well within the "apple", with RED forces at B soon to be. If BLUE Battle Line continues to eastward (course 105°), the RED light forces are outside of the "apple"; D & E well outside, C 3000 to 7000 yards outside. The most threatening area for BLUE, therefore, appears to be in the direction of A. It is assumed that BLUE decides to put the area A abaft his beam and use his light forces to clear away his van. There is yet time to stop the RED light forces at D, C & E with the superior BLUE light forces at X, Y, & Z.

Until the threat from them is removed, the BLUE Battle Line may not be able to turn more to the Southward, as the chase tails action will require. But he may have hopes that Desrons I & II, which are fighting in the smoke at A, may have gotten off some torpedoes at the RED Battle Line, which would probably force a turn away out of sight and give BLUE a breathing spell to restore his van.

To accomplish this, he will direct all his light forces, including his A.S. screen, to protect his van on a SE course. To do this the cruisers at X should strive to interpose between the Battle Line and the RED cruisers D on the "apple" for course 135°; the destroyers at Y in the same manner for the enemy C, and the destroyers at Z in the same manner for E or B, if B turns in. They should go out as far toward the "apple" as they can to bring effective gunfire to bear on their opponents and the secondary battery of the RED Battle Line will permit. The BLUE Battle Line, in the meantime, should turn to the SE as far as the clearing operations will permit and not lose sight of the RED light forces at B, C and D. To lose sight of them might permit the RED Battle Line to put its main battery on X, Y and Z, when the enemy Battle Line went out of sight in the haze, without a corresponding opportunity for BLUE. By this means BLUE neglects his right flank and concentrates his effort on his left flank. His Battle Line secondary battery still is available, in its most effective arc, for use against the enemy at A, and B, if B stands further to the westward.

CHAPTER VII

CONCLUSION.

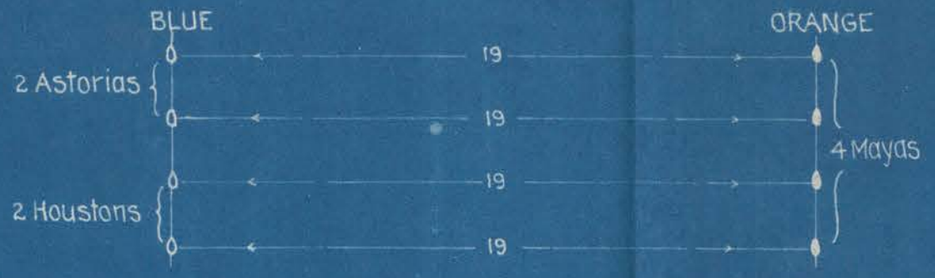
Nelson, in his Trafalgar Battle Plan, assigned to his second in command the task of cutting off the enemy's twelve rear ships and of following "up the blow until they are captured or destroyed". "The remainder of the enemy's fleet --- are to be left to the management of the Commander-in-Chief, who will endeavor to take care that the movements of the second in command are as little interrupted as is possible".

In the modern general action will it not be the role of the cruisers and destroyers to take care that the movements of the main striking force are as little interrupted as is possible? This main striking force will be the Battle Line, plus destroyers sallying from it like wolf cubs from the pack.

Or, in football language: guards block guards, tackles block tackles, ends block ends and the man with the ball goes through center.

KIND OF SPOT - LOCAL CONTROL - ROLL - PITCH - SPRAY - GAS - SUNGLARE - BATTERY INTERFERENCE - OVER CONCENTRATION - WIND AND SEA

Case I. No Penalties

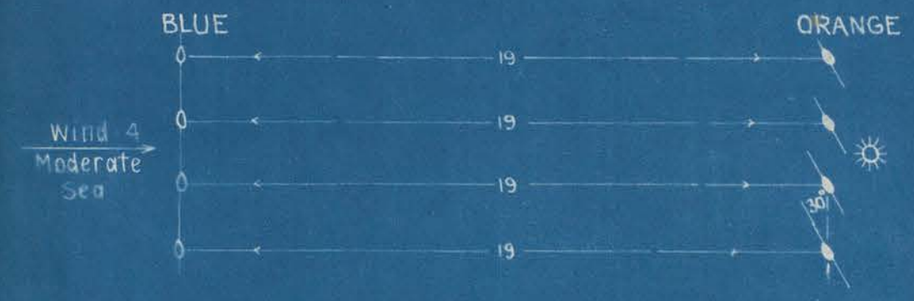


Blue - No Penalty
Orange - No Penalty

Blue on Orange	Orange on Blue
.48 plane spot	.20 plane spot
.48 " "	.20 " "
.48 " "	.53 " "
.48 " "	.53 " "
1.92	1.46

$\frac{\text{Blue}}{\text{Orange}} = \frac{1.92}{1.46} = 131\%$

Case II. Roll, Gas, Sunglare and Plane Spot.



Blue - Roll and Gas
Orange - No Penalties

Blue on Orange	Orange on Blue
.34 plane spot	.20 plane spot
.34 " "	.20 " "
.34 " "	.53 " "
.34 " "	.53 " "
1.36	1.46

$\frac{\text{Blue}}{\text{Orange}} = \frac{1.36}{1.46} = 93\%$

Blue - Roll, Gas and Sunglare
Orange - No Penalty

Blue on Orange	Orange on Blue
.30 plane spot	.20 plane spot
.30 " "	.20 " "
.30 " "	.53 " "
.30 " "	.53 " "
1.20	1.46

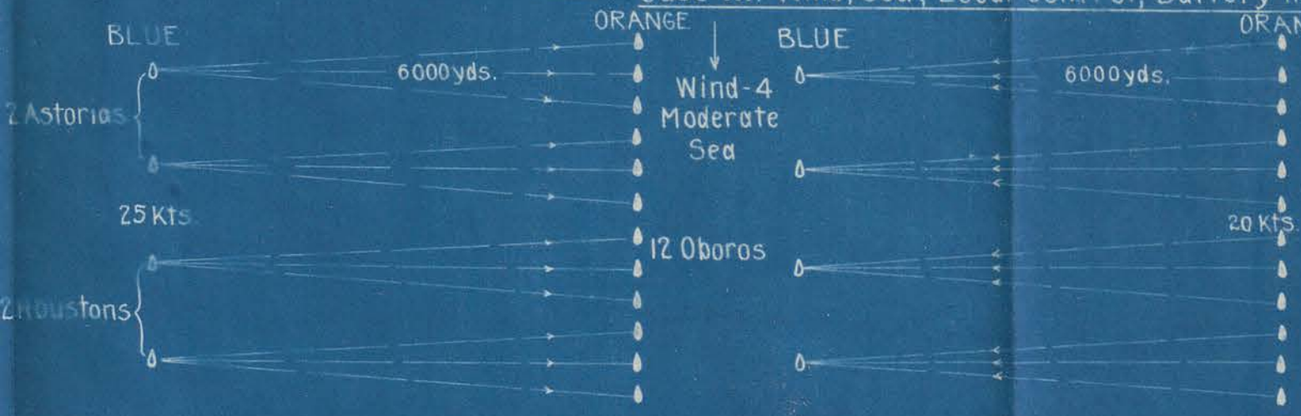
$\frac{\text{Blue}}{\text{Orange}} = \frac{1.20}{1.46} = 82\%$

Blue - Roll, Gas and Sunglare
Orange - Loses Plane Spot

Blue on Orange	Orange on Blue
.30 plane spot	.18 top spot
.30 " "	.18 " "
.30 " "	.44 " "
.30 " "	.44 " "
1.20	1.24

$\frac{\text{Blue}}{\text{Orange}} = \frac{1.20}{1.24} = 97\%$

Case III. Wind, Sea, Local Control, Battery Interference, Spray, Pitch, Over Concentration



(a) Blue - Pitch, Local Control, Under Minor Fire
Orange - Spray, Pitch, Over Concentration

Blue on Orange	Orange on Blue
1.21	.24
	.24
1.21	.24
	.24
1.21	.24
	.24
1.21	.65
	.65
4.84	.65
	.65
	.65
	.65
	5.34

$\frac{\text{Blue}}{\text{Orange}} = \frac{4.84}{5.34} = 91\%$

(b) Same as (a) except sea rough, Speeds reduced to 14 Kts for CA, 10 Kts for DL.

Blue on Orange	Orange on Blue
1.04	.19
	.19
1.04	.19
	.19
1.04	.19
	.19
1.04	.52
	.52
4.16	.52
	.52
	.52
	.52
	4.26

$\frac{\text{Blue}}{\text{Orange}} = \frac{4.16}{4.26} = 98\%$

C&D mCA Mod R&C Sept 1932.

PLATE I.

B35-322

ENFILADE

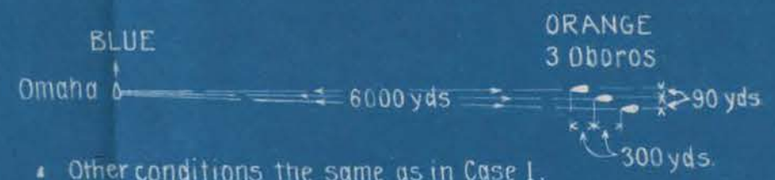
CASE I - NO ENFILADE

Rate of change of range 3000 yards in 3 minutes.
Both sides local control.
Oboros - bow fire and over concentration.
Omaha - presenting 90° target obliquity.
Omaha under normal fire.
Each Oboro under less than normal fire.

Blue on Orange	Orange on Blue
.88	.26
	.27
	.26
	.79

$$\frac{\text{Blue}}{\text{Orange}} = \frac{.88}{.79} = 111\%$$

CASE II - ORANGE SUFFERS ENFILADE

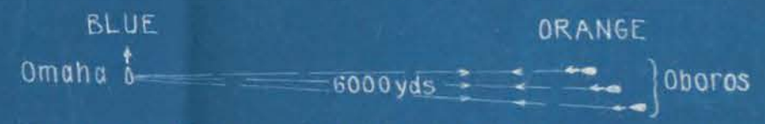


Other conditions the same as in Case I.

Blue on Orange	Orange on Blue
2.40	.26
	.27
	.26
	.79

$$\frac{\text{Blue}}{\text{Orange}} = \frac{2.40}{.79} = 304\%$$

CASE III - SURPRISE FIRE



Same conditions of Case I, except Blue suffers from surprise fire and fire not established. Orange suffers from fire not established.

Blue on Orange	Orange on Blue
.51	.21
	.21
	.21
	.63

$$\frac{\text{Blue}}{\text{Orange}} = \frac{.51}{.63} = 81\%$$

PLATE 2.

RATE OF CHANGE OF RANGE

CASE I - CHANGE OF RANGE LESS THAN 666 YARDS PER MINUTE

Both sides local control.
Blue - broadside fire.
Orange - bow fire and over concentration.
Blue - under normal fire
Each Oboro under less than normal fire

Blue on Orange	Orange on Blue
1.18	.16
	.16
	.16
	.48

$\frac{\text{Blue in Case II}}{\text{Blue in Case I}} = \frac{.73}{1.18} = 62\%$

CASE II - CHANGE OF RANGE MORE THAN 666 YARDS PER MINUTE

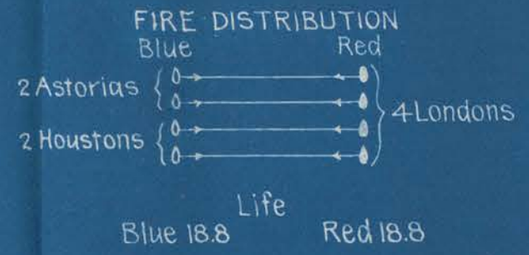
Same conditions as Case I, except rate of change of range is 1600 yards per minute

Blue on Orange	Orange on Blue
.73	.09
	.09
	.09
	.27

$\frac{\text{Orange in Case II}}{\text{Orange in Case I}} = \frac{.27}{.48} = 56\%$

FIGHTING STRENGTH COMPARISON CURVES – CA vs CA

Curves show damage received in one 3 minute move in percentage of original life.



		BLUE	RED
Maximum range all ships -		34,000	27,000
Displacement each ship -		10,000	10,000
Main battery each ship -		9-8"/55	8-8"/50
Guns in broadside -		9	8
Armor, side	Astoria -	5"	0
	Houston -	3"	
Armor, deck	Astoria -	2¼"	4"
	Houston -	1"	
Air each ship	–	4VS	1VS

Conditions assumed

Direct method	Director lay
Plane spot	Only main battery firing
Range has been established	Rate of change of range small
On steady course and speed	No enfilade
No change of target	No spray, smoke, gas, sunglare,
Visibility high	role, pitch or yaw.
No damage on firing ship	No silhouette
Broadside fire	No surprise fire

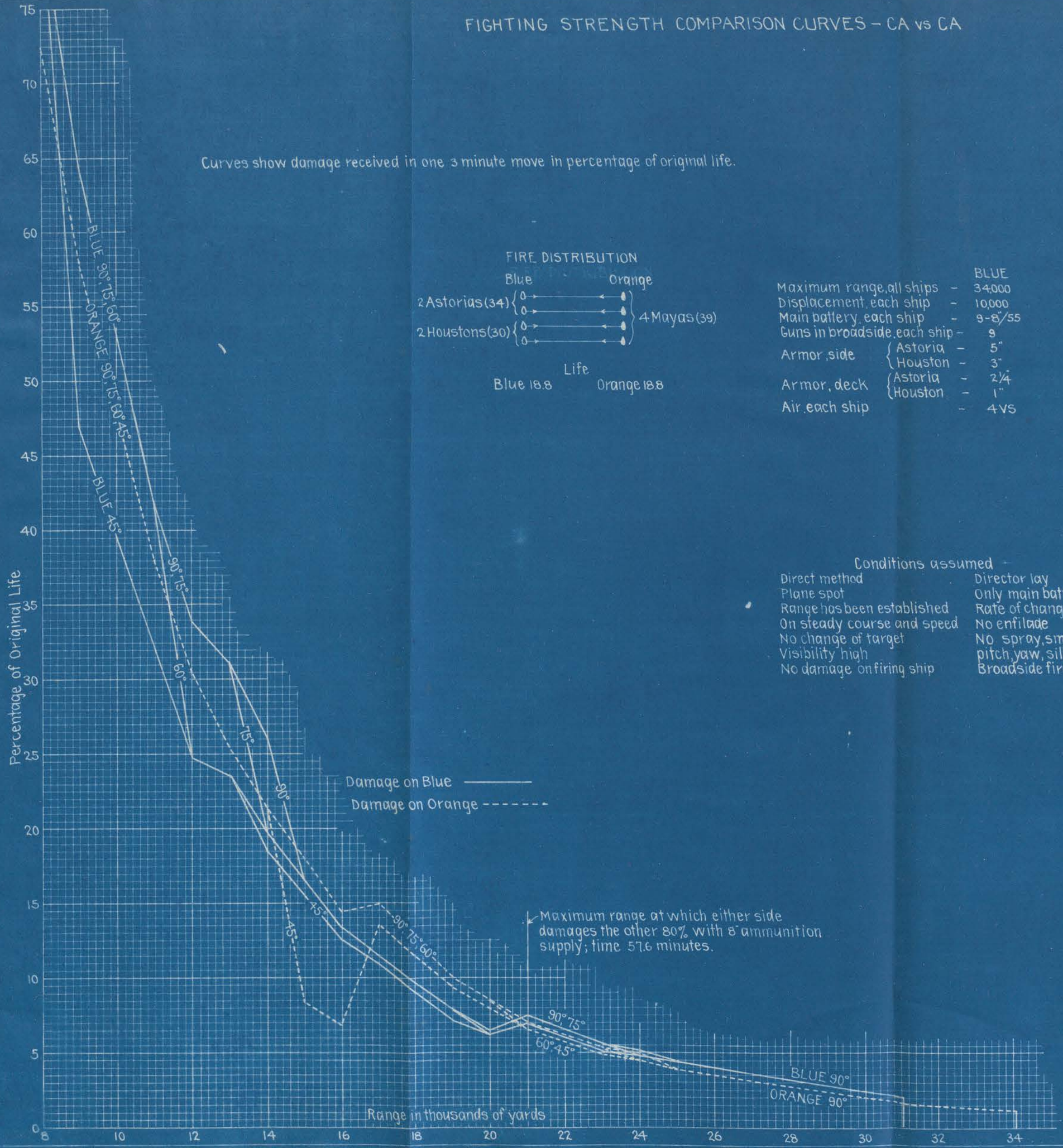
C. & D. in G. A." Capt. R.B.C. Sept. 1932

PLATE 4

B33-32.5

FIGHTING STRENGTH COMPARISON CURVES – CA vs CA

Curves show damage received in one 3 minute move in percentage of original life.



FIRE DISTRIBUTION

Life

Blue 18.8 Orange 18.8

		BLUE	ORANGE
Maximum range, all ships		34,000	31,000
Displacement, each ship		10,000	10,000
Main battery, each ship		9-8"/55	10-8"/50
Guns in broadside, each ship		9	10
Armor, side	Astoria	5"	4"
	Houston	3"	
Armor, deck	Astoria	2¼"	1¼"
	Houston	1"	
Air, each ship		4 VS	2 VS

Conditions assumed

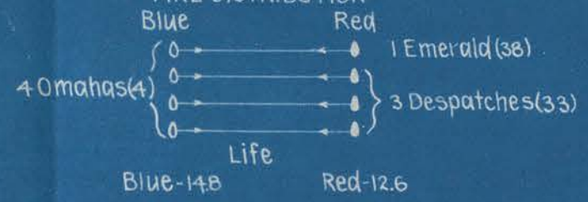
Direct method	Director lay
Plane spot	Only main battery firing
Range has been established	Rate of change of range small
On steady course and speed	No enfilade
No change of target	No spray, smoke, gas, sunglare, roll, pitch, yaw, silhouette or surprise fire.
Visibility high	Broadside fire.
No damage on firing ship	

PLATE 5

FIGHTING STRENGTH COMPARISON CURVES - CL vs CL

Curves show damage received in one 3 minute move in percentage of original life.

FIRE DISTRIBUTION



	BLUE	RED
Maximum range –	4 guns 22000 6 guns 18000	all guns 22000
Displacement –	7050	1 ship - 7550 3 ships - 4850
Main battery –	10 - 6"/53	1 ship - 7-6"/50 3 ships - 6-6"/50
Guns on broadside –	7	6
Armor, side –	3"	3"
Armor, deck –	1.5	1"
Air each ship –	2VS	1VS

Conditions Assumed

- Direct method
- Plane spot
- Range has been established
- On steady course and speed
- No change of target
- Visibility high
- No damage on firing ship
- Director lay
- Only main battery firing
- Rate of change of range small
- No enfilade
- No spray, smoke, gas, sunglare, role, pitch, yaw, silhouette, or surprise fire.
- Broadside fire

Damage on Blue ———

Damage on Red - - - - - - - -

Maximum range for Red to damage Blue 80% with 6" ammunition supply; time 67 minutes.

Percentage of Original Life

Range in thousands of yards

BLUE 90°,75°,60°

BLUE 45°

RED 90°,75°,60°

RED 45°

BLUE 90°,75°

BLUE 60°

RED 60°

RED 90°,75°

RED 75°

RED 75°,60°,45°

RED 90°

RED 90°,75°,60°,45°

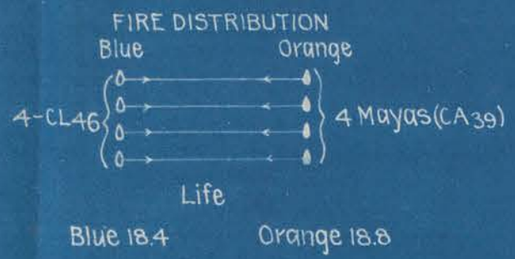
BLUE 90°,75°,60°,45°

PLATE 6

"C. & D. in G.A." Capt. R.B.C., Sept. 1932

FIGHTING STRENGTH COMPARISON CURVES – CA vs CL

Curves show damage received in one 3 minute move in percentage of original life.



	BLUE	ORANGE
Maximum range all ships –	27,000	31,000
Displacement each ship –	9600	10,000
Main battery each ship –	12-6"/53	10-8"/50
Guns in broadside each ship –	12	10
Armor, side –	5"	4"
Armor, deck –	2.25	1.25
Air each ship –	4VS	2VS

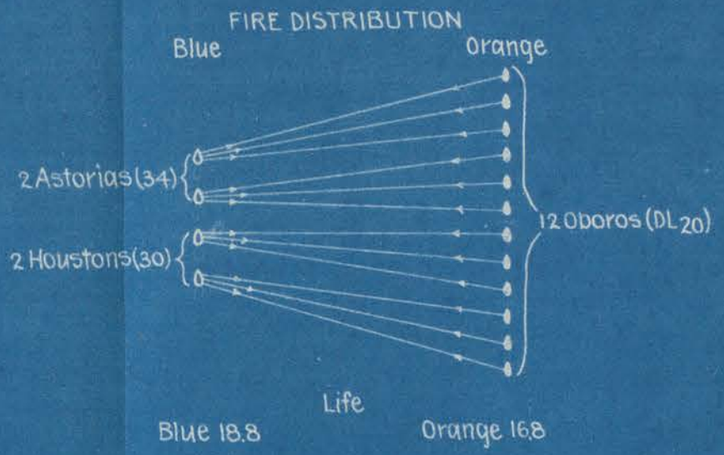
Conditions assumed

Direct method	Director lay
Plane spot	Only main battery firing
Range has been established	Rate of change of range small
On steady course and speed	No enfilade
No change of target	No spray, smoke, gas, sunglare, roll,
Visibility high	pitch, yaw, silhouette, or surprise fire.
No damage on firing ship	Broadside fire.

PLATE 7

FIGHTING STRENGTH COMPARISON CURVES – CA vs DL

Curves show damage received in one 3 minute move in percentage of original life.



		BLUE	ORANGE
Maximum range all ships	–	34,000	18,000
Displacement each ship	–	10,000	1,700
Main battery each ship	–	9-8"/55	6-5.1/50
Guns in broadside each ship	–	9	6
Armor, side Astoria	–	5"	
Armor, side Houston	–	3"	0
Armor, deck Astoria	–	2".25	
Armor, deck Houston	–	1"	0
Air each ship	–	4 VS	0

Conditions assumed

Direct method.
Local control, no plane spot, for Blue.
Range has been established.
Rate of change of range small
No enfilade.
No damage on firing ship.
Both under normal fire.
DLs suffering from over concentration, except at 3000 yards and less.

Director lay, top spot for Orange.
Only main battery firing.
On steady course and speed.
No change of target.
Visibility high.
No spray, smoke, gas, sunglare, roll, pitch, yaw, silhouette, or surprise fire.
Broadside fire.

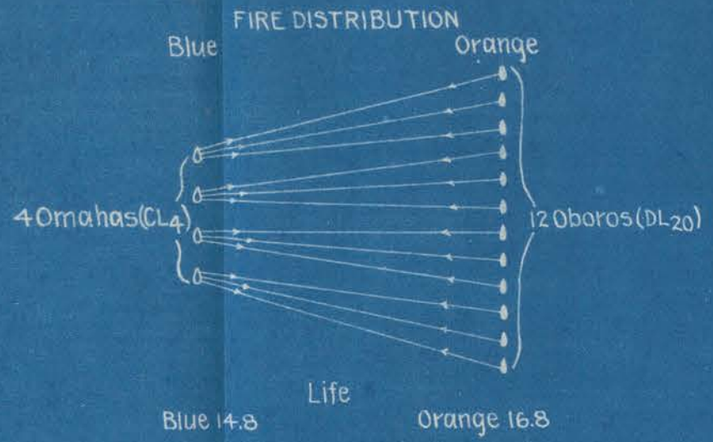
PLATE 8

"C & D. in G.A." Capt. R.B.C. Sept. 1932

B33-32.9

FIGHTING STRENGTH COMPARISON CURVES – CL vs DL

Curves show damage received in one 3 minute move in percentage of original life.



	BLUE	ORANGE
Maximum range all ships –	22000	18000
Displacement each ship –	7050	1700
Main battery each ship –	10-6"/53	6-5.1/50
Guns in broadside each ship –	7	6
Armor, side –	3"	0
Armor, deck –	1.5	0
Air each ship –	2 VS	0

Conditions assumed

Direct method.
Local control, no plane spot
On steady course and speed.
No change of target.
Visibility high.
No damage on firing ship.
Orange under less than normal fire; but suffering from over concentration, except at 3000 yards and less.

Director lay.
Only main battery firing.
Range has been established.
Rate of change of range small.
No enfilade.
No spray, smoke, gas, sunglare, roll, pitch, yaw, silhouette, or surprise fire.
Broadside fire.
Blue under concentration.

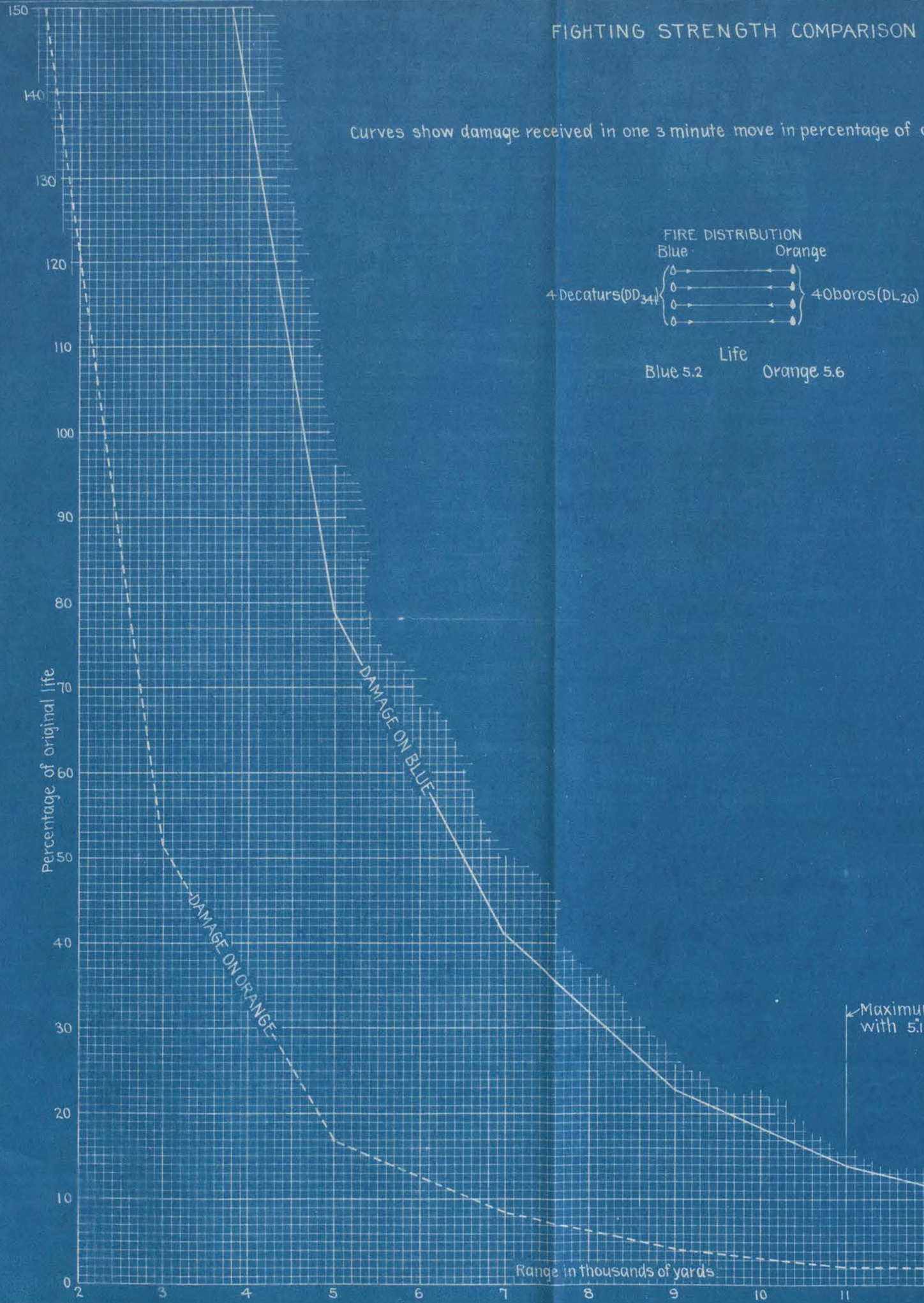
PLATE 9

"C&R U.S.A." Capt. R.C. Sept 1932

B33-330

FIGHTING STRENGTH COMPARISON CURVES – DD vs DL

Curves show damage received in one 3 minute move in percentage of original life



FIRE DISTRIBUTION

Blue · Orange

4 Decaturs (DD$_{341}$) { 0 → ← 1 ; 0 → ← 1 ; 0 → ← 1 ; 0 → ← 1 } 4 Oboros (DL$_{20}$)

Life

Blue 5.2 Orange 5.6

	BLUE	ORANGE
Maximum range all ships –	13000	18000
Displacement each ship –	1051	1700
Main battery each ship –	4-4"/50	6-5.1/50
Guns in broadside each –	3	6
Armor –	0	0

Conditions assumed.

Direct method.
Top spot.
Range has been established.
On steady course and speed.
No change of target.
Visibility high.
No damage on firing ship.
Under normal fire.

Director lay.
Only main battery firing.
Rate of change of range small.
No enfilade.
No spray, smoke, gas, sunglare, roll, pitch, yaw, silhouette or surprise fire.
Broadside fire.

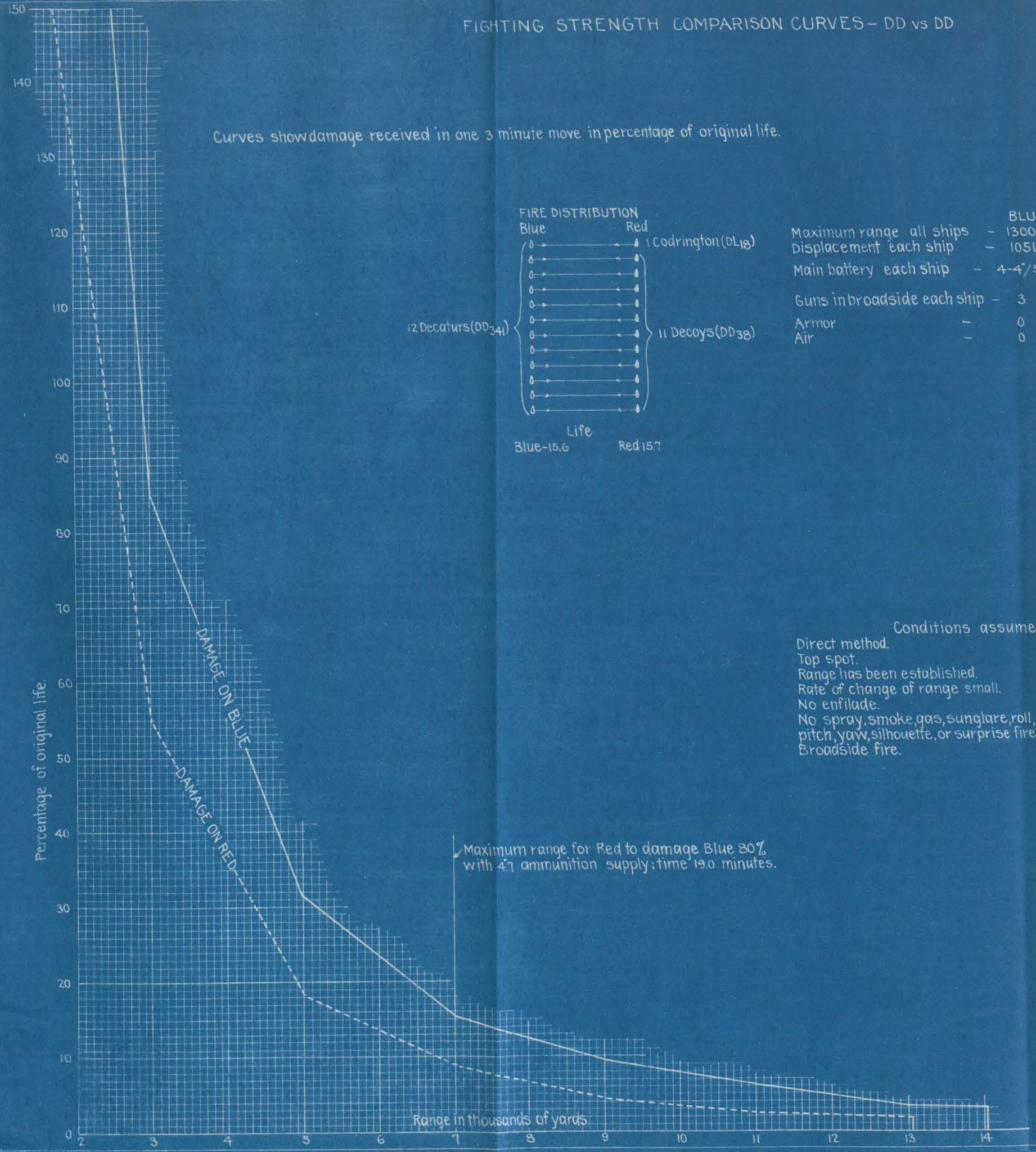
PLATE 10

C&D in G.A. Capt R.B.C. Sept. 1932.

B33-33/

FIGHTING STRENGTH COMPARISON CURVES – DD vs DD

Curves show damage received in one 3 minute move in percentage of original life.



FIRE DISTRIBUTION

Life

Blue – 15.6 Red 15.7

	BLUE	RED
Maximum range all ships	13000	14000
Displacement each ship	1051	DL-1540, DD-1375
Main battery each ship	4-4"/50	DL-5-4.7/45 DD-4-4.7/45
Guns in broadside each ship	3	DL-5 DD-4
Armor	0	0
Air	0	0

Conditions assumed

Direct method.
Top spot.
Range has been established.
Rate of change of range small.
No enfilade.
No spray, smoke, gas, sunglare, roll, pitch, yaw, silhouette, or surprise fire.
Broadside fire.
Director lay.
Only main battery firing
On steady course and speed.
No change of target.
Visibility high.
No damage on firing ship.
Under normal fire.

"C.B. in G.A." Capt. R.B.C. Sept. 1932

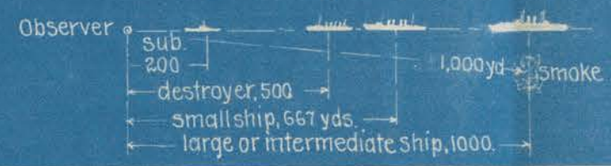
PLATE II
B30-332

NATURAL NIGHT VISIBILITY

with the observer on the bridge of a large or intermediate size ship.

CASE I. Night - Low Visibility

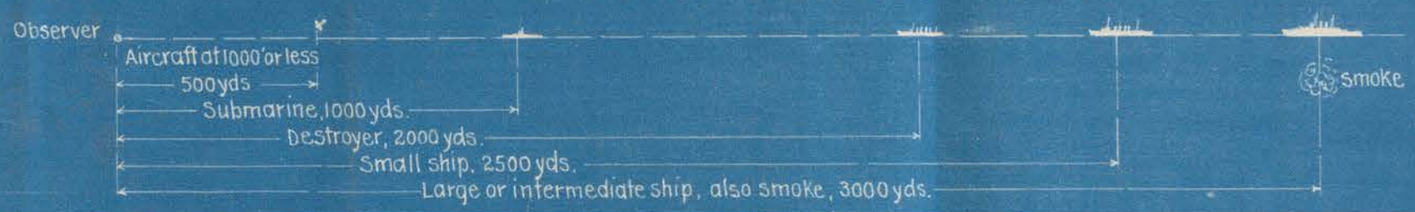
Sky overcast, moist atmosphere, no horizon.



Aircraft in air and submarine periscopes cannot be seen.

CASE II. Night - Normal Visibility

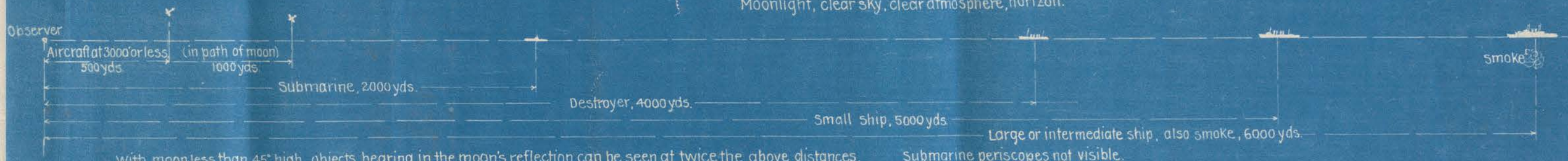
Clear sky, clear atmosphere, no moon, horizon.



Submarine periscopes not visible.

CASE III Night - High Visibility

Moonlight, clear sky, clear atmosphere, horizon.



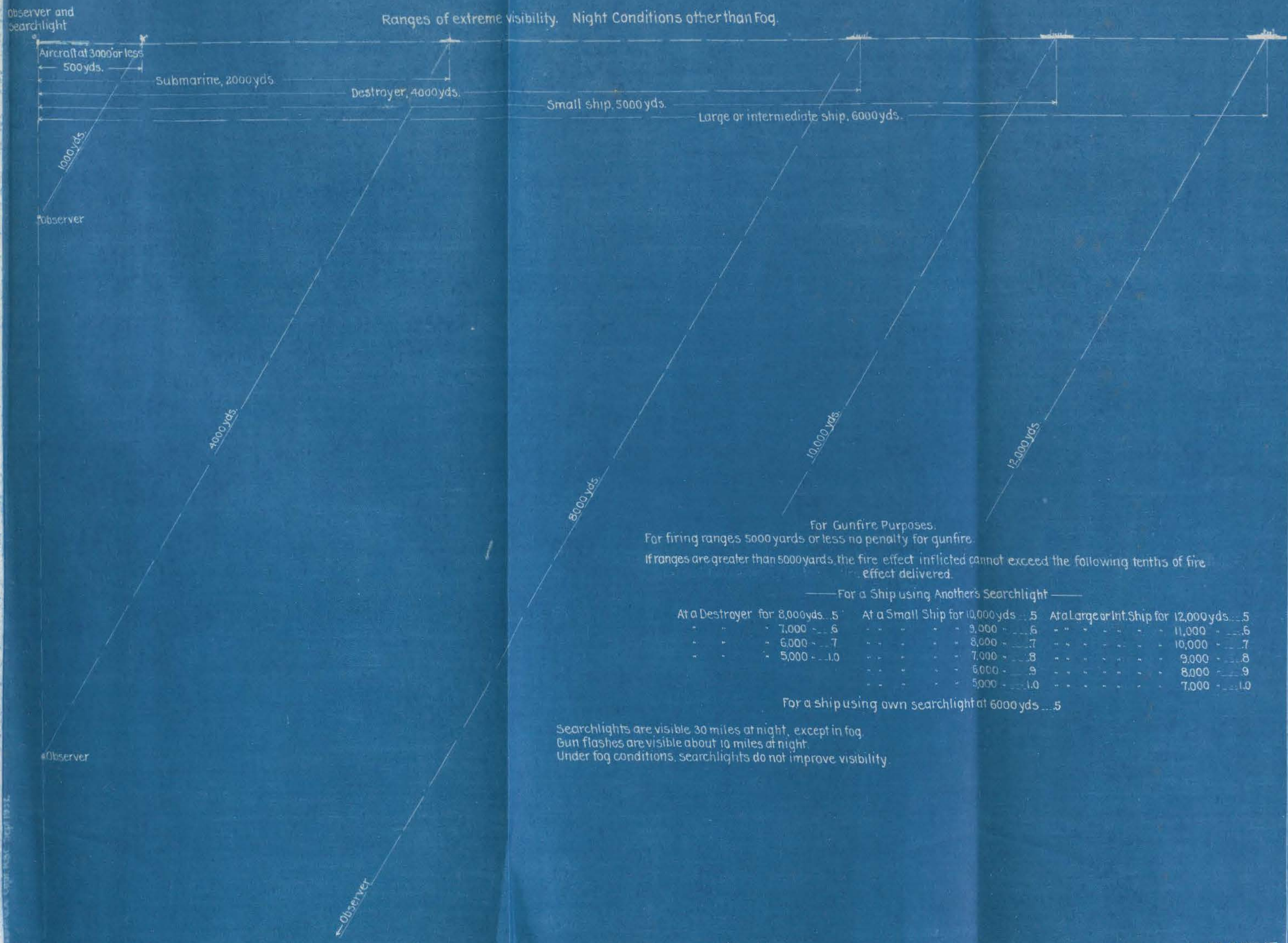
With moon less than 45° high, objects bearing in the moon's reflection can be seen at twice the above distances. Submarine periscopes not visible.

Ranges given are those within which the object indicated can be seen without artificial illumination, and beyond which they cannot be seen.

C&D in G.A. Capt R.B.C. Sept. 1932 (mod. July 1933)

PLATE 14.

SEARCHLIGHTS



For Gunfire Purposes.

For firing ranges 5000 yards or less no penalty for gunfire.

If ranges are greater than 5000 yards, the fire effect inflicted cannot exceed the following tenths of fire effect delivered.

——For a Ship using Another's Searchlight——

At a Destroyer for 8,000 yds.	.5	At a Small Ship for 10,000 yds	.5	At a Large or Int. Ship for 12,000 yds	.5
" " " 7,000 "	.6	" " " " " 9,000 "	.6	" " " " " " " 11,000 "	.6
" " " 6,000 "	.7	" " " " " 8,000 "	.7	" " " " " " " 10,000 "	.7
" " " 5,000 "	1.0	" " " " " 7,000 "	.8	" " " " " " " 9,000 "	.8
		" " " " " 6,000 "	.9	" " " " " " " 8,000 "	.9
		" " " " " 5,000 "	1.0	" " " " " " " 7,000 "	1.0

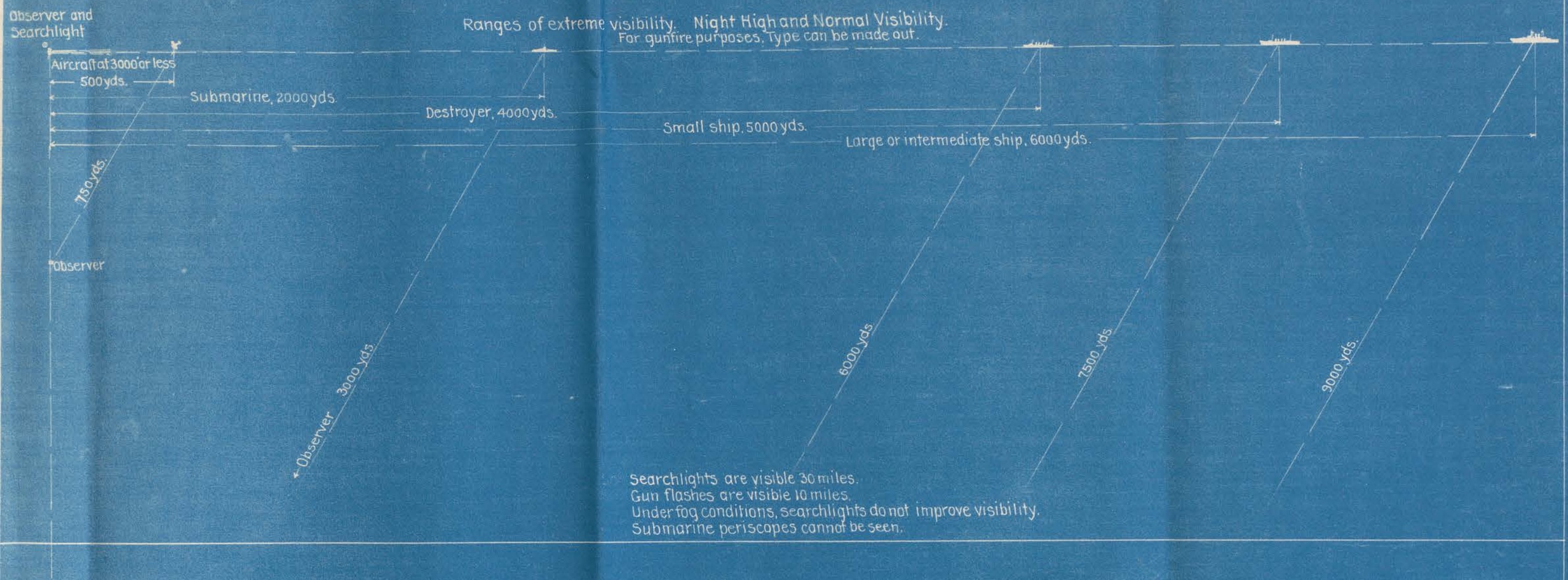
For a ship using own searchlight at 6000 yds .5

Searchlights are visible 30 miles at night, except in fog.
Gun flashes are visible about 10 miles at night.
Under fog conditions, searchlights do not improve visibility.

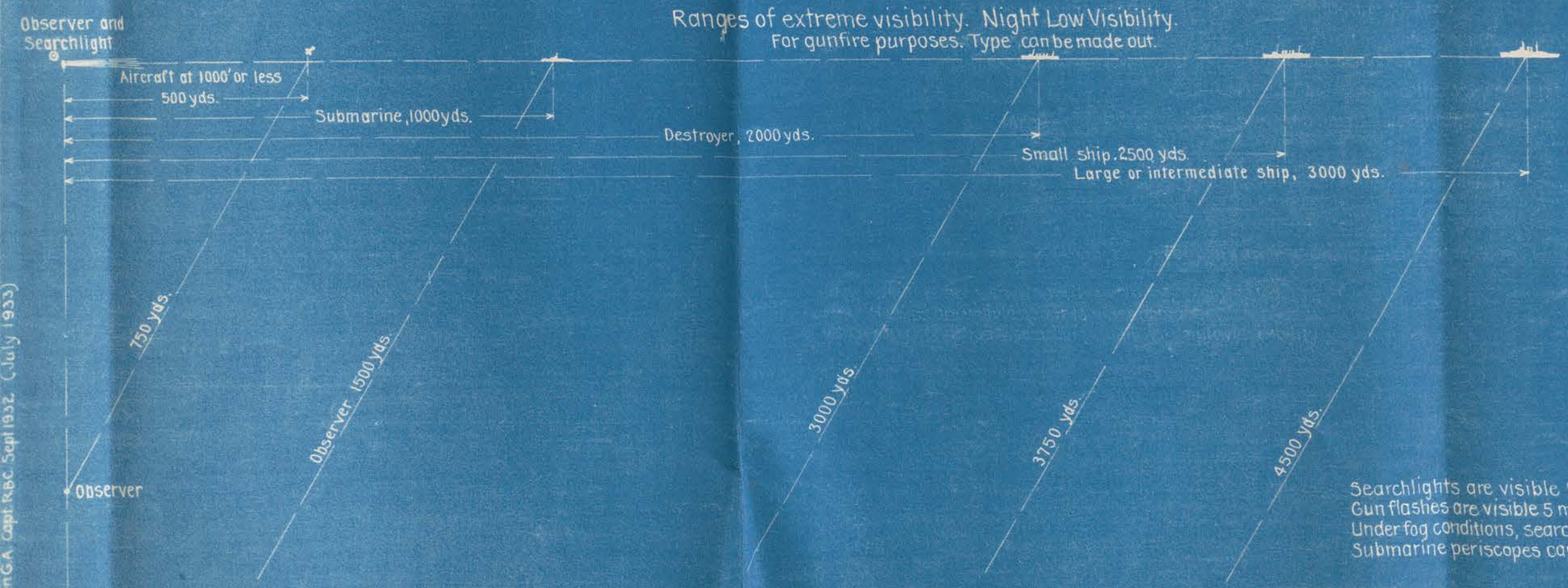
PLATE 15.

B33-336

SEARCHLIGHTS



Searchlights are visible 30 miles.
Gun flashes are visible 10 miles.
Under fog conditions, searchlights do not improve visibility.
Submarine periscopes cannot be seen.

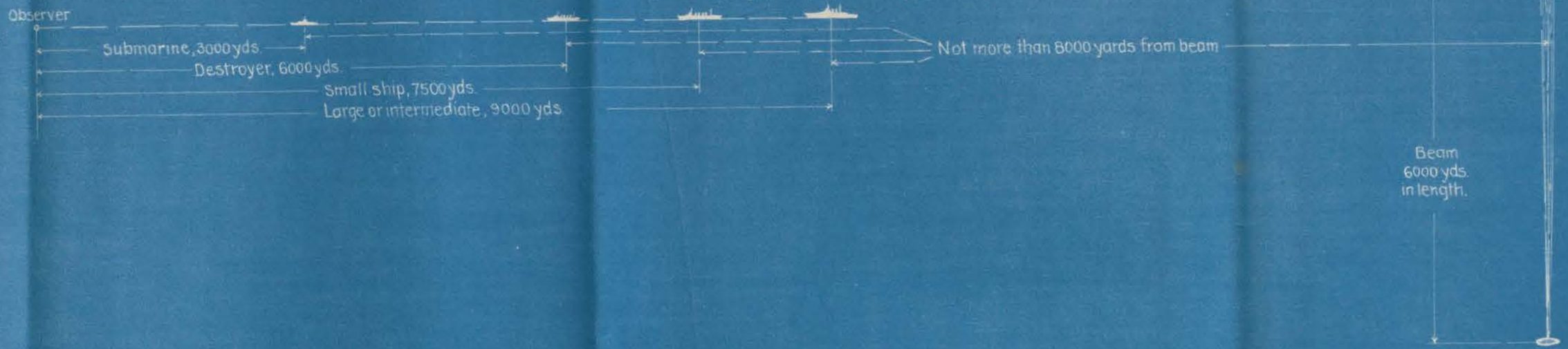


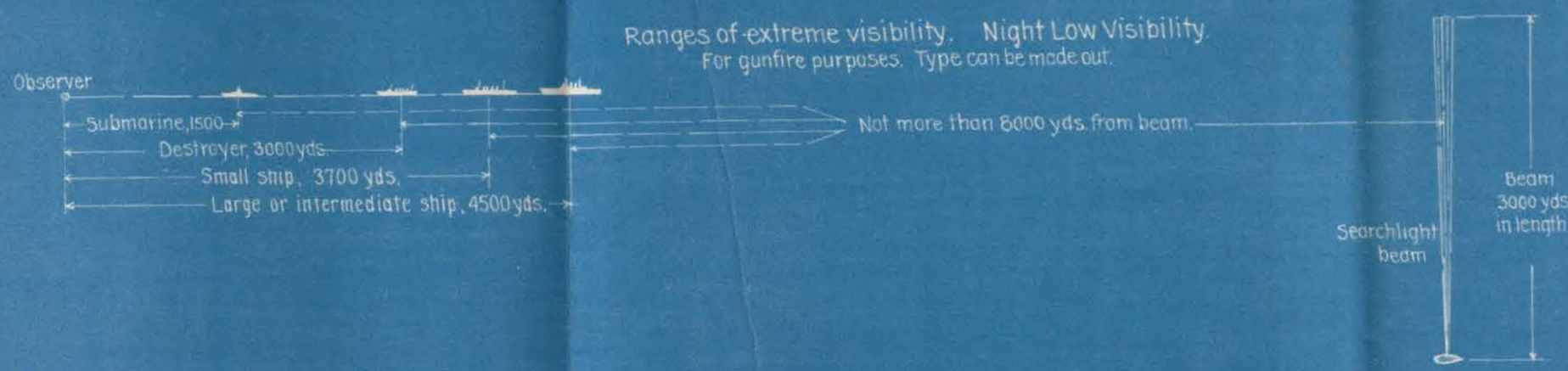
Searchlights are visible 15 miles.
Gun flashes are visible 5 miles.
Under fog conditions, searchlights do not improve visibility.
Submarine periscopes cannot be seen.

PLATE 15-A.

C&D in G.A. Capt. R.B.C. Sept 1932. (July 1933)

SEARCHLIGHTS - VESSEL SILHOUETTED.





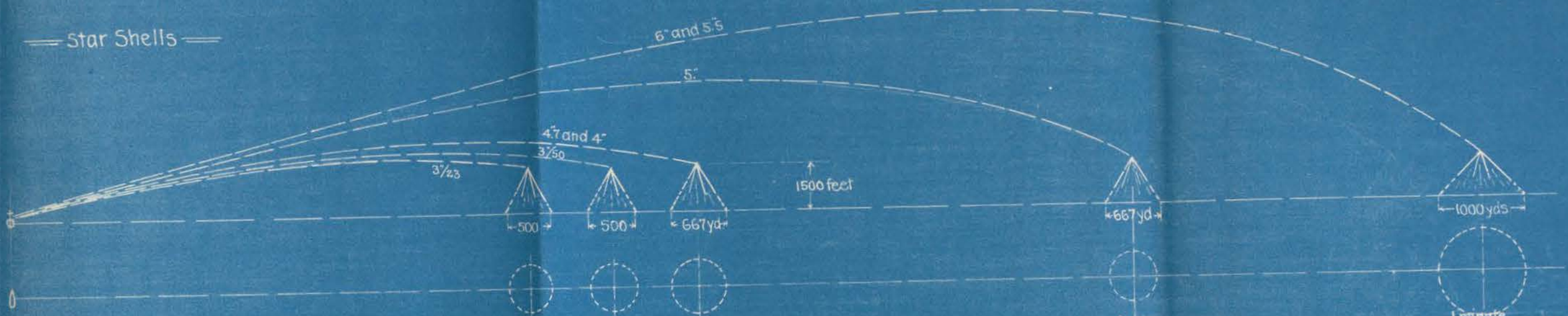
Silhouetted vessel must be no more than 8000 yards from beam.
In fog searchlights do not improve visibility.
Submarine periscopes cannot be silhouetted

PLATE 15-B.

Cdr. W.G.A. Capt. R.D.C. July 1933.

STAR SHELLS AND PARACHUTE FLARES.

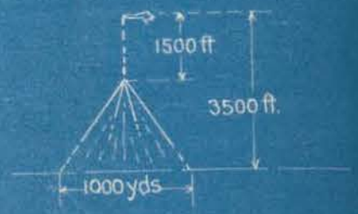
Star Shells



Duration of one illumination	¼ min.	¼ min.	⅓ min.	½ min.	1 minute
Maximum horizontal range at which effective star shell can be burst	6,000	7,000	8,000	13,000	17,000
Minimum number of bursts per minute required to maintain illumination of target at moderate speed	8	8	6	4	3

During illumination star shells and flares drop 300 feet per minute and drift with the wind.

Parachute Flares



Duration of one illumination.. 5 minutes

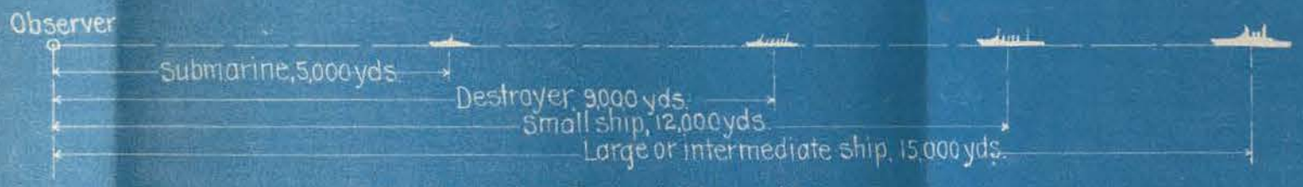
Minimum number of bursts per minute required to maintain illumination at moderate speed ..-1.

C&D in G.A. Capt RBC. Sept 1932 (mod. July 1933)

STAR SHELLS AND PARACHUTE FLARES.

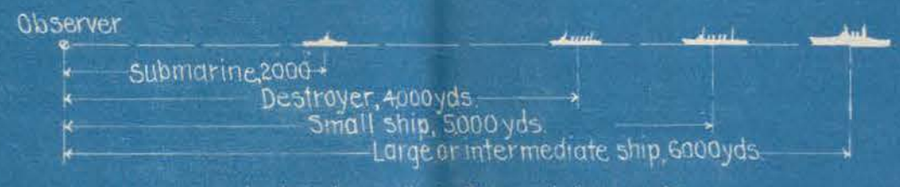
Ranges of extreme visibility. For gunfire purposes, type can be made out.

Night High or Normal Visibility



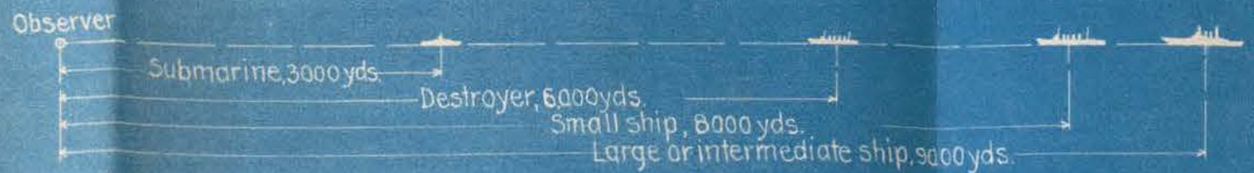
Starshell and parachute flares visible 30 miles.

Night Low Visibility.



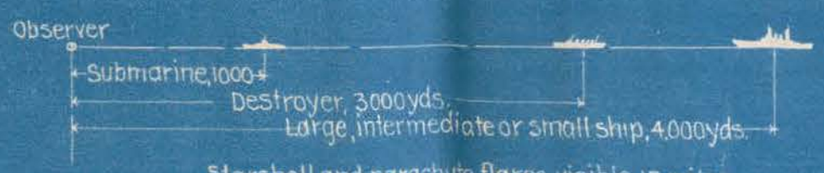
starshell and parachute flares visible 15 miles.

Night High or Normal Visibility



Starshell and parachute flares visible 30 miles

Night Low Visibility.



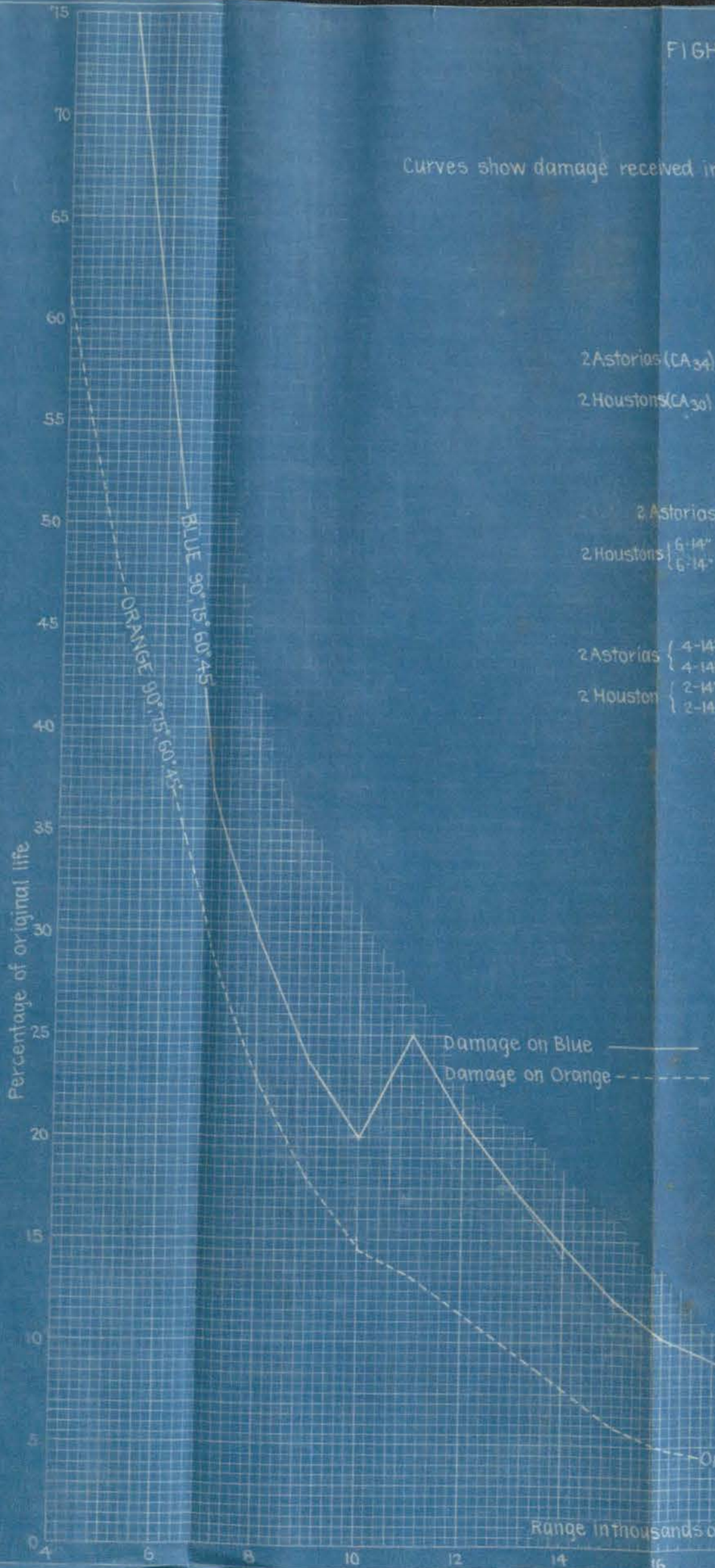
Starshell and parachute flares visible 15 miles

Burst must be between 0 and 8000 yds. beyond target and must cross the line of sight.
Burst less than 0 yds. or greater than 8000 yds. provide no illumination.
Point of burst should be at an altitude of 1500 feet.
Under fog conditions starshells or flares do not improve visibility.

C.N.O. & G.A. Capt. R.B.C. July 1933

FIGHTING STRENGTH COMPARISON CURVES – BB vs CA

Curves show damage received in one 3 minute move in percentage of original life.



FIRE DISTRIBUTION

11000 yards and above

Below 11000 yards

Life

Blue 18.8 Orange 16.3

		BLUE	ORANGE
Maximum range all ships	–	34,000	30,000
Displacement each ship	–	10,000	29,990
Main battery each ship	–	9-8"/55	12-14"/45
Guns in broadside	–	9	12
Armor, side	– Astoria	5"	12"
	– Houston	3"	
Armor, deck	– Astoria	2.25	3.75
	– Houston	1"	
Air each ship	–	4VS	2VO

Condition assumed

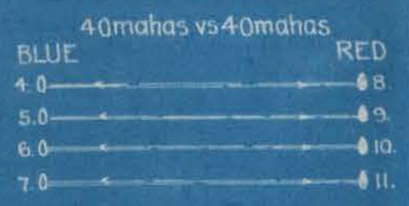
Direct method.
Plane spot.
Range has been established.
Rate of change of range small.
No enfilade.
No spray, smoke, gas, sunglare, roll, pitch, yaw, silhouette, or surprise fire.
Broadside fire.
Orange under minor fire.
Blue under normal fire, except above 11000 when 2 Astorias are not under effective fire.
Director lay.
Only main battery firing.
On steady course and speed
No change of target, except as indicated on fire distribution.
Visibility high.
No damage on firing ship.
Orange uses local control below 11000 yards.
Orange is concentrating on soft ships.
Blue is suffering from overconcentration.

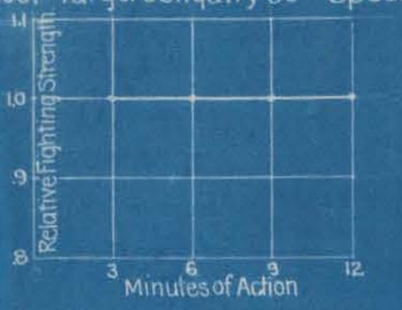
Note: ORANGE can put BLUE out of action (80% damaged) with ammunition supply at any range - except when BLUE presents a 45° target obliquity above 24,000 yards.

PLATE 12

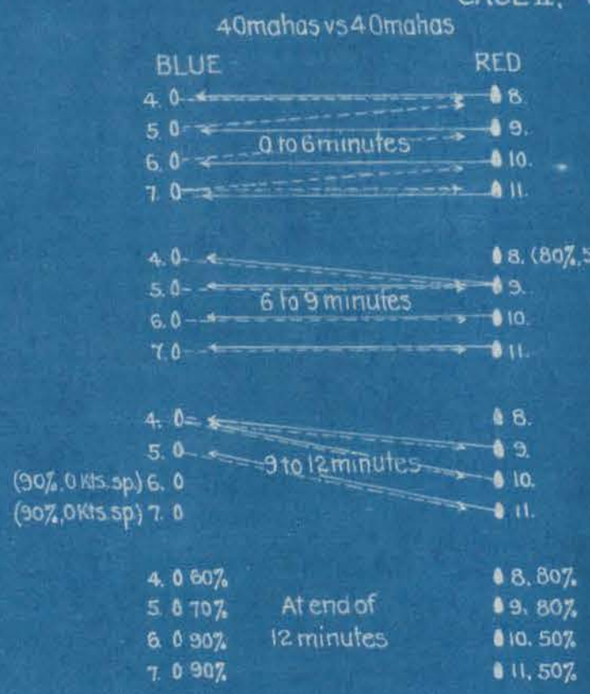
ARTIFICIAL CONCENTRATION.

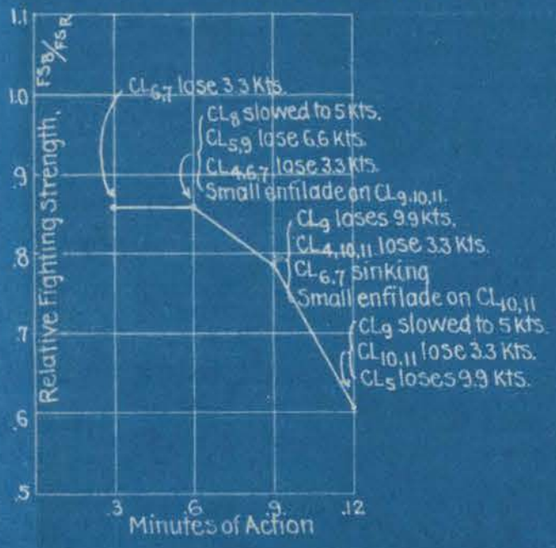
CASE I. - Range 10,000; Target Obliquity 90° - Speed 28.





CASE II. - Range 10,000, Target Obliquity 90°, Speed 28, Distribution as shown





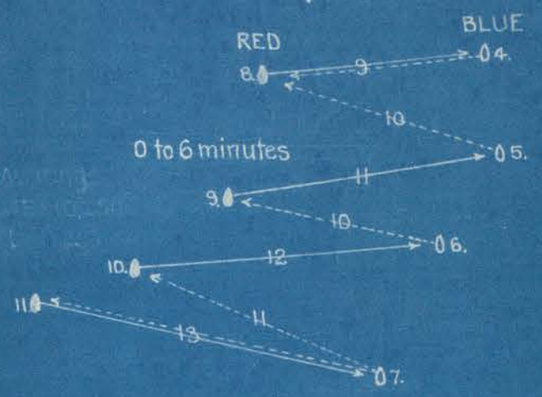
Conditions Assumed -

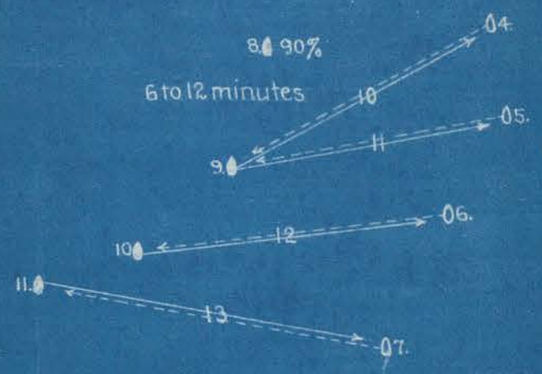
Direct Method, Director Lay, Top Spot. No surprise fire, Change of Range small, No Masked Fire, No Spray, Smoke, Gas or Silhouette. Roll, Pitch & Yaw negligible. Visibility good.

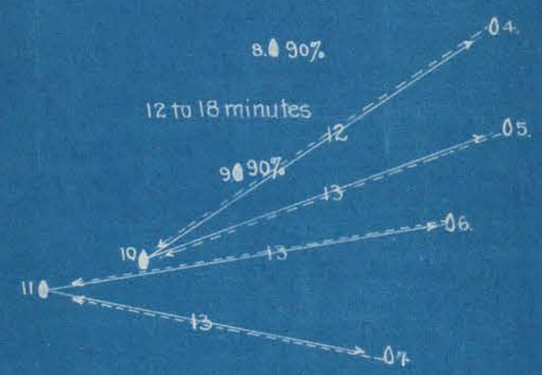
ARTIFICIAL CONCENTRATION WITH A LESS MEAN RANGE

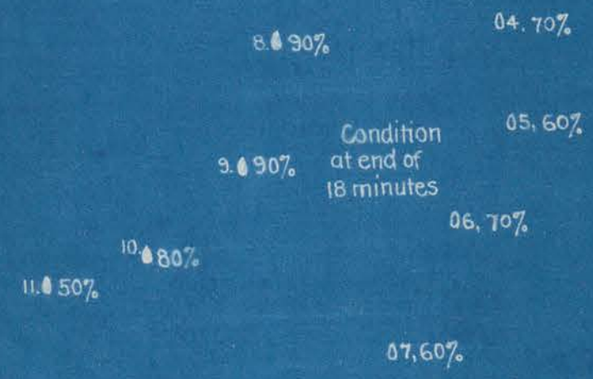
CASE II.

Average Range, BLUE-10,250, RED-11,250



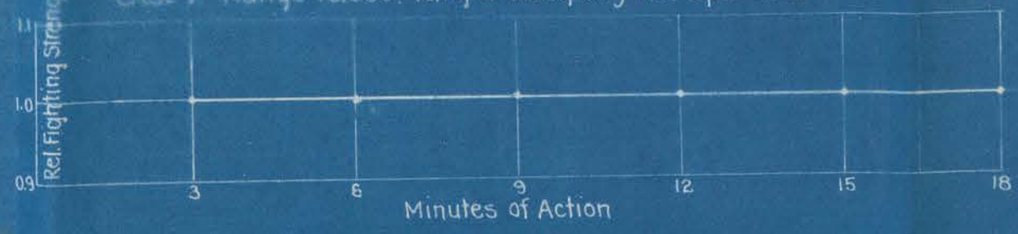






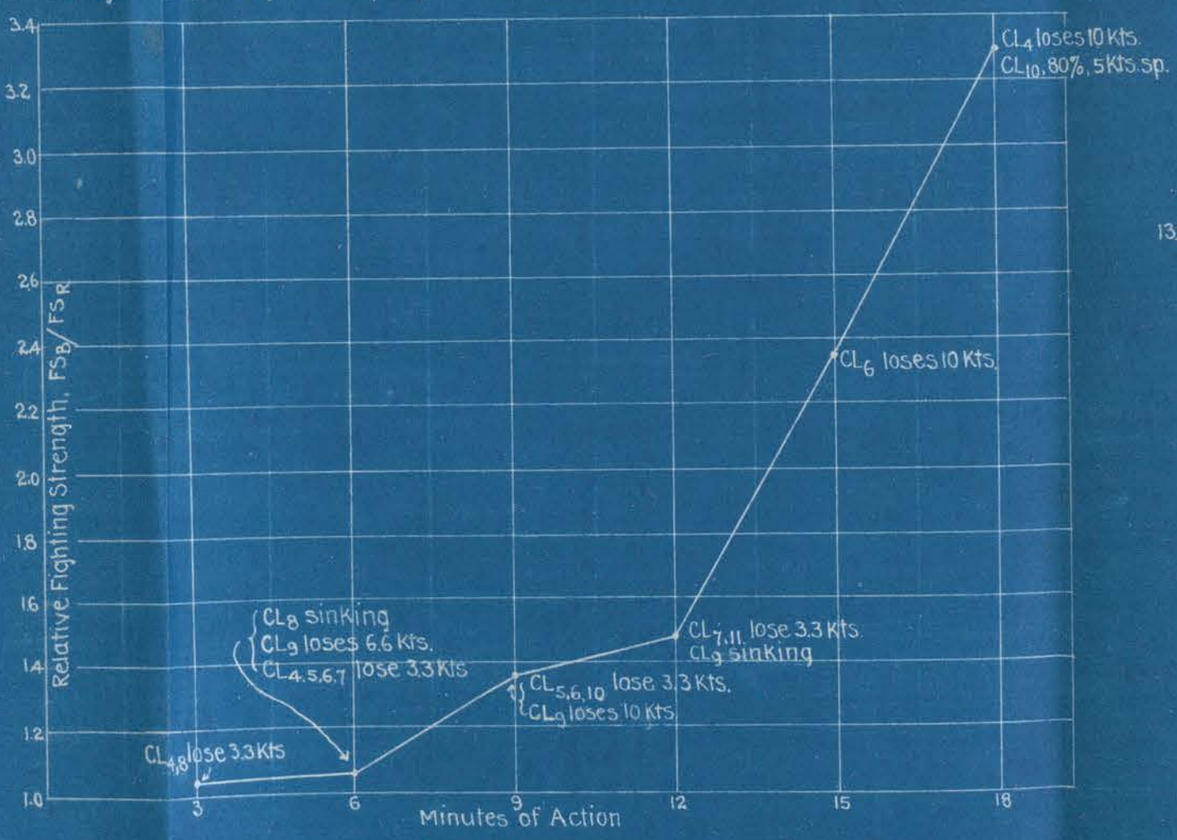
4 Omahas vs 4 Omahas

CASE I Range 10,000. Target Obliquity 90°. Speed 28.



4 Omahas vs 4 Omahas

CASE II. Range 10,000. Target Obliquity 90°, Speed 28, Distribution as shown.

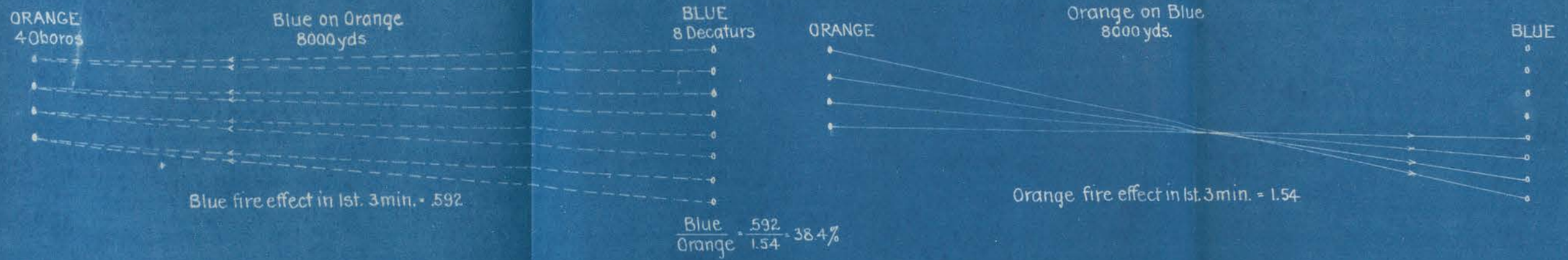


Conditions Assumed

Direct Method. Director Lay. Top Spot. No Surprise Fire. Change of Range small. No Masked Fire. No Spray, Smoke, Gas or Silhouette. Roll, Pitch and Yaw negligible. Visibility good. No Enfilade.

SHIFTING FIRE.

CASE I.

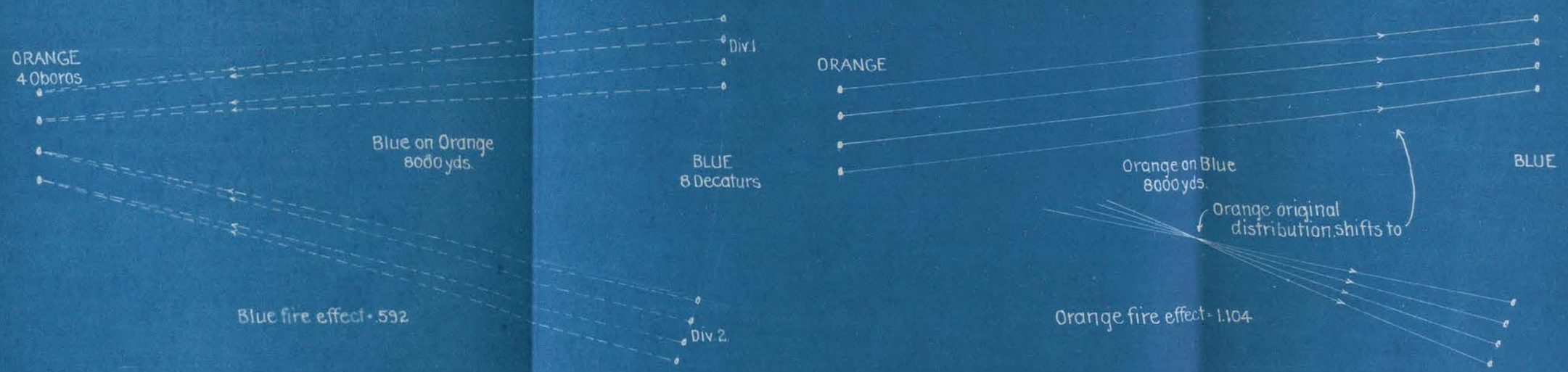


$$\frac{\text{Blue}}{\text{Orange}} = \frac{.592}{1.54} = 38.4\%$$

CASE II. Orange shifts fire to remove cross fire and fire at nearest ships.

$$\frac{\text{Blue}}{\text{Orange}} = \frac{.592}{1.305} = 45.2\%$$

CASE III. Orange shifts fire as in CASE II, but the new targets cause a change of target bearing of over 15°. Orange must re-open fire.



$$\frac{\text{Blue}}{\text{Orange}} = \frac{.592}{1.104} = 53.6\%$$

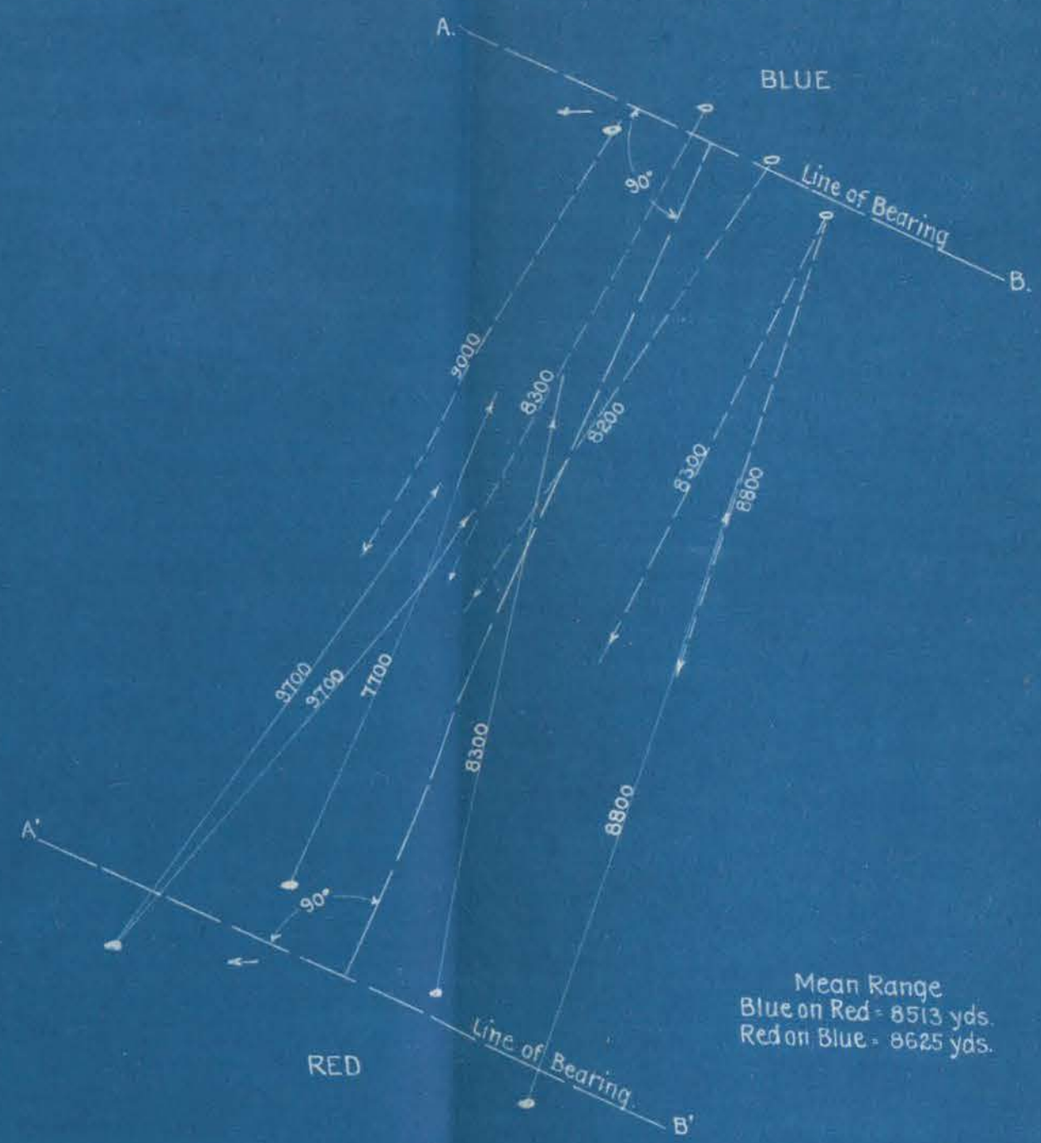
LINES OF BEARING.

Case I.

Mean Range
Blue on Red - 10587 yds.
Red on Blue - 11375 yds.

COMPACTNESS.

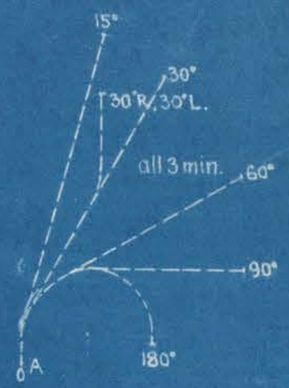
Case II.



Mean Range
Blue on Red - 8513 yds.
Red on Blue - 8625 yds.

CHANGE OF COURSE

Ships A and B are Omahas (CL_4). Guns 10-6"/53, one side 7-6"/53. Armor, side 3", deck 1.5, Life 3.7



Ship A maintains speed, 28 kts, changes course

Ship B maintains course, speed 28 kts, target obliquity 90°

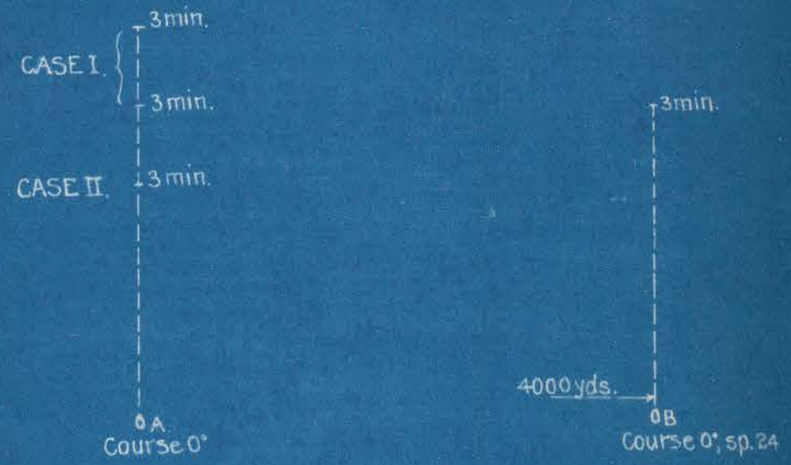
Ratio of fire effect during change of course $\frac{A}{B}$, for 3 minutes of firing.

	11,000 yds. Pointer Lay for A	11,000 yds. Director Lay for A	16,000 yds. Pointer Lay for A	16,000 yds. Director Lay for A
CASE I. Ship A changes course 180° — Ship B maintains course	$\frac{0}{.52}$ = 0%	$\frac{.20}{.47}$ = 43%	$\frac{0}{.09}$ = 0%	$\frac{.03}{.08}$ = 38%
CASE II. " " " 30° — " " "	$\frac{.20}{.54}$ = 37%	$\frac{.70}{.54}$ = 129%	$\frac{.03}{.08}$ = 38%	$\frac{.09}{.08}$ = 112%
CASE III. " " " 60° — " " "	$\frac{.50}{.74}$ = 68%	$\frac{.80}{.74}$ = 108%	$\frac{.07}{.10}$ = 70%	$\frac{.10}{.10}$ = 100%
CASE IV. " " " 30° — " " "	$\frac{.80}{.98}$ = 82%	$\frac{100}{.98}$ = 102%	$\frac{.10}{.13}$ = 77%	$\frac{.13}{.13}$ = 100%
CASE V. " " " 15° — " " "	$\frac{.90}{100}$ = 90%	$\frac{100}{1.00}$ = 100%	$\frac{.12}{.13}$ = 92%	$\frac{.13}{.13}$ = 100%
CASE VI. " " " 30°R, 30°L — " " "	$\frac{.50}{.95}$ = 53%	$\frac{.80}{.95}$ = 84%	$\frac{.07}{.13}$ = 54%	$\frac{.10}{.13}$ = 77%

Note:- Target obliquity of A during change of course was considered. In order to eliminate the effect of target obliquity, except as a result of changing course, target obliquity of A at the beginning and end of the turn was assumed to be 90°. No masked fire or change of range is considered.

CHANGE OF SPEED.

Ships A and B are Omahas.



Ratio of fire effect, $\frac{A}{B}$, during first 3 minutes

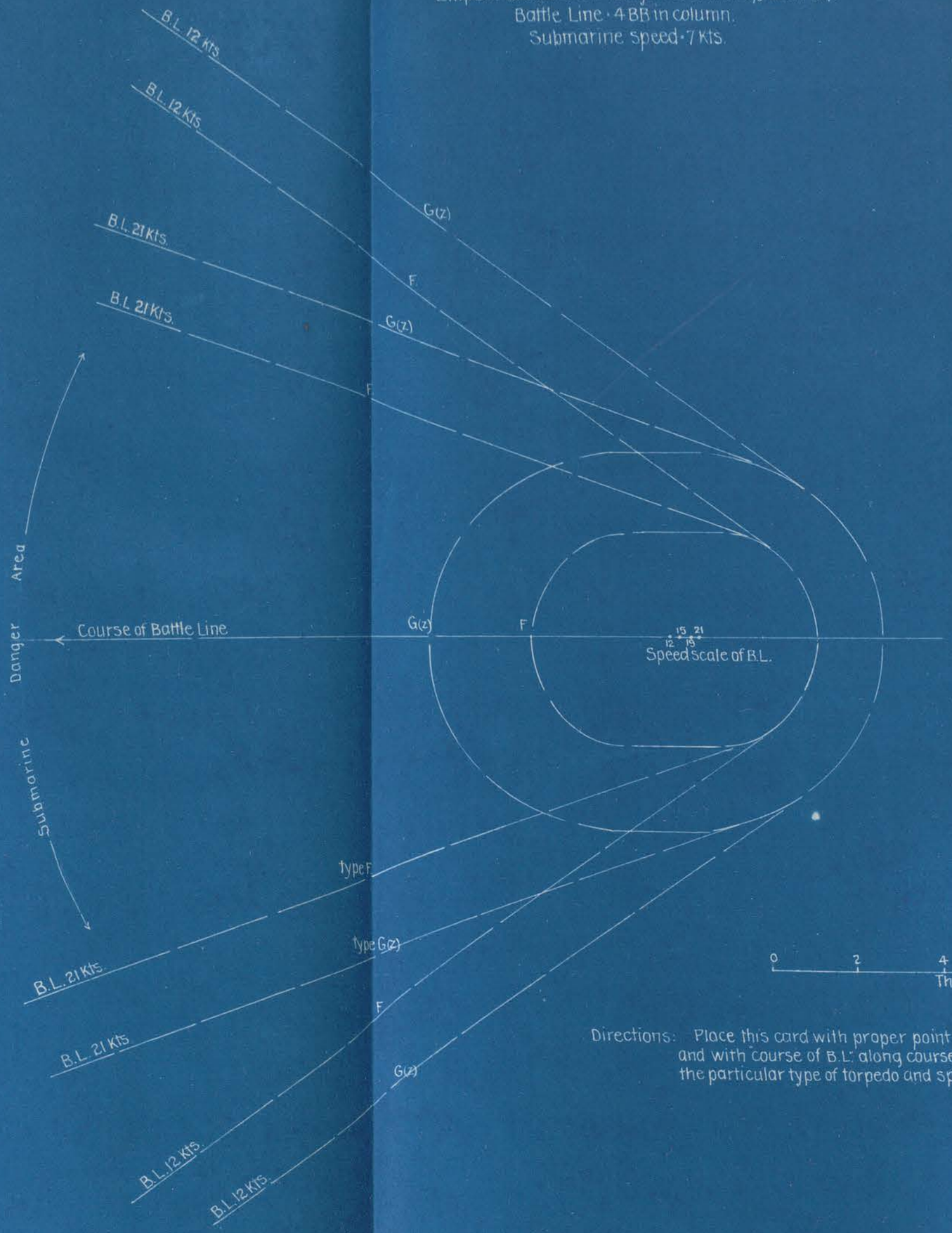
	4000 yds.	11,000 yds.	16,000 yds.
CASE I. Ship A increases, or decreases, speed 6 Knots voluntarily from 24 Knots, in 3 minutes.	$\frac{4.02}{5.74}$ = 70%	$\frac{.70}{.70}$ = 100%	$\frac{.09}{.09}$ = 100%
CASE II. Ship A loses 6 Knots speed due to damage from 24 Knots in 3 minutes	$\frac{4.02}{5.74}$ = 70%	$\frac{.70}{1.00}$ = 70%	$\frac{.09}{.13}$ = 70%

C & D in G.A. Capt R&C. Sept 1932.

PLATE 22.

SUBMARINE DANGER AREA CARD.

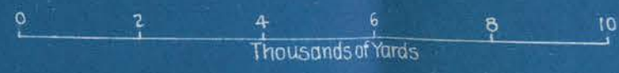
Ellipses are effective range loci with 25% overrun.
Battle Line - 4 BB in column.
Submarine Speed - 7 Kts.



Torpedoes

Type	Speed	Range
G(z)	46	6000
F	35	3500

Type G(z) & F carried by Red and Orange Submarines.
Type F carried by Red and Orange Aircraft.



Directions: Place this card with proper point on speed scale over leader of B.L. on Mooring Board and with course of B.L. along course of B.L. on Mooring Board, trace out danger areas for the particular type of torpedo and speed of B.L. under consideration

C.D.N.G.A. Capt R.B.C. Mch 1933

PLATE 23.

B&S-1180

TRIANGLES OF TORPEDO AND GUN FIRE

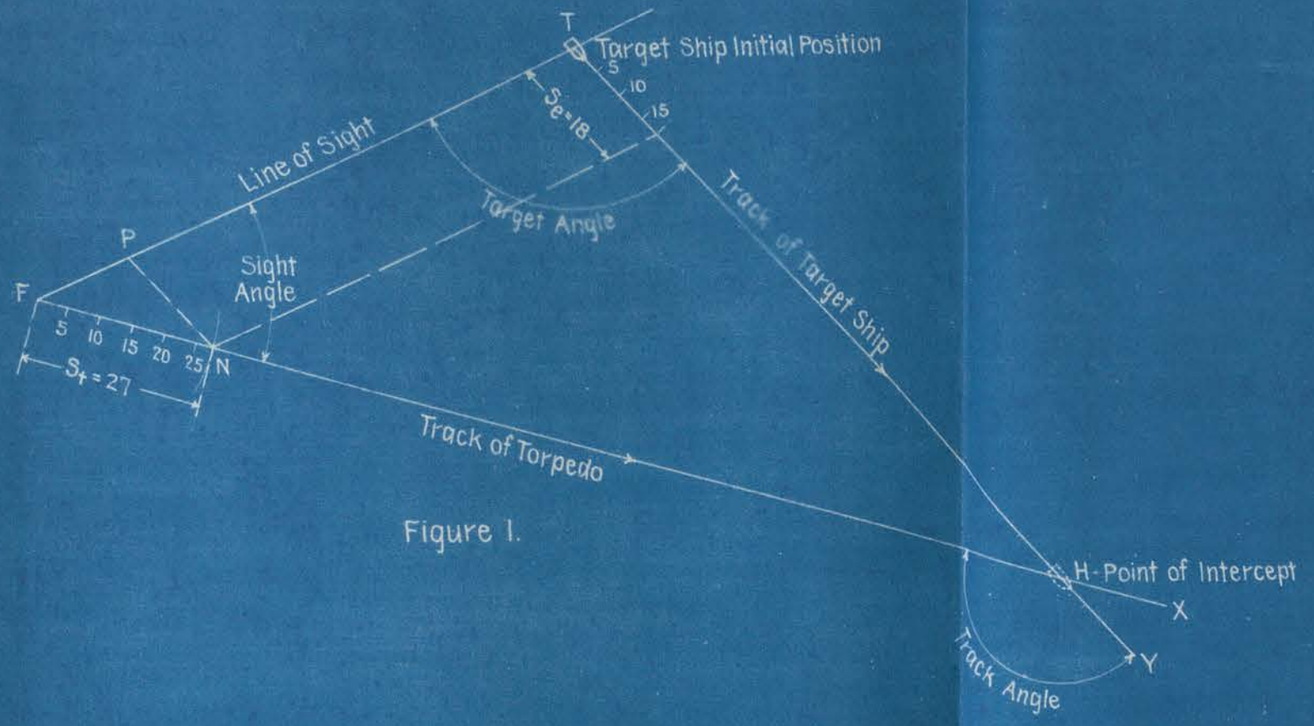


Figure 1.

Triangle of Torpedo Fire

Type C Torpedo

Torpedo Speed (S_t) = 27 kts.
Range = 13500 yards
Firing Range = 6725 yards
Time of Flight = 13.8 minutes (828 seconds)
Run of Target Ship = 8274 yards

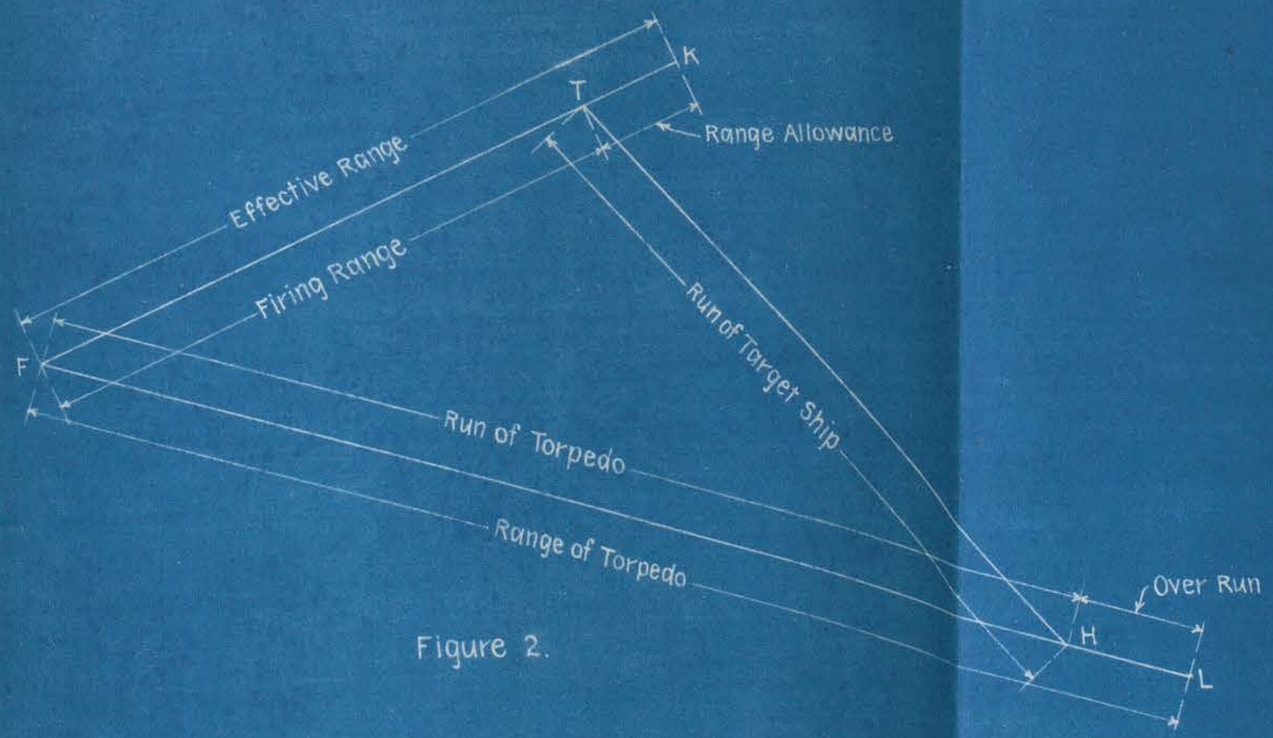


Figure 2.

Triangle of Gun Fire

14"/45 gun

Average speed of Shell = 1,443 kts.
Range = 33,000 yards
Firing Range = 6725 yards
Time of Flight = 8.34 seconds
Run of Target Ship = 83.4 yards

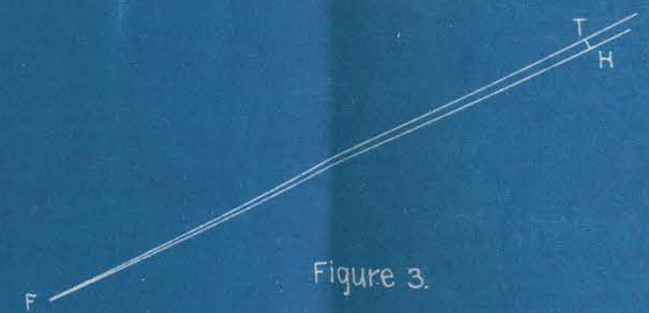
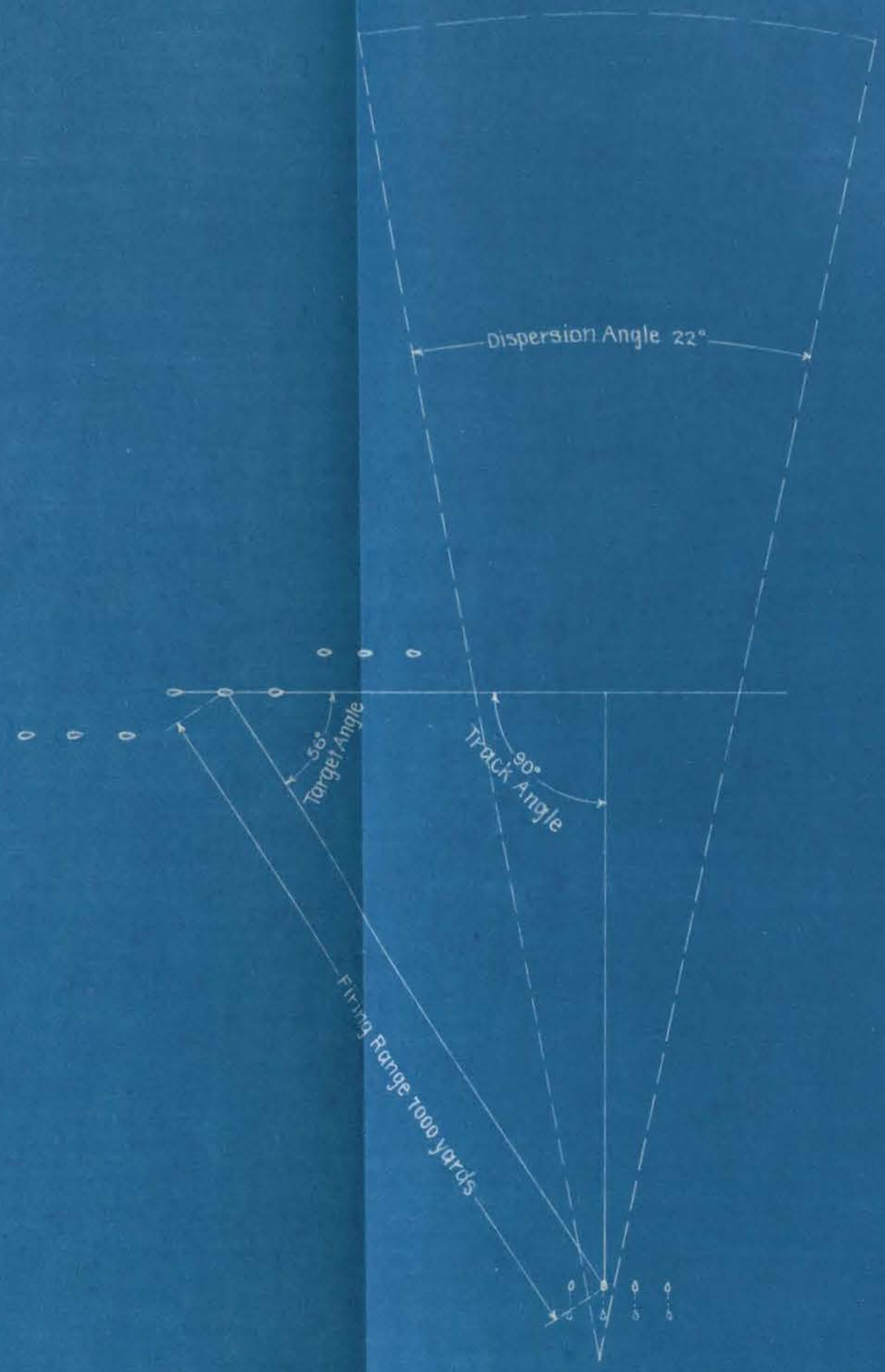


Figure 3.

PLATE 24

B.33-34.5

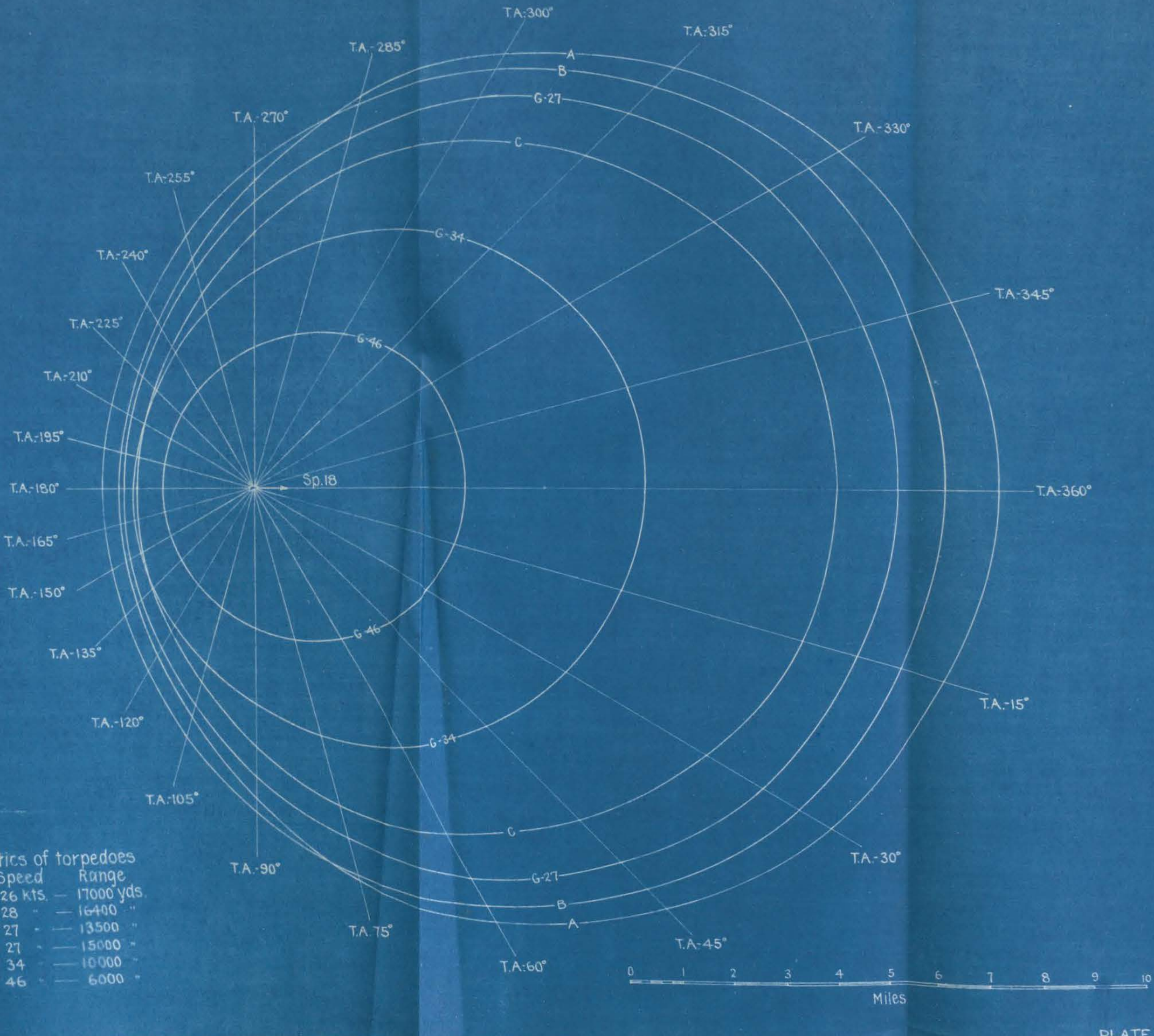
THE BEST TARGET ANGLE



Assumed target speed (S_e) = 18 kts.
Assumed target course = 90°
Torpedo speed (S_t) = 27 kts
Torpedo range = 13500 yards

$\tan^{-1} \frac{S_t}{S_e} = 56°$

LOCI OF EFFECTIVE TORPEDO RANGES



Characteristics of torpedoes

Type	Speed	Range
A	26 kts.	17000 yds.
B	28 "	16400 "
C	27 "	13500 "
G-27	27 "	15000 "
G-34	34 "	10000 "
G-46	46 "	6000 "

"CAL-TEA" Capt R.E.E. Sept 1932

PLATE 26

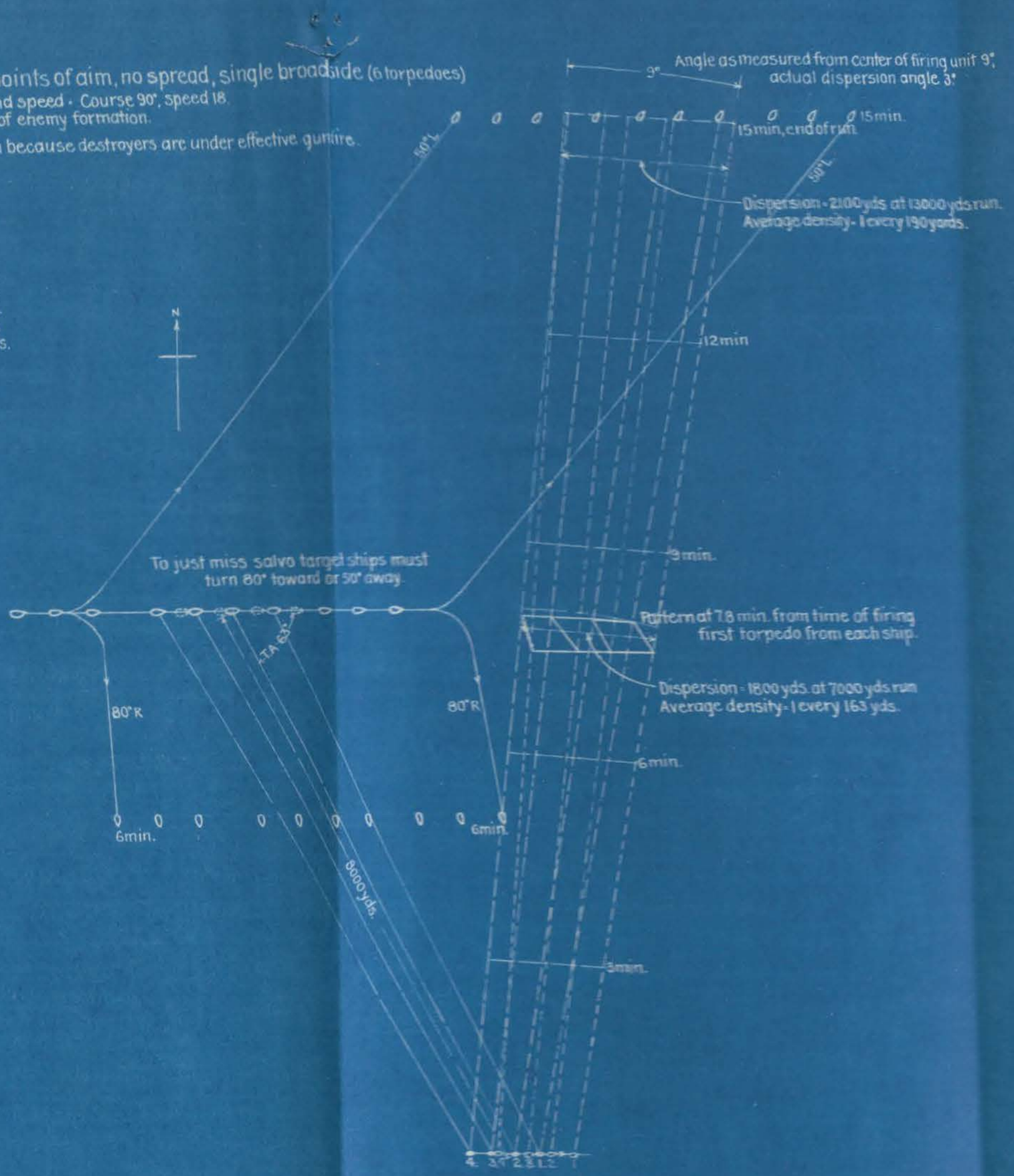
SALVO FIRING WITH SMALL DISPERSION.

Salvo firing, individual points of aim, no spread, single broadside (6 torpedoes)

Enemy sight bar course and speed - Course 90°, speed 18.
Target - Middle four ships of enemy formation.

Half of torpedoes fail to run because destroyers are under effective gunfire.

Firing ships speed - 30 Kts.
Targets speed - 18 Kts.
Firing period - 30 sec.
Torpedo Speed - 27 Kts.
Torpedo range - 13,500 yds.



C.A.D. in G.A. Capt R.B.C. Sept 1932

PLATE 27

SALVO FIRED WITH LARGE DISPERSION

Salvo fired in accordance with
"Tactical Employment, Destroyers, U.S. Fleet, 1932."

Twelve torpedoes fired from each destroyer by curved fire ahead.
Enemy sight bar course and speed - Course 90°, Speed 18.
Target - leading half of enemy formation.
Points of dim as shown
Salvo offset 10° towards target's rear.
One half of torpedoes fail to run because destroyers are under effective fire.

Firing ships speed - 15 Kts.
Target speed - 18 Kts
Firing period - 30 sec.
Torpedo speed - 27 Kts.
Torpedo range - 13,500 yds.

SQUADRON FIRING
(Divisions firing as in Plate 27)

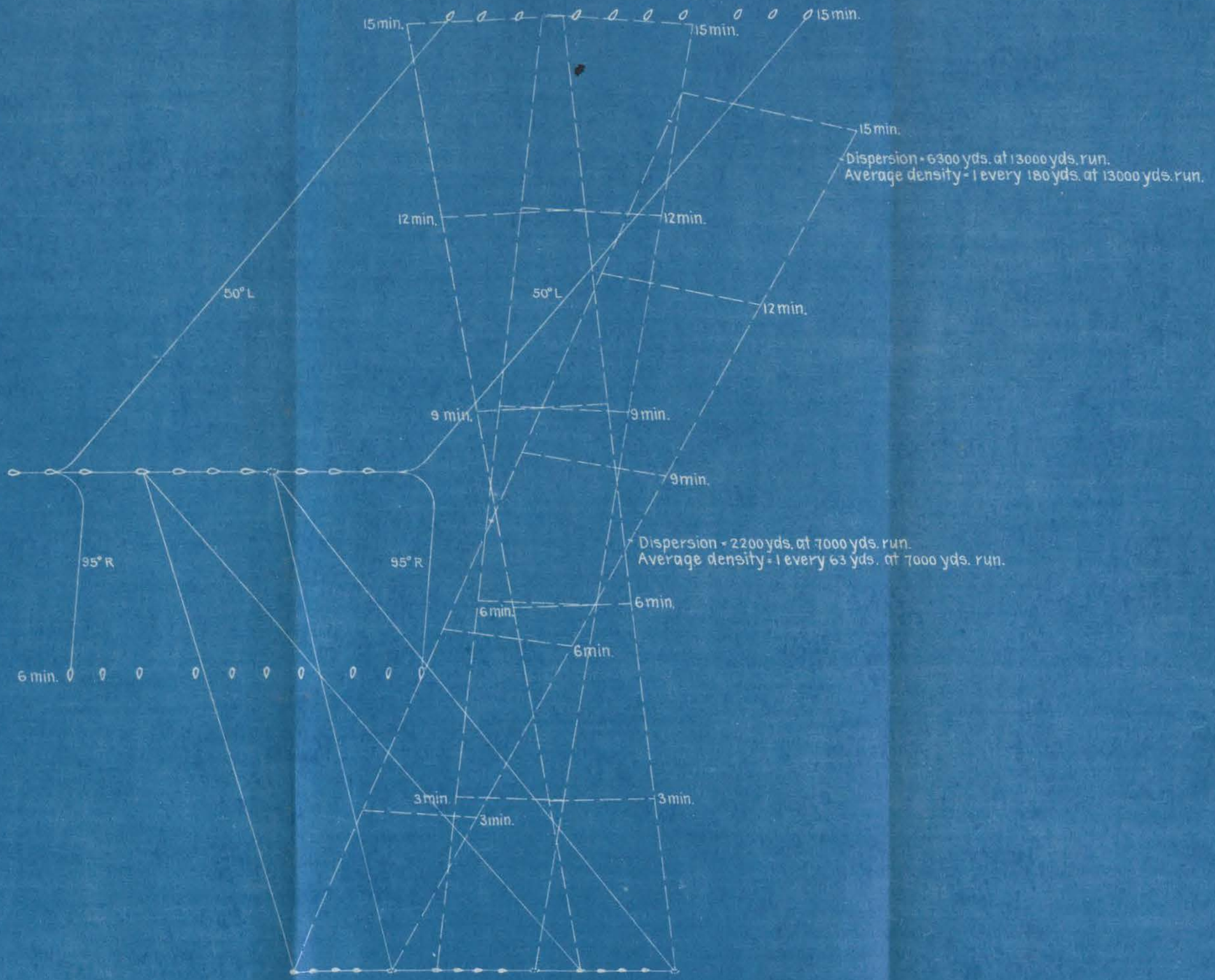


PLATE 29

B33-350

CASE I.

A commander who shall have so disposed of his force, that no one division or part can be attacked, without a possibility of being immediately supported by the whole, or at least by some other part, has taken not only the first precaution to prevent a defeat, but also has taken the first step to obtain a victory.

CASE II.

The commander who, in leading on his force, shall make his attack with great superiority, upon any one division or part of his enemy, and while this division shall be posted so as it cannot be supported, has, in like manner, not only taken the first step to obtain a victory, but also has laid hold of the first precaution to secure a retreat, should it ever be necessary.

CASE III.

Hence, on the other hand, and in opposition to CASE I, should ever a commander have so disposed of his force, that any one division or part may be attacked, by a great superiority, without a possibility of having it supported by the whole, or by any one part of his remaining force, that commander must be defeated.

CASE IV.

Hence also, in reverse of CASE II, a commander who, by the mode of his attack, shall so dispose of his force, that any one division or part, difficult to be supported, shall be exposed to his enemy when greatly superior, suppose it a cannonade greater, by many degrees, than he can bring up to oppose it, such commander undoubtedly will be worsted.

MODERN FACTORS OF FIRE ACTION

I

FACTORS WHICH ARE WHOLLY IN IN OUR HANDS TO USE

Own formations
Own maneuvers
Own speed
Own course
Own method and lay of fire control
Own selection of targets
Distribution of own fire
Own target obliquity presented
Own time of opening fire
Own batteries to fire
(main and/or secondary)
Own expenditure of ammunition
Own guns bearing

II

FACTORS WHICH ARE ONLY PARTIALLY IN OUR HANDS TO USE

Range bands to use
Priority of fire
Kind of spot to use
Rate of change of range
Effects of spray
Effects of smoke and gas
Effects of sunglare
Effects of roll, pitch, and yaw
Effects of silhouette
Own ship or target under enfilade
Surprise fire

III

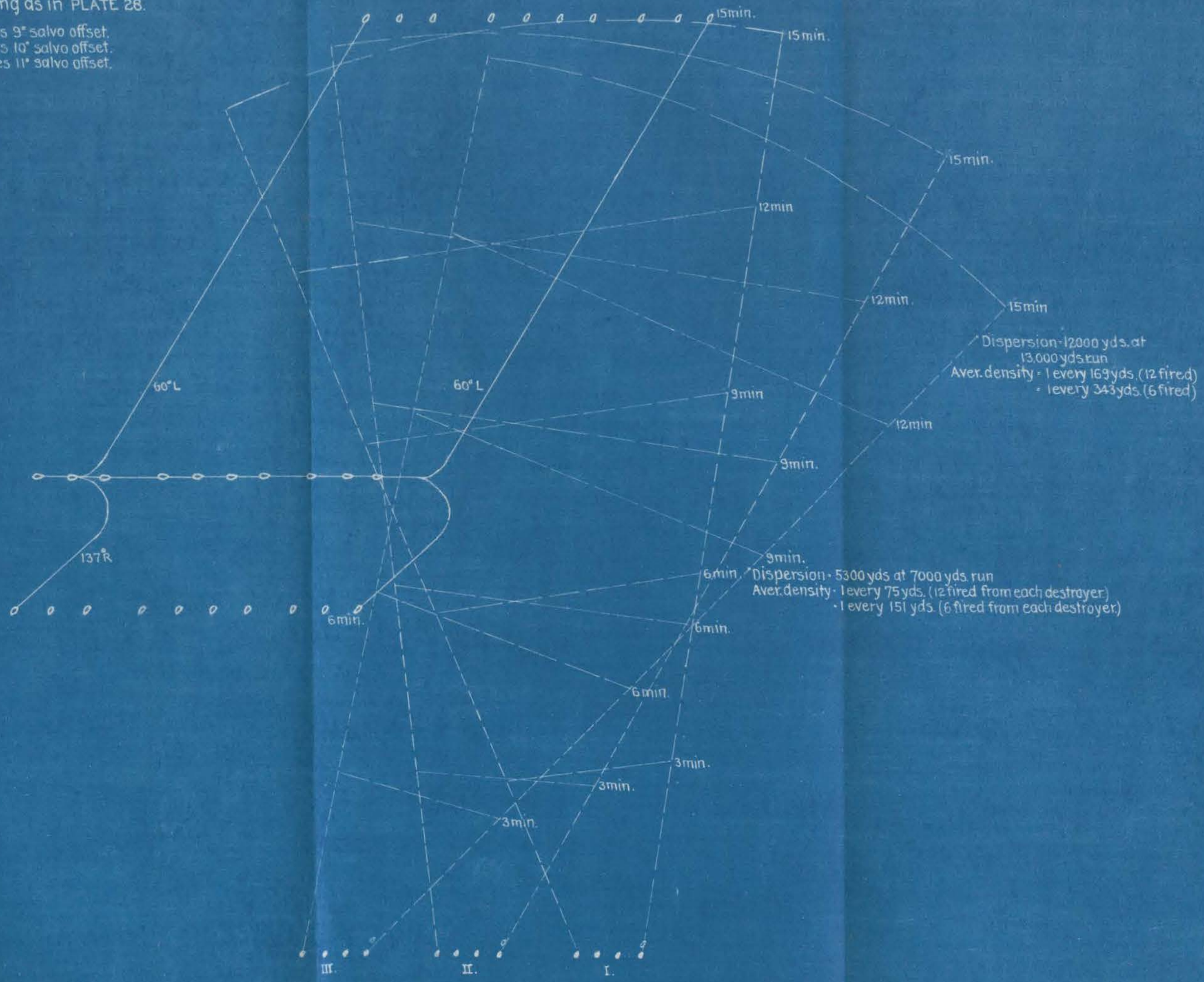
FACTORS ENTIRELY OUT OF OUR HANDS TO CONTROL

Course and speed of target
Visibility conditions
Own ship damaged
Enemy's fire distribution

SQUADRON FIRING

Divisions firing as in PLATE 28.

Div. I uses 9° salvo offset.
Div. II. uses 10° salvo offset.
Div. III. uses 11° salvo offset.



Dispersion - 12000 yds. at 13,000 yds. run
Aver. density - 1 every 169 yds. (12 fired)
- 1 every 343 yds. (6 fired)

Dispersion - 5300 yds at 7000 yds. run
Aver. density - 1 every 75 yds. (12 fired from each destroyer)
- 1 every 151 yds. (6 fired from each destroyer)

C&D, in G.A. Capt. RBE. Sept 1932.

PLATE 32.
B.33-353

THE MAJOR DESTROYER ATTACK AT THE BATTLE OF JUTLAND.

Time - 1925 to 1935.

German Attack Units.

Half Flotilla XI. (4 boats) fired 11 torpedoes at about 1926. Firing range about 5500 yds. T.A.-85°
Average density at target is 1 every 500 yards. Two destroyers damaged.

Flotilla IX. (9 boats) fired 20 torpedoes at about 1927. Firing range about 6000 yards. T.A.-75°
Average density at target is 1 every 200 yds. One destroyer sunk, two damaged.

British notes.

19 torpedoes were reported sighted, of which 13 are definitely located as shown.
The remaining 6 were sighted by the 4th. L.C.S. and may have been identical with some of the 13. Percentage which reached target line - 42%. Speed of target - 15 Knots.
Hits - 0.

5th. B.S.

9th. & 10th. Flots.

12th. Flot.

13th. Flot.

Agincourt
Hercules
Revenge
-6th-
Marlborough

20 torpedoes fired by Flotilla IX (9 boats) about 1927.

13½°

11 torps. fired by H.F.XI. (4 boats) about 1926.

9°

St Vincent
-5th-
Neptune
Collingwood
Colussus

Vanguard
Temeraire
-4th-
Bellerophon
Benbow
Canada
Superb
-3rd-
Royal Oak
Iron Duke

2nd. Batdiv.

1st. Batdiv.

4th. Flot.

11th. Flot.

2nd. C.S.

Von der Tann
Moltke
Seydlitz
Derfflinger
Regensburg
Flots. II, IX, H.F. XI

II

4th. L.C.S.

3rd. L.C.S.

1st. L.C.S.

Batcrudivs

TRUE

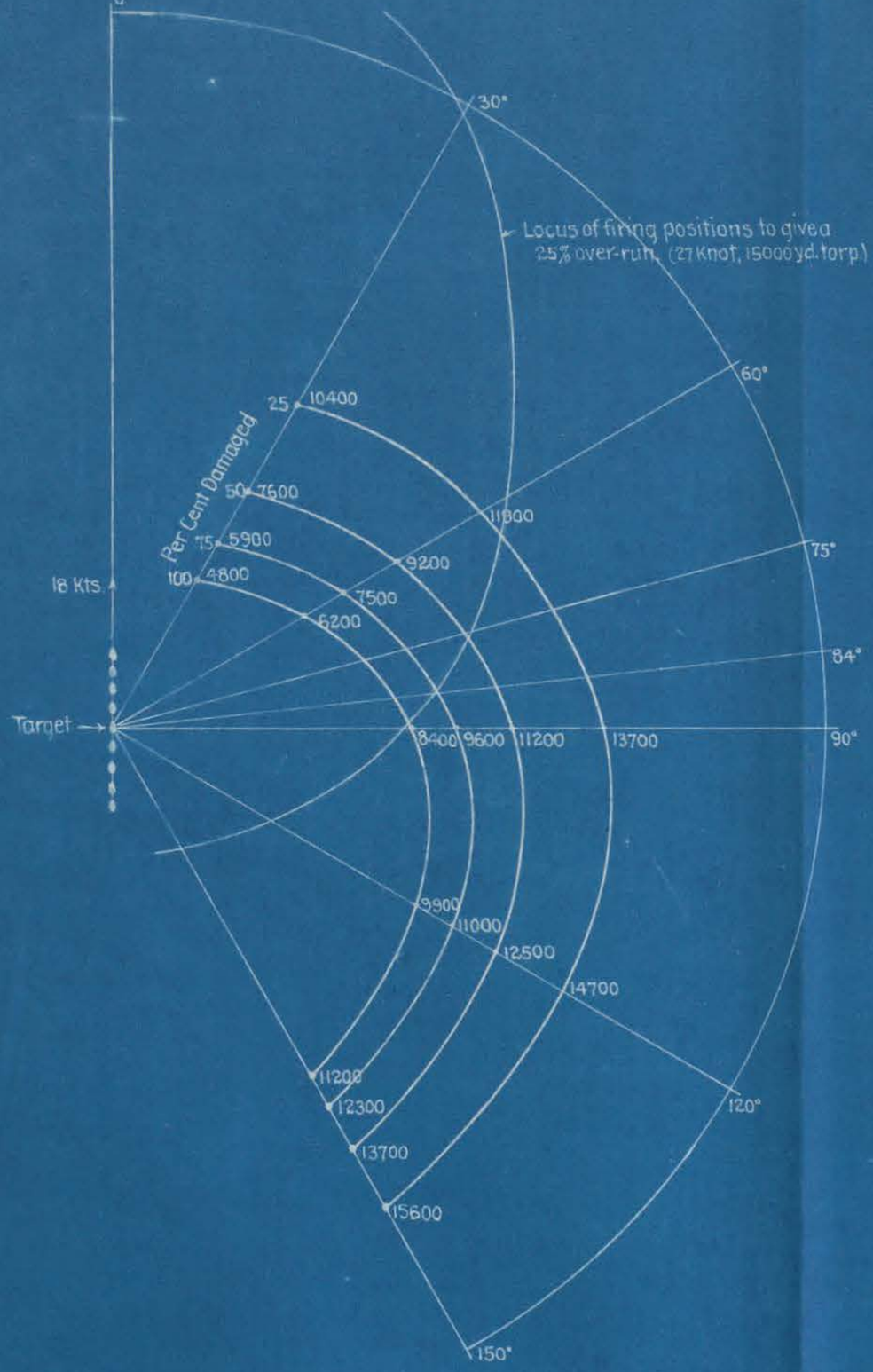
Light Breeze

0 1 2 3 4 5 6 7 8
Thousands of Yards.

C.B.D.M.G.A. Capt. A.B.C. Oct. 1932.

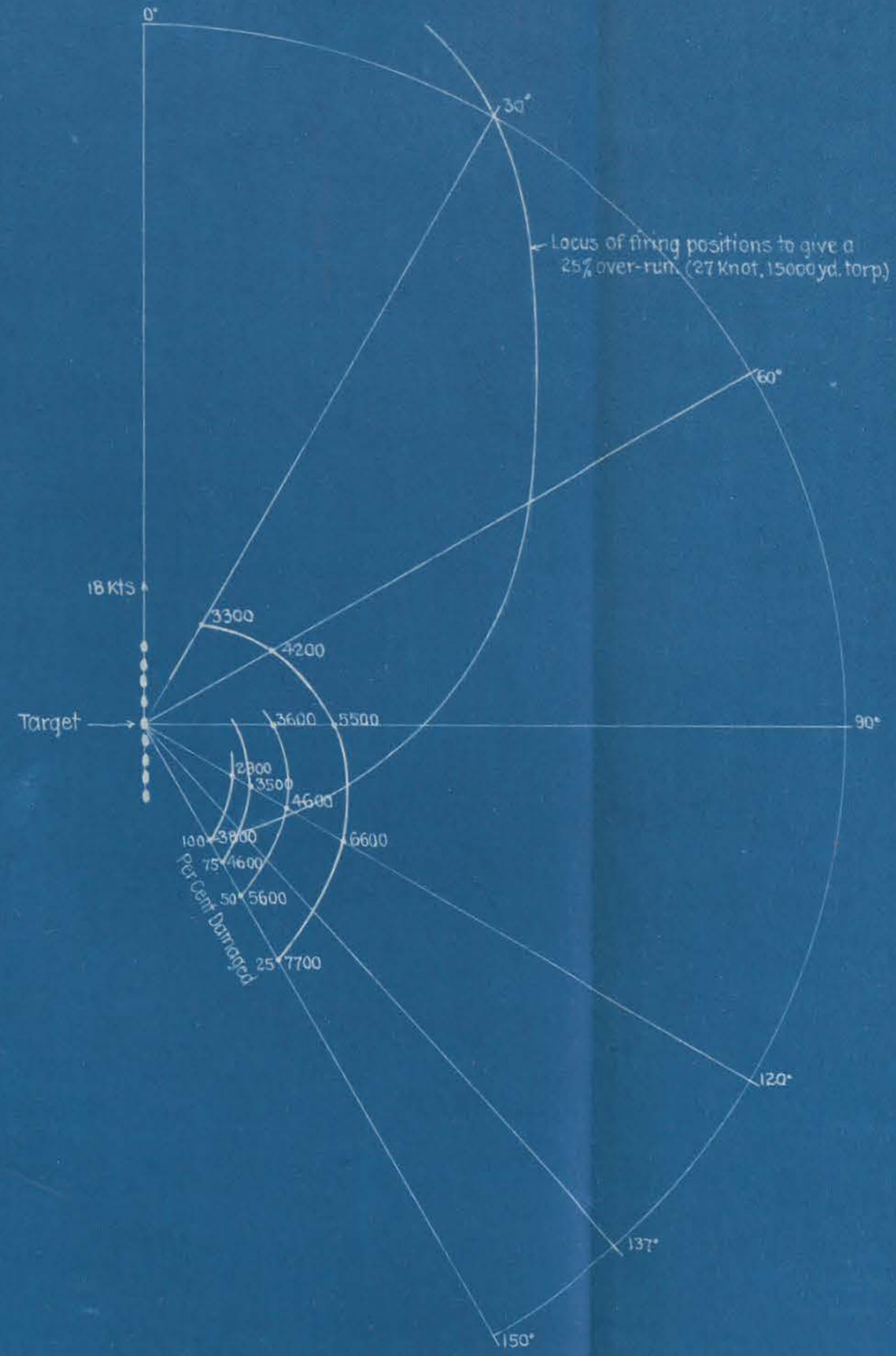
PLATE 33

MAIN AND SECONDARY BATTERY OF BATTLESHIPS ON ATTACKING DESTROYERS.



Main Battery - 3 BBs - 36-14"/45 guns on 1 Destroyer Squadron, 12 DD - life 1.3 each.
Conditions assumed:- DDs attack on collision courses, DD speed 30 Kts. Battle line speed 18 kts. BBs under normal fire

Figure A.



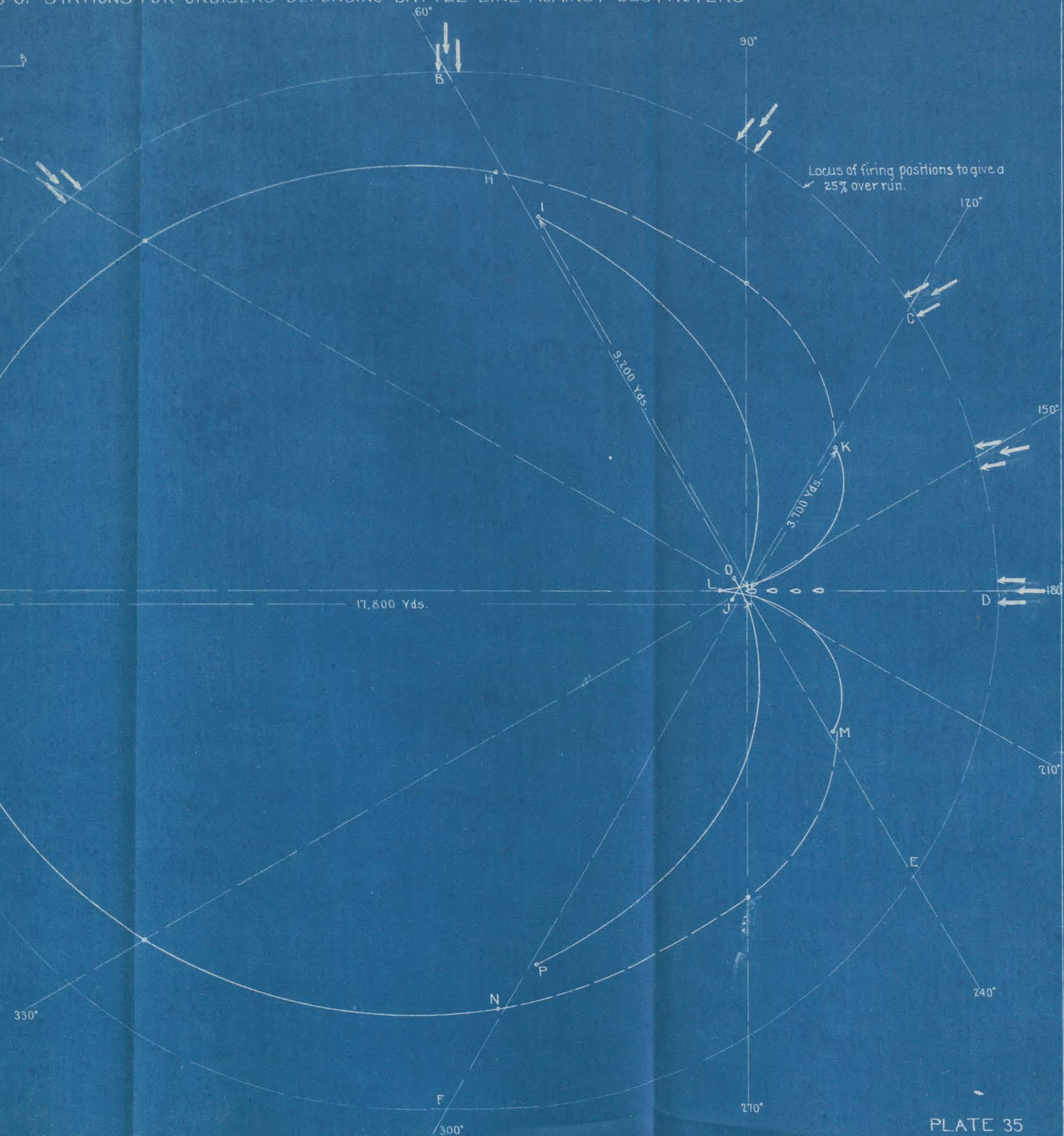
Secondary Battery - 9 BBs on 1 Destroyer Squadron - 12 DD
Conditions Assumed: DDs attack on collision courses, DD speed 30 kts. Battle line speed 18 kts. Main Battery engaged. Rate of change of range penalty applied. Broadside of each BB - 6-5"/51. No over-concentration. BBs under normal fire.

Figure B.

PLATE 34.

B33-1182

TYPE LOCUS OF STATIONS FOR CRUISERS DEFENDING BATTLE LINE AGAINST DESTROYERS



Attacking Force

Orange CL_{20} and 12 Oboros (DL). Speed 30 Kts. Course to intercept leader of B.L. (collision course). Type G torpedoes (27 Kts. 15000 yds). Must reach ABCDEF to fire torpedoes to hit B.L with 25% over-run

Battle Line

4BB in column on course West, speed 18 Knots

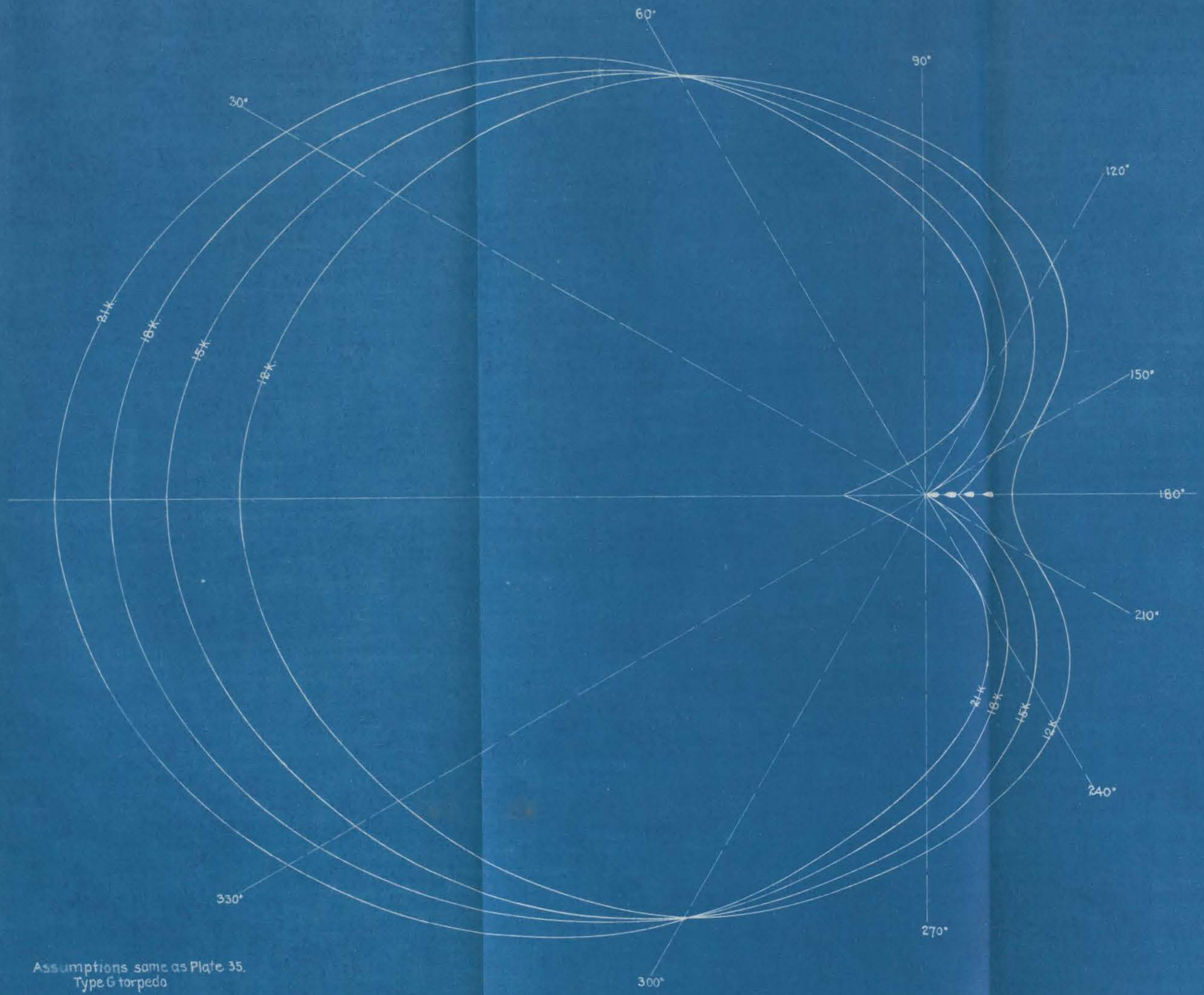
Target Angle	0° to 60° (360° to 300°)	60° to 120° (300° to 240°)	120° to 180° (240° to 180°)
Attacking Force	Bow fire for 1CL and ⅔ of DL only. No other ships fire guns.	Broadside fire for 1CL and ⅔ of DL only. No other ships fire guns.	Bow fire for 1CL and ⅔ of DL only. No other ships guns fire.
Defending Force	4 Omahas interposed between B.L. and Attacking force and use broadside fire. NGH is locus of distances from leader of B.L. for 4 Omahas to damage Attacking Force 70% by the time it reaches FAB. Fire opened at 15,000 yards.	6 Omahas interposed between B.L. and Attacking Force and use broadside fire. IJ-PO- locus of distances from leader of B.L. for 6 Omahas to damage Attacking Force 70% by the time it reaches BC, or FE respectively. Fire opened at 15,000 yds.	3 Omahas interposed between B.L. and Attacking Force and use broadside fire. KLM is locus of distances from leader of B.L. for 3 Omahas to damage Attacking Force 70% by the time it reaches CDE. Fire opened at 15,000 yards.

Gunfire calculations by Lt. Comdr. R. L. Conolly, U.S.N.

PLATE 35

B.33-1183

LOCI OF STATIONS FOR CRUISERS DEFENDING BATTLE LINE AGAINST DESTROYERS WHERE BATTLE LINE HAS VARIOUS SPEEDS.

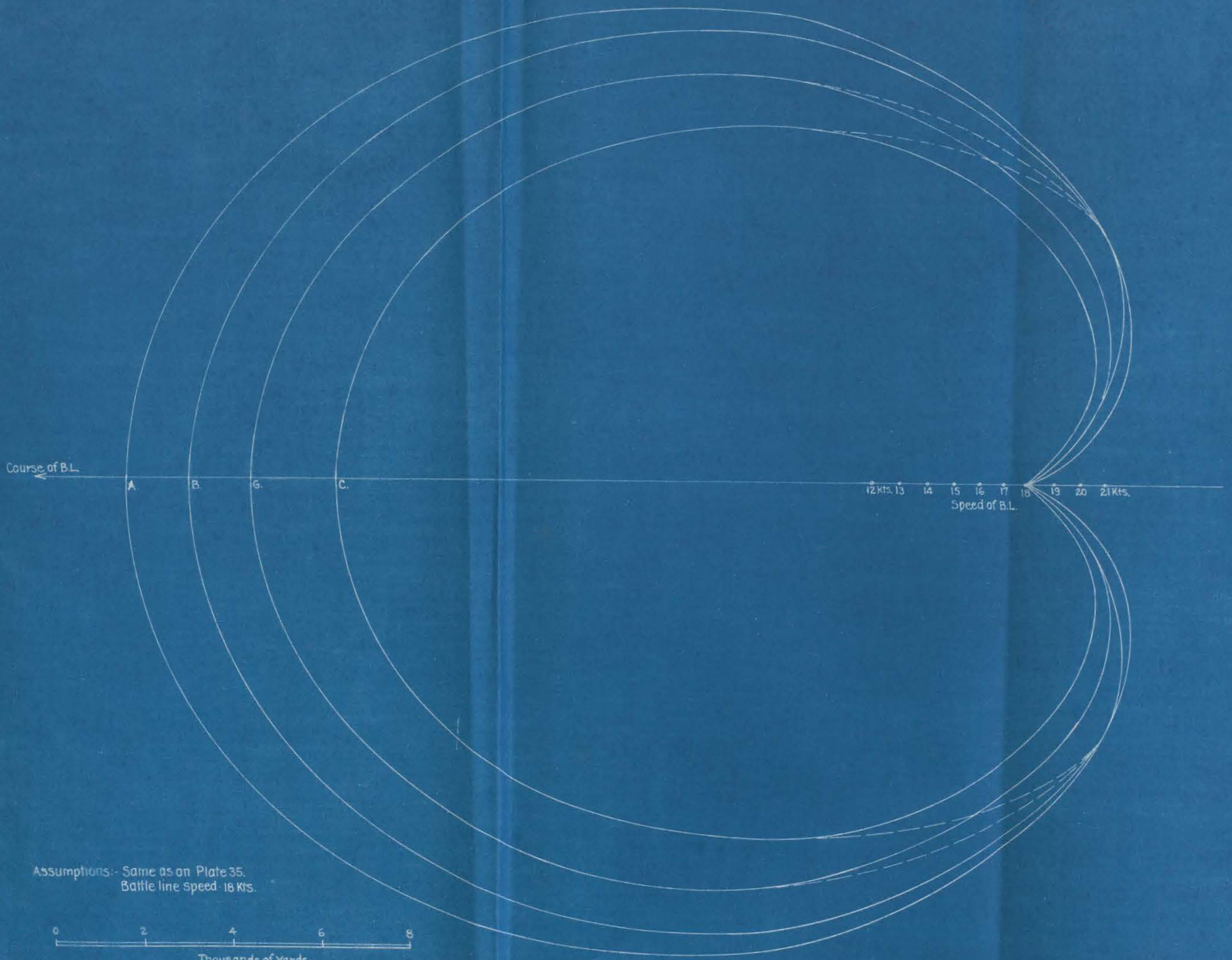


Assumptions same as Plate 35.
Type G torpedo

0 2 4 6 8
Thousands of Yards

PLATE 36.

LOCI OF STATIONS FOR CRUISERS DEFENDING BATTLE LINE AGAINST DESTROYERS WHERE DIFFERENT TYPES OF TORPEDOES ARE USED BY DESTROYERS.



Assumptions:- Same as on Plate 35.
Battle line speed 18 Kts.

0 2 4 6 8
Thousands of Yards.

C.& D. in C. Capt. R.E. Dec. 1912.

PLATE 37.

LOCI OF CRUISER STATIONS TO DEFEND BATTLE LINE AGAINST DESTROYERS.
(APPLE CARD)

Example:

B.L. of 12 BB (3 divs) on course 65°, speed 14 Knots, in Battle Formation 30° Right. Where should Blue Omahas be stationed to stop 24 Orange DL in time, approaching to intercept on target angles 20°, 80° or 130°. How many Omahas are required in each case?

Solution:

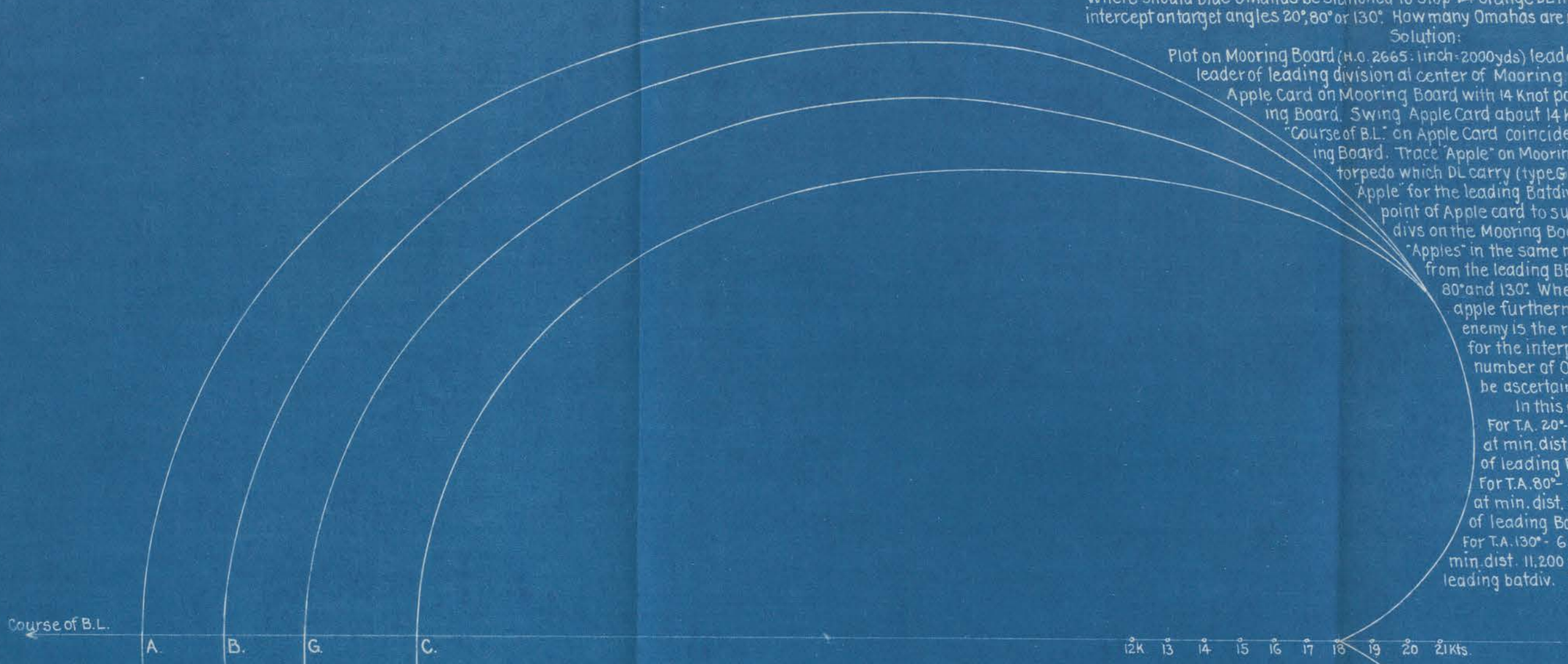
Plot on Mooring Board (H.O. 2665: 1 inch-2000 yds) leaders of batdivs with leader of leading division at center of Mooring Board. Superpose Apple Card on Mooring Board with 14 Knot point at center of Mooring Board. Swing Apple Card about 14 Kt point as pivot until "Course of B.L." on Apple Card coincides course 65° on Mooring Board. Trace "Apple" on Mooring Board for type of torpedo which DL carry (type G in this case) This is the "Apple" for the leading Batdiv in column. Shift 14 kt. point of Apple card to successive leaders of Batdivs on the Mooring Board and draw in their "Apples" in the same manner. Then draw lines from the leading BB at target angles 20°, 80° and 130°. Where these lines cut the apple furthermost out toward the enemy is the recommended station for the interposing Omahas. The number of Omahas required will be ascertained from the ratio table.

In this example:

For T.A. 20° - 8 Omahas interposed at min. dist. 14,500 yds. from leader of leading Batdiv.

For T.A. 80° - 12 Omahas interposed at min. dist. 11500 yds. from leader of leading Batdiv.

For T.A. 130° - 6 Omahas interposed at min. dist. 11,200 yds. from leader of leading batdiv.



Torpedoes

Type	Speed	Range
A	26	17000 yds.
B	28	16400 "
C	27	13,500 "
G	27	15000 "

Attacking Force

Orange DL, any speed, on collision course to intercept leader of B.L. Type of torpedo: A, B, G or C.

Defending Force

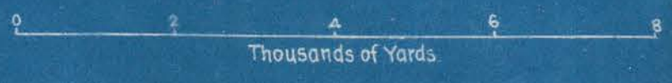
Omahas interposed between leader of B.L. and Attacking Force

Battle Line

4 BB in column at any speed, as per speed scale.

Ratio of Defending to Attacking Force to stop Attacking Force in time.

Target Angles	0° to 30° (360° to 330°)	30° to 120° (330° to 240°)	120° to 180° (240° to 180°)
Ratio	4 Omahas to 13 DL (or 7 DL & 12 DL)	6 Omahas to 13 DL	3 Omahas to 13 DL



These Curves are based on Plate 35.

PLATE 38.

B.33-1186

EFFECT ON CRUISER LOCUS BY A 30° TURN BY BATTLE LINE TOWARD ENEMY

A, B, C, D, E, F, G - Locus for Cruisers defending Battle Line in Battle Formation zero, course 270°, speed 18 kts., against Type G torpedoes.

H, I, J, K, L, M, N, - Locus for Cruisers defending Battle Line in Battle Formation 30° Right, toward enemy, on course 300°, speed 18 kts., against Type G torpedoes.

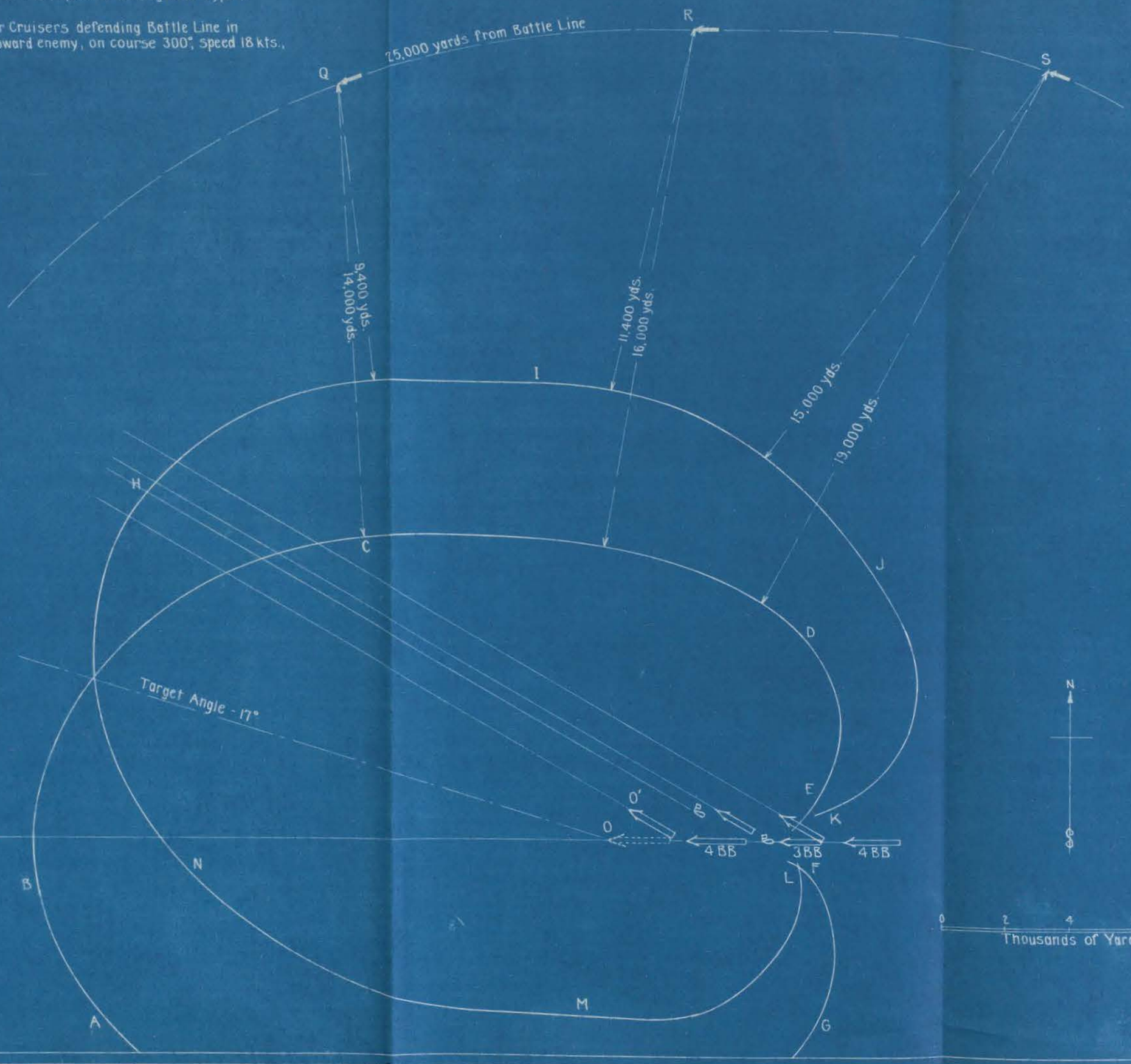
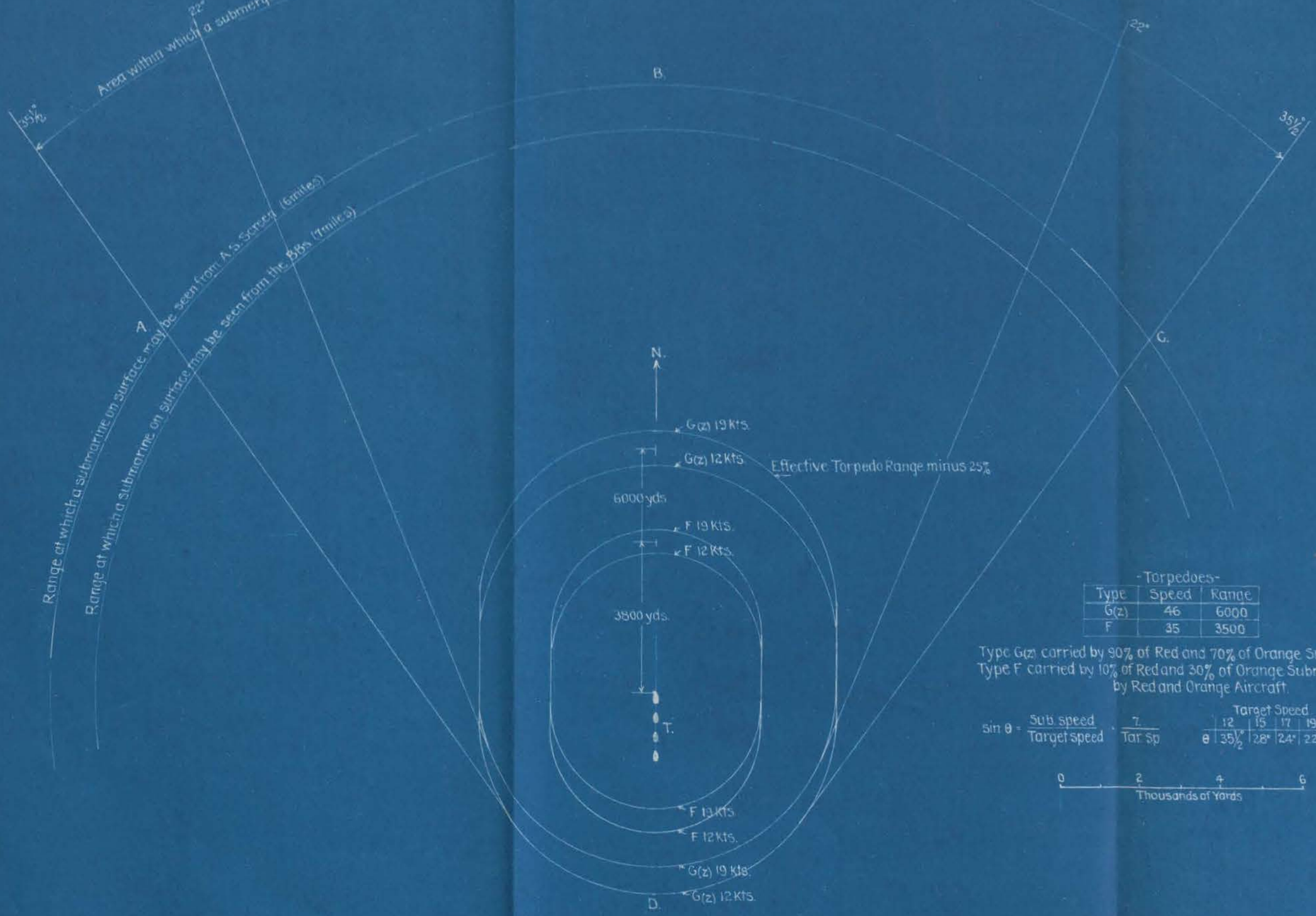


PLATE 39

SUBMARINE DANGER AREA

Area within which a submerged submarine, firing type G(z) torpedoes must be to be able to reach 'T' with his torpedoes. 'T' speed 12 to 19 kts. 'T' course - N.



- Torpedoes -

Type	Speed	Range
G(z)	46	6000
F	35	3500

Type G(z) carried by 90% of Red and 70% of Orange Submarines.
Type F carried by 10% of Red and 30% of Orange Submarines, also by Red and Orange Aircraft.

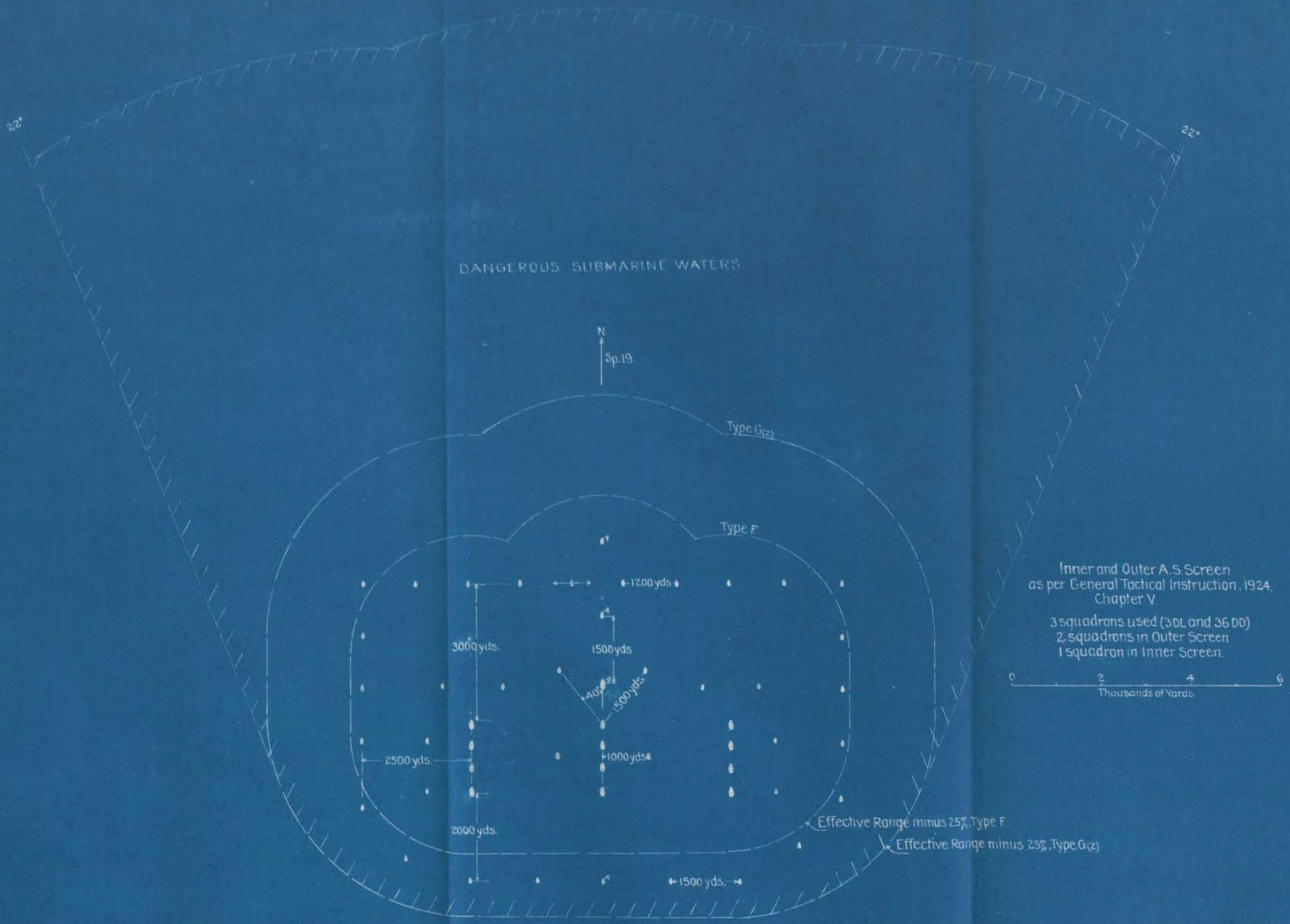
$$\sin\theta = \frac{\text{Sub speed}}{\text{Target speed}} \cdot \frac{7.}{\text{Tar Sp}}$$

Target Speed	12	15	17	19
θ	35½°	28°	24°	22°

0 — 2 — 4 — 6
Thousands of Yards

CADM G.A. Post R.B. Mch. 1933

ANTI-SUBMARINE SCREEN



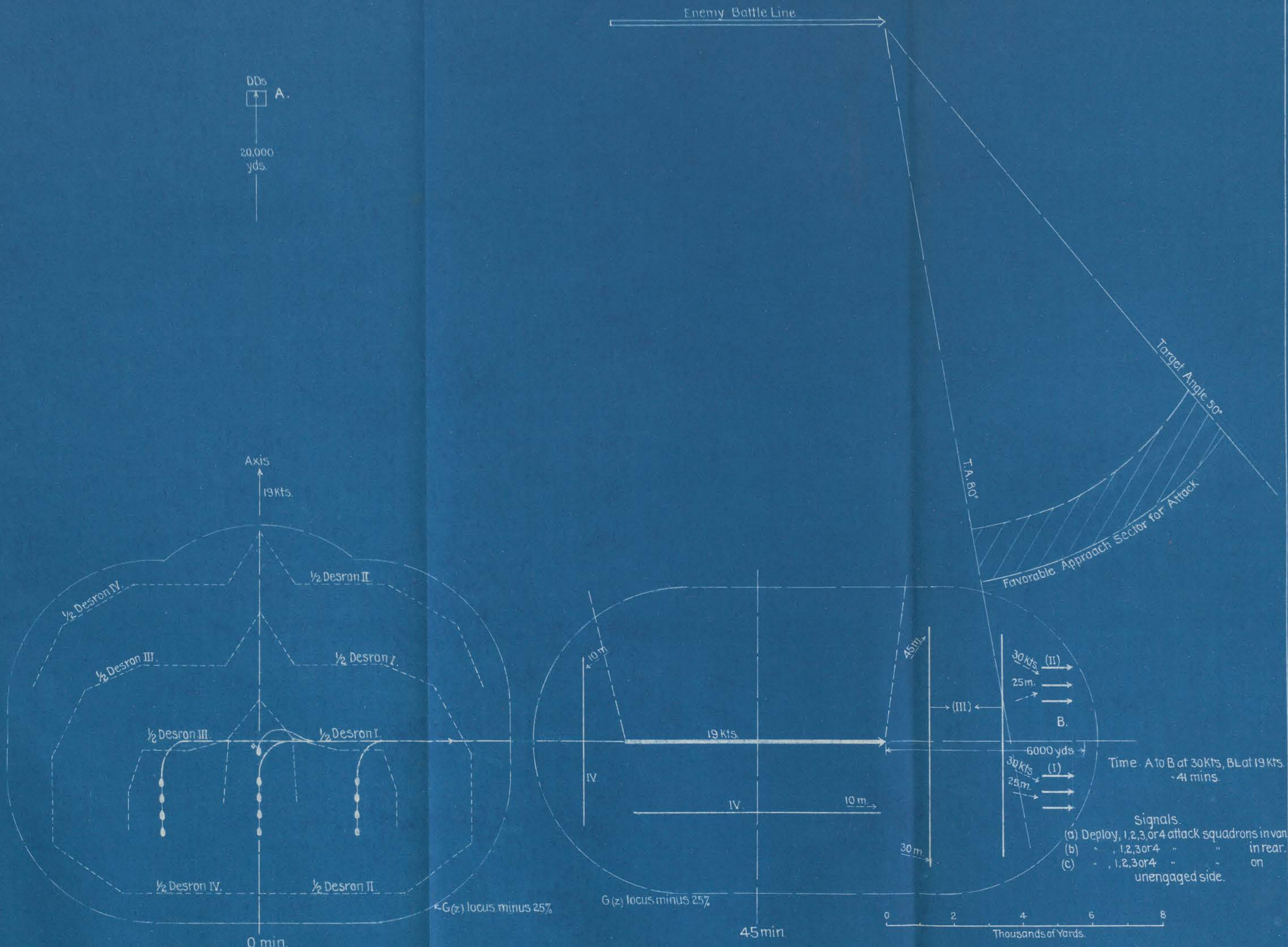
Inner and Outer A.S. Screen
as per General Tactical Instruction, 1924.
Chapter V.

3 squadrons used (3 DL and 36 DD)
2 squadrons in Outer Screen
1 squadron in Inner Screen.

0 2 4 6
Thousands of Yards.

PLATE 41.

ANTI-SUBMARINE SCREEN IN APPROACH AND DEPLOYMENT.



Time. A to B at 30 Kts, B L at 19 Kts. - 41 mins.

Signals.
(a) Deploy, 1,2,3, or 4 attack squadrons in van.
(b) " , 1,2,3 or 4 " " in rear.
(c) " , 1,2,3 or 4 " " on unengaged side.

PLATE 42.

B33-1190

LINES OF APPROACH FOR DESTROYER ATTACK.

T.A. 80°

T.A. 67° K

T.A. 61° G

T.A. 120° L

T.A. 130°

T.A. 51° J

50°

Most favorable arc in which to approach against light force opposition.

G to H - 12.4 mins. collision course to 6000 yds. T.A. 61°

G to I same to 5000 yds. T.A. remains same

T.A. 33° - best target angle from which to approach to the predetermined firing position of T.A. 61° and firing range of 6000 yards, to arrive in quickest time.

Arc EC includes all best target angles from which to approach this predetermined firing position from 20,000 to 30,000 yards with all probable speed ratios

T.A. 33° C

C to D - 10.8 mins. DD are steadily dropping aft in bearing

C to F - 10 mins. collision course to 6000 yds. T.A. remains 33°

L to M - 20 min. collision course to 6000 yards

T.A. 16° E

M

H.

I.

D'

D

Predetermined firing position
(T.A. 61° - $\tan^{-1}\frac{27}{15}$. Firing Range 6000 yds)

F.

T.A. 0° →

A to B - 9.3 minutes, collision course

A

B

Sp. 15

T.A. 0° - best target angle from which to approach to any predetermined firing range, without regard to T.A., to arrive in quickest time.

6000 yds. (Firing Range)

Apple Card for Type C torpedo

20,000 yds

N

Speed of Target - 15 Knots, course - west.
Speed of Destroyer - 30 Knots.

0 2 4 6 8
Thousands of Yards.

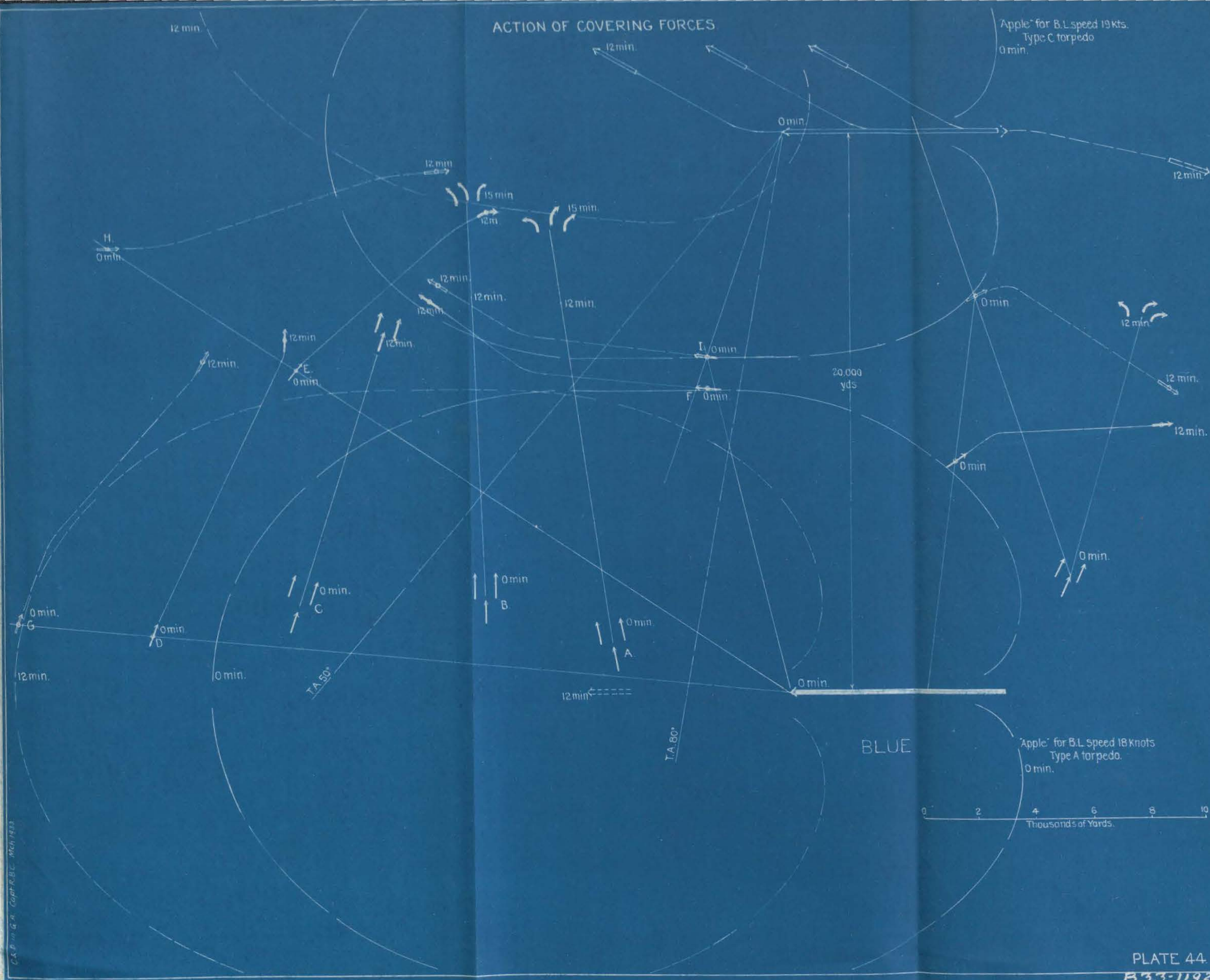
PLATE 43.

B330/191

ACTION OF COVERING FORCES

"Apple" for B.L. speed 19 kts.
Type C torpedo

"Apple" for B.L. speed 18 Knots
Type A torpedo.



C.D. in G.A. Copt. R.B.C. March 1933

PLATE 44.

B33-1192

SMOKE SCREENS.

Case I. Blue engaging Red.

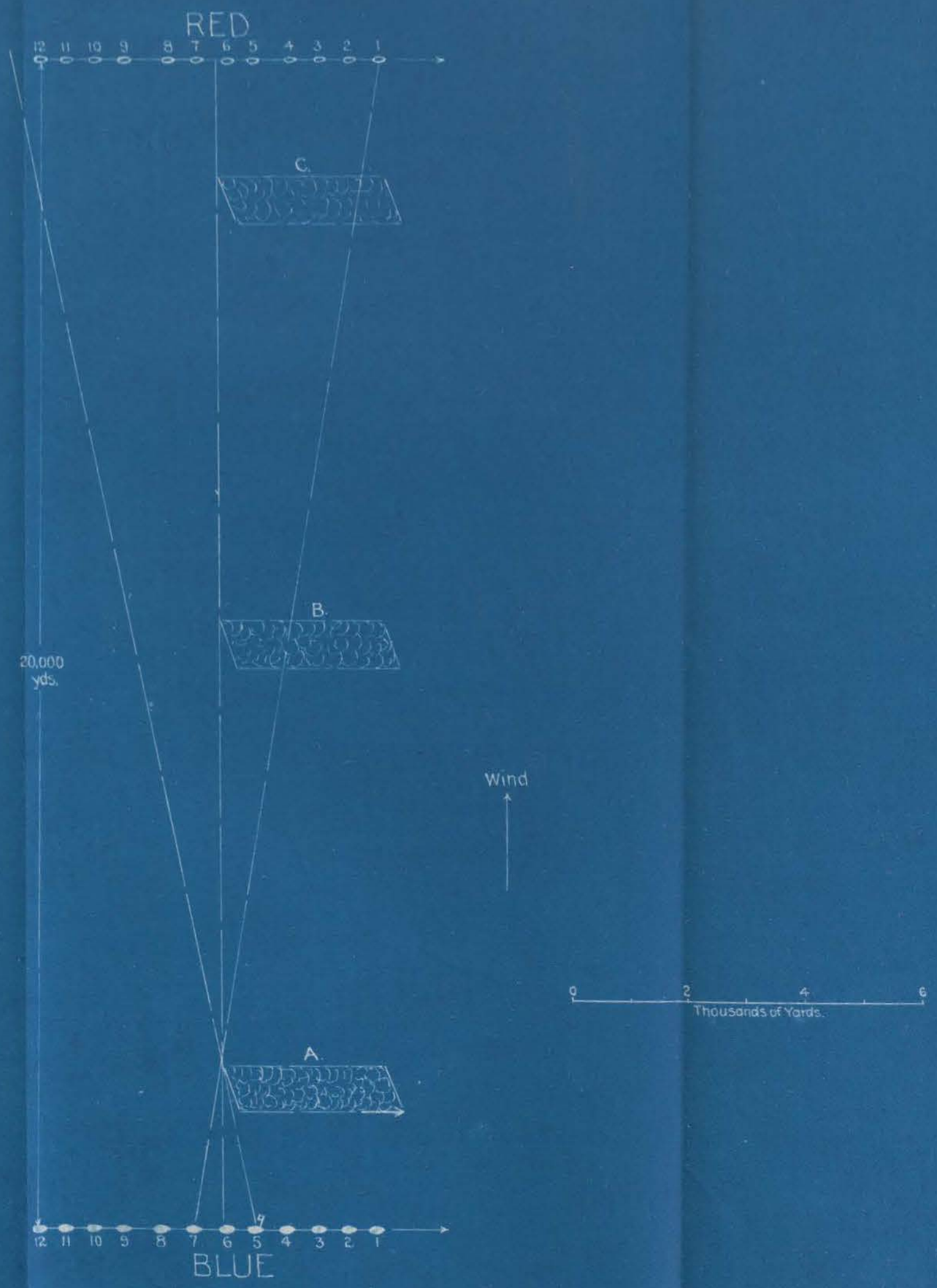
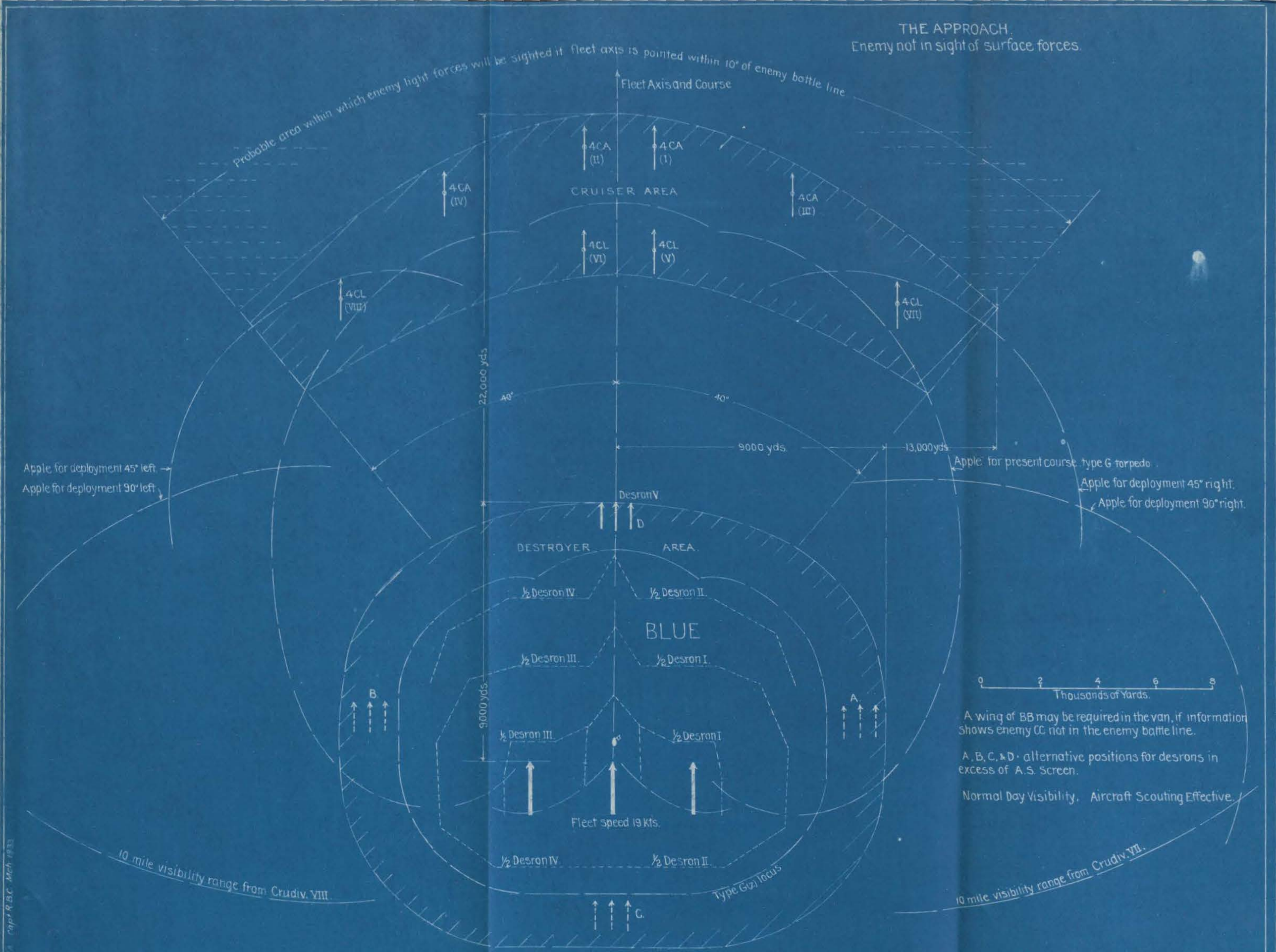


PLATE 45.

THE APPROACH.
Enemy not in sight of surface forces.



A wing of BB may be required in the van, if information shows enemy CC not in the enemy battle line.

A, B, C, & D · alternative positions for desrons in excess of A.S. Screen.

Normal Day Visibility. Aircraft Scouting Effective.

PLATE 46.

THE APPROACH

Fleet Axis 45° to right of Fleet Course.

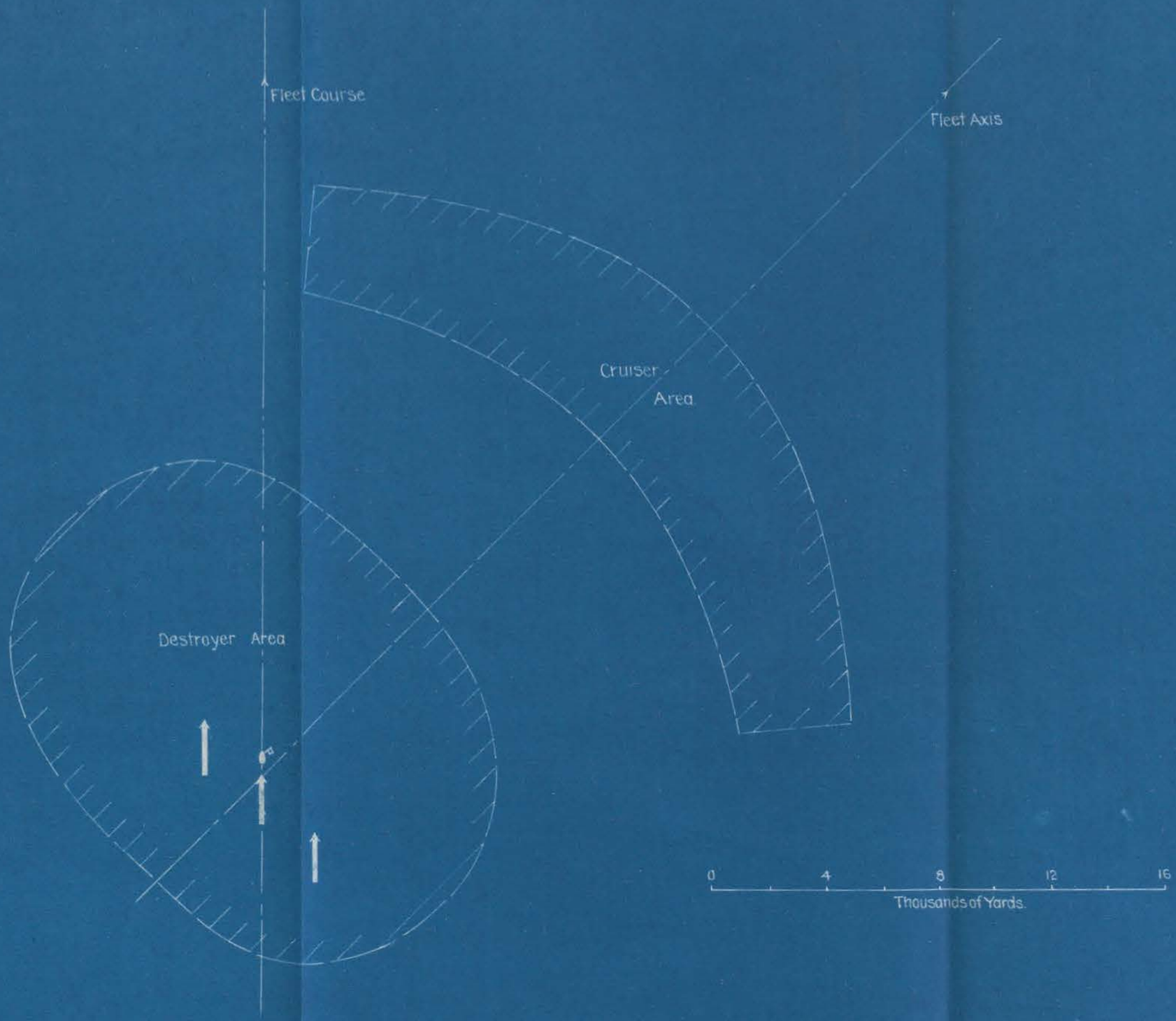


PLATE 47.

B33-1195

THE BATTLE

Blue superior to Orange in Cruisers and Destroyers

Note: Orange disposed as per F.D. and B.P. 1930 (revised)
Blue disposed as per C.&D. in G.A.

Blue B.L. has freedom to slow, and freedom to change course to any direction except into the arc between 45° toward and 150° toward. Otherwise he is practically immune from surface torpedo attack.

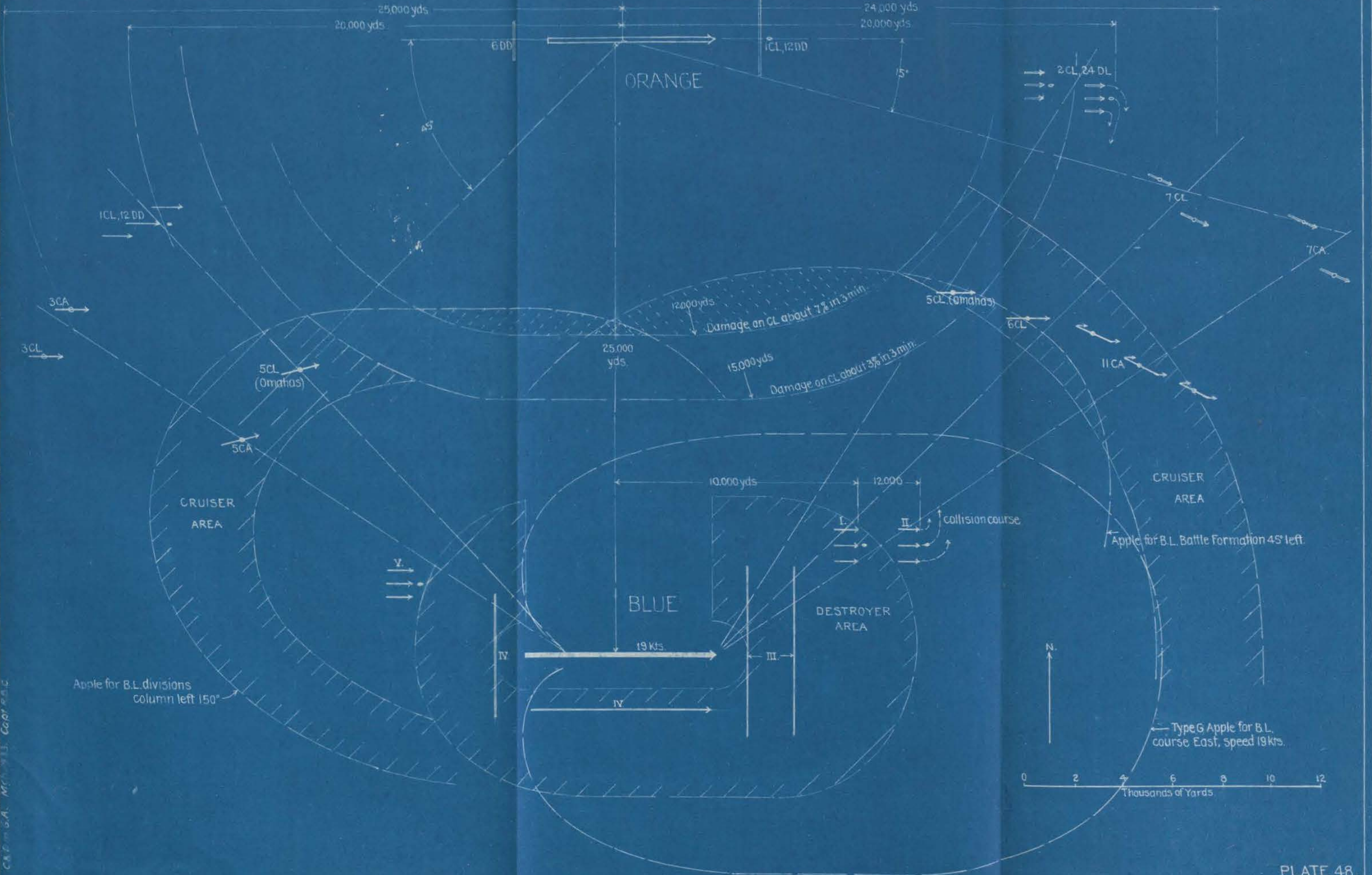


PLATE 48.

THE BATTLE.

Blue inferior to Red in Cruisers and Destroyers.

Initial positions are for 1648, Tac. Prob. IV. 1933, Sr.

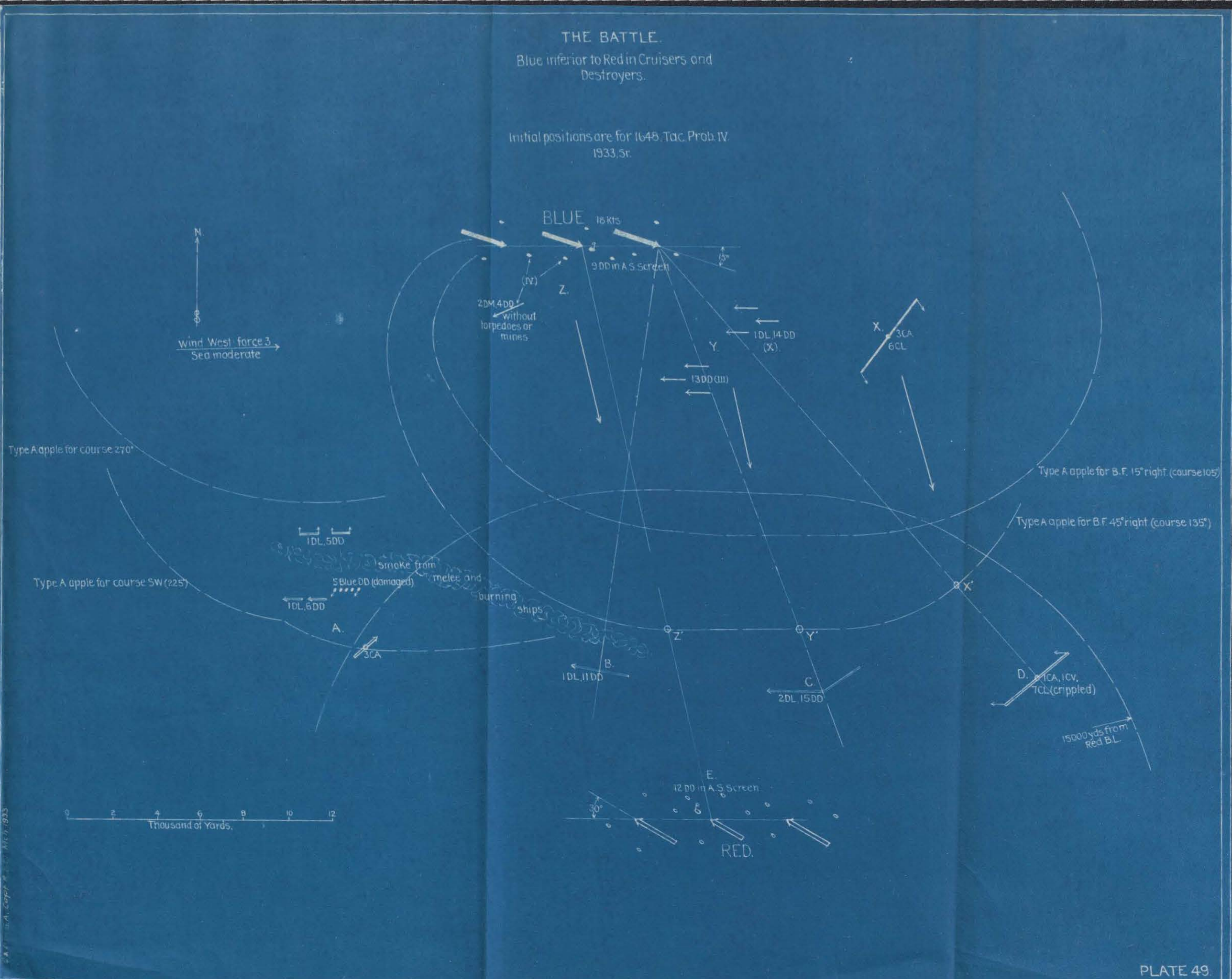


PLATE 49.

SMOKE SCREENS.

Case II. Blue blanKing off A and concentrating on B.