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SUMMARY

OF

PROGRESS IN NAVAL GUNNERY, 1914-1936

TRAINING AND STAFF DUTIES DIVISION,
NAVAL STAFF,
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NOTE.

The following summary has been compiled from data extracted from the various editions of “Progress in Naval Gunnery” published up to 1936 inclusive, and represents a record of the experience accumulated since 1914.

CHAPTER I

Single Ship Fire Control – War Experience and Development

Section 1. – Capital Ships.

Section 2. – Cruisers.

Section 3. – Destroyers.

CHAPTER I

War Experience and the Development of Single Ship Fire Control

SECTION 1. – CAPITAL SHIPS

System 1914

1. In the year 1914 a high standard of efficiency in the control of fire was attained; the system used was thoroughly understood and there was no lack of confidence in the ability of the fire control system to compete successfully with the accepted standards of range and general battle conditions.

2. Briefly, the rangefinder equipment was used to feed the fire control gear, and the latter was relied upon to furnish the requisite information for successful attack on a moving target. In conjunction with this, the bracket system of spotting was universally used to correct the best mean range into the actual gun range after opening fire.

The correction of the remaining factors, such as rate and deflection, was primarily dependent upon observation of fire, although great importance was attached to the use of the fire control gear as a guide.

Battle Experience

3. The earliest engagements of the war gave no cause to suspect that the firing rules were inadequate to deal with battle conditions.

4. The Battle of Heligoland Bight in 1914, fought in very low visibility was not of a character to produce any reliable evidence one way or another. It showed, however -

The impossibility of taking ranges in low visibility conditions.

5. The action off the Falkland Islands in the same year demonstrated the following :-

(i) *The rangefinder equipment failed to provide much information. (This was chiefly due to the range at which the action was fought, which outclassed the 9-ft rangefinders.)*

(ii) *The use of defensive tactics (zigzagging) rendered the control of fire extremely difficult, and placed a high premium on rapidity of fire as soon as the gun range was found.*

6. In January, 1915, the Battle of the Dogger Bank afforded the first real experience of battle under modern conditions, with capital ships of similar class opposed to one another in line.

While, as already stated, the system in use depended on observation of fire, supported but not dependent on rangefinder ranges, this action confirmed the lessons learnt from the Battle of Falkland Islands and demonstrated that –

Spotting (observation of fire) was extremely difficult, hits and "overs" could rarely be observed, and, therefore, "shorts" were the only guide to the fall of shot relative to the target.

Other lessons learnt from this battle in connection with the control of fire were:-

(i) *Rapidity of fire is essential.*

(ii) *Owing to lack of range observations the rate of change of range could not be plotted, and the gun was mainly used as its own rangefinder and ratekeeper.*

It is of interest to note that after this battle the suggestion was made that as soon as the range is found, ships *fitted with director** should fire a "double salvo," thus introducing the germ of an idea which was later to revolutionise the control of fire.

7. On 31st May, 1916, the Battle of Jutland was fought between the two main fleets.

Again the great difficulty experienced by control officers was in observing the fall of shot, while range-taking and rate-keeping were again found immeasurably harder than at target practices.

The severe punishment to which the enemy were subjected under difficult conditions clearly proved that efficiency in the use of the accepted system of control was great, but it also clearly proved that –

Under the conditions of modern battle, with vessels of great mobility and manoeuvring power, the system of control must not be based on rate-finding alone.

It was also shown that –

At great ranges and with a long time of flight, the system of firing one salvo, and awaiting its fall, was much too slow, although it had answered well enough at pre-war ranges.

It was further demonstrated that a battle was liable, under certain conditions, to devolve into a series of fleeting opportunities, frequently of short duration, and that for this reason also –

Any system of control depending on range finding would be wrong in principle, and incapable of developing the maximum hitting power of the armament.

8. One of the more far-reaching reforms was the introduction in September, 1916, of a new system of control and the 1916 “Spotting Rules.”

9. These spotting rules have never undergone the test of battle, and such modifications as have since been made are in consequence of circumstances arising during practice firings of all natures, and the post-war development of material.

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* At the date of this action, the director system was fitted to only a few capital ships and to none of the smaller ships.

SECTION 2. – CRUISERS

System

10. The system of control used in cruisers followed a somewhat similar line of development to that outlined for the capital ship.

Battle experience

11. Cruisers participated in practically every sea battle, but no radical improvements were effected in fire control as the result of lessons of early actions, it generally being accepted that these ships were normally spread, and therefore unlikely to be called upon to fight ore than a single-ship action.

After the Battle of Jutland a series of spotting rules was drawn up for use in cruisers.

12. A cruiser action was fought on 17th November, 1917. This action was the real turning point of cruiser gunnery, as was Jutland in the case of capital ships. The enemy made considerable use of smoke screens.

(i) *Owing to the smoke, "overs" were practically never seen, so that straddles could be judged only by the number of short shots observed out of a salvo of a known number of guns.*
(ii) *Splashes showed up badly against the smoke.*
(iii) *Hits with H.E. nose fuzed shell were distinguishable, and were not confused with the flash of enemy's guns.*
(iv) *Great difficulty was experienced in judging inclination of enemy due to smoke and frequent zigzags.*
(v) *No inconvenience to spotting was caused by the splash of enemy salvos.*

13. It was generally reported that the Spotting Rules met requirements. It was in this action that a "blind ladder" was employed, a form of control which has since been embodied in the Spotting Rules. It is not known if this method was effective.

SECTION 3. – DESTROYERS

System

14. Pre-war policy was to employ local control without instruments of any sort, on the assumption that destroyer actions would be fought at close range.

The commencement of the war showed an inclination on the part of destroyers to open fire at long range and this consequently led to elementary methods of primary control in all ships.

After the Battle of Jutland improved fire control arrangements were fitted, and a set of Spotting Rules introduced.

CHAPTER II

Review of Modifications affecting the Control of Fire of Single Ships when Aircraft Observation is not available

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Section 1. – Explanatory Remarks

Section 2. – Affecting all Ships

Section 3. – Affecting Capital Ships (Main Armament) and Cruisers.

Section 4. – Affecting those Ships to which the Destroyer and/or Submarine Spotting Rules are applicable.

Section 5. - Affecting Capital Ships (Secondary Armaments) only.

Section 6. – Affecting Cruisers only.

Section 7. – Affecting Aircraft Carriers only.

Section 8. – Affecting Submarines only.

CHAPTER II

Review of Modifications affecting the Control of Fire of Single Ships when Aircraft Observation is not available

SECTION 1. – EXPLANATORY REMARKS

1. In this chapter is contained a review of the various modifications to the rules for the Control of Fire by day of single ships, when aircraft spotting is not available.

2. The Spotting Rules in their present form were adopted :-

Capital Ships (Main armament)	1917
Capital Ships (Secondary armament)	1921
Cruisers	1917
Aircraft Carriers	1933
Leaders and Destroyers	1923
Submarines	1930
Sloops, etc.	1923

Since these dates various minor modifications have been proposed some of which have been adopted and others decided against Each class of ship has worked independently, with the result that proposals similar in principle to those made by other classes of ship, have been reviewed on more than one occasion.

3. In summarising the proposed modifications they have been grouped into sections. Sections 2-4 contain those proposals which, although perhaps only proposed and investigated by one class of ship, contain principles which are applicable to others. Sections 5-8 contain those proposals applicable only to the class of ship concerned.

SECTION 2. – AFFECTING ALL SHIPS

INITIAL DEFLECTION SPREAD

4. In 1930 it was realised that the rules for finding the deflection in various classes of ships differed unnecessarily in minor ways, such as the amount and direction of the spread.

5. As a step towards attaining consistency, it was decided to carry out trials of spreading the first salvo towards the enemy's bow and the second towards the stern. This procedure was selected on the grounds that a salvo missing ahead may give information

As to elevation due to target travel during the time the splashes are visible. Against this, there appeared to be a chance that the second salvo might be obscured by the first.

6. Reports received during 1930 were generally in favour of this proposal, though it was represented that the probability of information being gained fr0m a miss ahead is not so great as to justify the complication to the rules. It was suggested that greater simplicity would result, and the possibility of error be removed by using a standard spread to the right for the first salvo, and to the left for the second.

7. *This proposal was adopted* in 1932. In addition, a standard magnitude was ordered, the total spread to be at least two-thirds the width of the target with a minimum of 4 knots (or equivalent in units) for capital ship main armaments, and 8 knots (or equivalent in units) for all other armaments.

USE OF 100-YARD CORRECTIONS

8. Reports were called for at the end of 1932 regarding the desirability of limiting the occasions on which corrections of 100 yards for range are permissible, in view of the frequent occasions on which range spotting corrections are insufficiently bold.

9. As a result of these reports it was not considered that a case had been made out for altering the existing rules, but it was stressed that control officers must constantly bear in mind the necessity for the use of bold spotting corrections, especially when aircraft are not available for spotting.

SECTION 3. – AFFECTING CAPITAL SHIPS (MAIN ARMAMENT) AND CRUISERS

SIZE OF STEPS OF A REGAINING LADDER

10. It was reported by cruisers in 1929 that, in a number of high speed practices, mistakes in estimation of inclination and delay in observation of target alterations of course had resulted in several failures of a 200-ard regaining ladder (three steps of 200 yards) to refind the target, and proposals were put forward to amend the Cruiser Spotting Rules to make the normal regaining ladder of 40-yard steps, and an abnormal one of 200-yard steps. It was further proposed that with 8-inch cruisers, owing to the larger spread of salvos, the steps should be one of 400 yards followed by two of 200 yards.

11. That the first step should be 400 yards was considered sound, observing that it is usual to wait for a confirming salvo before ordering a regaining ladder. The accumulated error in range is therefore likely to be more than 200 yards.

12. It was considered, however, that further steps of 400 yards were wrong. In the first place, although this would make certain of crossing the target, two large zones would be left in which no hits on a ship would be obtained. In the second place, the accumulated error between the last straddling salvo and the last step of the regaining ladder should rarely be as much as 1,000 yards, and this area would be effectively covered by a ladder of one 400 and two 200-yard steps.

13. The rules finally adopted are as laid down in the Firing Manual, namely:-

The normal regaining ladder is-

(*a*) First step 400 yards, second and third steps 200 yards each.

Abnormal regaining ladders are-

(*b*) Three steps of 200 yards each for use when firing at slow targets, such as a damaged ship in action, a towed target in peace practices, or in a chase.

(*c*) Three steps of 400 yards each when firing at a very fast target, when alterations are difficult to observe or in bad visibility.

INDIRECT FIRE-SPOTTING RULES FOR LINE – NECESSITY FOR A LINE SPOTTING OFFICER

Spotting Rules for Line

14. In 1931 approval was given to spread deflection salvos for line if aircraft reports indicated that salvos were 200 yards or more from the target.

15. As a result of practices carried out, the opinions were formed in 1933 that-

(i) The spotting rules for line should be based on the same principles as those for range.

(ii) Spotting corrections for line should not be given when the firing ship is altering course, if line has been correct previously.

(iii) Corrections for line should generally be based on the trend of a number of salvos.

(iv) The opening double salvo should not be spread for range or line.

These opinions have been subsequently confirmed.

Line Spotting Officer

16. Concurrently with the foregoing, the necessity or otherwise of a line spotting officer was investigated. The conclusion was reached that a separate line spotting officer was neither necessary nor desirable; *officers should have the same duties in indirect fire as in direct fire.*

SECTION 4. – AFFECTING THOSE SHIPS TO WHICH DESTROYER AND/OR SUBMARINE SPOTTING RULES ARE APPLICABLE

SPOTTING RULES – LADDER v. SINGLE STEP SYSTEM OR COMBINATION OF BOTH SYSTEMS

Destroyers

17. Spotting rules embodying double salvos were introduced subsequent to the Battle of Jutland, the target being found for range on the ladder principle, which is still in force.

Ladder versus Single Step

18. This principle has been questioned in past years, however, and suggestions were put forward that the secondary armament method, i.e., rapid salvos and single step corrections, might be preferable. This point of view was first advance din 1921, mainly with a view to increasing the rate of fire, which was reduced to a point below that of which the guns (Q.F. 4-inch) were capable by control delays.

19. It was foreshadowed that a combination of the ladder method for finding the target, and the single step for keeping the range or regaining the target, might prove the most successful. This procedure was adopted as Standard early in 1923 after a series of trials.

20. These rules stood the test of *Agamemnon* firings during 1924 and 1925, but again the opinion was put forward that the single step system might be preferable, and further investigations were carried out during 1926.

21. The arguments advanced in favour of the single step system (though sea opinion was sharply divided on the merits of the two systems) were-

(*a*) Control officer has only to think of one step at a time.
(*b*) Should a critical salvo be unobserved, due to an error in laying, smoke, or other interference, there are others in the air that can be spotted on with very small delay.
(*c*) The rules for finding and regaining the target are similar.

22. Those who were in favour of the Standard Rules maintained that they were the fruit of war experience, had not in practice proved difficult for the average officer to apply, and would on the whole obtain earlier hitting.

23. Theoretical considerations tended to favour the Standard Rules, except when the initial salvos were 700-900 yards from the target. The results of 54 firings in 1926, showed 19 favoured the Standard Rules as against 10 for the Single Step System, 25 showing no advantage either way.

In addition mistakes appeared in the application of the Single Step System, which showed it to be not so simple to use as was supposed; these were principally caused by loss of control due to continuous firing in rapid salvos.

24. At the end of 1927, a scrutiny of practices carried out gave the relative advantage of each in obtaining early hitting as follows:-

		Percentage in favour of Standard Rules	Percentage in favour of Single Step.	Percentage in favour of neither
1925	(A.F.)	35	48	17
	(Med.)	40	25	35
1926	(54 firings)	35	19	46
1927	(132 firings	49	23	47

A decision was made in favour of the Standard Rules.

Combination of two systems

25. Nevertheless, there were an appreciable number of practices which favoured the Single Step System, and it was decided to carry out an investigation (by the A.F. Flotillas) into the value of a combination of the two.

26. In its elementary form, the Control Officer, on observing a deflection salvo over or short, fired two salvos, each preceded by a correction of 400 yards in the direction of the target, immediately ordering "Rapid Salvos" after firing the second salvo. If the target was not located by either of these two salvos, he reverted to salvos and repeated the procedure.

27. Reports were strongly in favour of these modified rules, and a scrutiny of all practices (107) carried out during 1928 suggested that there was little to choose between the standard and modified rules. Further investigation was ordered in 1929.

At the end of that year, after a very careful scrutiny of all destroyer practices, the following questions were considered to be answered as indicated:-

Question.	*Answer.*
(i) Which rules result in the earliest hitting?	(i) Neither one shows any advantage
(ii) Which rules are least expensive of ammunition?	(ii) Standard.
(iii) Which rules are simplest of application?	(iii) Indications were that the Standard Rules were more simple.

28. It was therefore *decided to adhere to the Standard Rules*. These are the ones now in force.

POINT OF AIM AT VERY SHORT RANGES

Destroyers

29. It was suggested in 1930 that, at very close range, it would be very difficult to obtain shorts if the standard point of aim were adhered to, and that, in consequence, it would become necessary to aim at the waterline under the foremast. It was further suggested that the waterline should be the standard point of aim, except when in director or gyro firing.

30 It was *considered undesirable to have a different point of aim for different methods of firing,* and that requirements would be med by giving the order "Water line" if a very close range was reached.

Submarines

31. A similar proposal was received from submarines in 1934. *Further information was asked for* but none has yet been received.

Sloops

32. A similar proposal was received from the A/S Training Flotilla, as a result of some practices in which the Asdic was used for ranging on the B.P. target before it was officially "in sight" (i.e., a submarine surfacing during a hunt).

There was an appreciable difference between the Asdic range and the hitting gun range, and it was suggested that this was due to the top of the target being used as the point of aim.

Attention was drawn to the proposal made by submarines.

SPREAD FOR DEFLECTION AT VERY SHORT RANGES

33. The desirability of spreading the initial deflection salvos at very short ranges was questioned by submarines in 1933. It was pointed out that the minimum spread of 8 knots (total) was about 20 feet, which was quite sufficient to miss either side of a submarine's conning tower.

It was suggested, on the score of simplicity, as well as to save delay, that whenever a single step was used for range, it should also be used for finding the target for deflection.

34. *This proposal was adopted* after trial during 1934.

USE OF AN INITIAL LARGE CORRECTION

Destroyers

35. The use of a 1,000 yard correction as the initial step of a range ladder was first authorised in 1922. Its use was dependent on the accuracy of the rangefinder, and instructions were given that it should not be used when reliabl rangefinder ranges were available.

Two cautions were added:-

(i) When opening fire under conditions of poor visibility, if shots are short, caution is necessary as regards the deployment of the initial 1,000-yard step since it may cause shots to be lost altogether. (Ships were armed with 4-inch guns.)
(ii) If the 1,000-yard correction crosses the target, a reverse 400-yard ladder with an initial 800-yard step was to be fired in the reverse direction until the target was crossed, i.e., steps must not be diminished when the limit covered by the large initial correction is approached, owing to the possibility of an error in rate.

36. In 1927 it was suggested that the use of an initial 1,000-yard correction should be made obligatory at ranges over 10,000 yards. It was considered undesirable to lay down a hard and fast ruling, and that Control Officer should judge each case on its merits, bearing in mind the following:-

(i) A 9-ft. rangefinder in a destroyer will give a range of the target within the scope of a 400-yard ladder up to a maximum splash visibility, provided the instrument is in adjustment, and the operator is accurate.
(ii) Accuracy increases as range decreases, due both to instrumental and personal causes.
(iii) Accuracy decreases rapidly with poor visibility, motion on ship due to sea, vibration due to speed, etc.

37. It will be appreciated that in the foregoing paragraphs the 1,000-yard correction was the step of ladder. This was subsequently modified, the instructions directing that "if the deflection salvos are observed to be far out of range, a correction of 1,000 yards is to be applied in the direction of the target, and a further double salvo fired. These salvos may be spread for direction, if desired, and are to be treated exactly as deflection salvos."

38. In 1931 these instructions were questioned and instructions for deflection salvos over or short modified to read:-

"The steps of the ladder are normally to be 400 yards, but if the deflection salvos have been observed very far wrong for range, or if Control Officer considers his range is probably largely in error, the first step is to be 1,000 yards."

39. <u>This amendment was promulgated</u> in "Progress in Naval Gunnery, 1931," but not inserted in the current "Destroyer Firing Manual," <u>and subsequently overlooked.</u>

40. Further remarks on the use of this correction were promulgated in 1935, and it was pointed out that there appeared to be a reluctance among G.C.O.s to use the initial large steps.

The limitations of a rangefinder were again pointed out, and it was suggested that the logical tendency should be towards the use of the large correction, except at short and medium ranges.

41. A suggestion had also been received that a ladder with an initial step of 800 yards should be authorised.

42. No remarks on this proposal have been received from sea, but *the principle has been embodied in the new "Destroyer Firing Manual."*

Submarines

43. In 1933 a proposal was received that for submarines a 1,000-yard correction should be made compulsory in all "long range" practices.

44. The range-finding facilities in submarines are dependent on knowledge of the height of the target, which may give satisfactory results in peace practices when this is accurately know, but such accuracy cannot be expected in war. Neither does the low height of eye make it easy to judge if the error in range is large.

45. It was not considered desirable to amend the existing rules to make the use of this correction compulsory, but *the wording was altered to read-*

> "if the deflection salvos have been observed to be very far wrong for range, or if Control Officer considers his range *may be* largely in error, the first step *is to* be 1,000 yards."

LIMITED RANGE FOR LADDER SYSTEM OF SPOTTING

Submarines

46. It was suggested in 1932 that the ladder system is unsuitable for submarines because, at the ranges at which submarine actions are likely to be fought, the time of flight will not permit of two salvos being in the air at once.

47. The "Submarine Firing Manual," however, does order the rules to be used under these circumstances, but at present there is no limit defined.

It was proposed for trial that the short range rules should be used below 4,000 yards.

48. Subsequent experience showed this range to be excessive. Although in one firing, the ladder system was successfully employed down to 2,200 yards, evidence tended to show, with well drilled personnel, the limiting range to be of the order of 2,500 to 3,000 yards. Opinion tends towards a limit of 3,000 yards, unless the standard of control and gun drill is above the average.

49. *Further information is required.*

THE MAGNITUDE OF VERIFYING CORRECTIONS

Submarines

50. It has been suggested that a verifying correction shall be 200 yards instead of 100 yards.

Opinion appears to favour this proposal, but no definite evidence in its favour has been put forward.

51. *Further information is required.*

SIZE OF STEPS OF A REVERSE LADDER WHEN A STEP OF A LADDER FALLS OUT FOR LINE

Destroyers

52. In 1934 the instructions were that if a salvo of a ladder fell out for line, but the next salvo crossed, the 800-yard gap was to be swept out be a reverse ladder of 200-yard steps.

53. The proposal was made that a reverse ladder of 400 yards should be used, in order to find the target more simply, and to make the application simpler in operation.

54. No great amount of experience was obtained on this proposal, but in 1936 it was decided that this was similar in principle to the action in cruisers when firing a regaining ladder after the target had been lost, and *it was decided that* the reverse ladder should normally be of 400-yard steps, except when engaging a slow-moving target, or under other conditions when the rate of change of range could not be large, in which case the steps could be 200 yards.

Submarines

55. The instructions direct that if a 400-yard step falls out for line, and the next step crosses the target, the reverse corrections shall be 200 and then 400 yards.

This was questioned in 1931, and it was proposed to fire a reverse ladder using continuous 200 yard steps.

56. *It was decided not to alter the existing instructions*, unless further experience showed this to be necessary.

RULES FOR O.O.Q. CONTROL

Destroyers

57. This problem was investigated in 1923-4. Considerations of space and personnel in destroyers render it impracticable for the O.O.Q. to make use of any instrumental aids, with the exception of a time of flight watch, and the question arose as to how the simultaneous fire of the foremost and after groups could most efficiently be carried out when being controlled by their respective O.O.Q.s in local control.

58. Considerable experience in 1923-24 gave rise to the following instructions:-

> ”The primary control communications between the guns of a group are to be used so far as they remain efficient.
>
> Range and deflection orders are to be given as spotting corrections only.
>
> One sight setter in each group is the master, and passes total range and deflection to the other gun or tuns of his group as soon as his own sights are set.
>
> Destroyer spotting rules are to be adhered to in principle.
>
> If no appreciable interval elapses between failure of the primary control and the O.O.Q. taking over the range may be assumed to be nearly correct, and, should his first salvo miss, a 400-yard ladders should be started. In other cases the first step of the ladder is to be 1,000 yards.
>
> An isolated gun should not fire, unless it can do so during the silent interval, or unless another target is available.”

59. The above rules did not deal with the question of mutual interference to the control of two groups by the fall of shot. Confusion naturally arose from this cause, and was also attributable to the O.O.Q.’s firings being carried out at ranges of 4,000-6,000 yards.

60. These difficulties led to emphasis being laid on the necessity for not abandoning primary control whilst the Transmitting Station and communications to the guns, remained serviceable, and that casualties to the G.C.O. or to bridge personnel should be met by summoning an officer from another station to carry on the control of fire for the whole armament.

61. Consideration was given to the method whereby the firing of the after group depended upon that of the foremost group, a salvo from the latter being considered the executive order to the after group to fire. This method showed promise, but the question was raised as to the minimum interval that cold be allowed between the firing of the two groups if mutual interference was to be avoided. It was suggested that, as the time of flight might differ by from 2-3 seconds between groups, and as all guns would not fire exactly together, 5 seconds was a suitable interval. Tho achieve this interval it was thought that 3 seconds should be aimed at.

62. It was also pointed out in “Progress in Naval Gunnery, 1927” that the rules in the Destroyer Firing Manual” governing this form of practice allowed the firing to be begun at 4,000 yards with a closing rate.

63. Further trials disclosed the fact that the arrangement, whereby the after group depended on the foremost one, became a case of each group waiting for the other, and the method to be used was reiterated in “Progress in Naval Gunnery, 1930,” as follows:-

"The forward group is to develop its maximum rate of controlled fire, the after group being regulated so as not to interfere, and endeavouring to fire within three seconds of the

(vii) *Keeping the Range*.- If a "Down 200" correction causes the shot to fall short, it should be reversed. Unless hits are observed, if three consecutive salvos produce no short shots, the target is to be considered lost.

(viii) *Regaining the Target*.- Use a 400-yard bracket.

(ix) Rate is to be allowed for by an estimated correction superimposed on spotting corrections.

(x) An isolated gun is not to be allowed to interfere with the control of the remainder. If there is no separate target available such a gun is to check fire.

65. These rules proved generally successful. *It was proposed*, however, that when "finding the range," an initial 800-yard bracket should always be used, if in primary control the target has not been crossed; and that in most cases it would be better to use an 800-yard bracket, unless the target was actually straddled.

66. These views are concurred in, but *further information is required* before amending the rules.

SECTION 5. – AFFECTING CAPITAL SHIPS (SECONDARY ARMAMENTS) ONLY

SPOTTING RULES

"Nelson" and "Rodney" only

67. After trials of triple 2-gun deflection salvos, and a continuous ladder for finding the range, *it was decided* to use the standard secondary armament spotting rules in *Nelson* and *Rodney*.

CORRECTION TO RANGEFINDER RANGES FOR LAG ON OPENING FIRE

15-inch Ships

68. The original instructions were that a correction, equal to the rate in use, was to be applied to the rangefinder range obtained prior to opening fire. This allowed for a delay of one minute due to the accumulation of the following intervals:-

(i) Time taken by rangetaker, when he has obtained a cut, to read off and call the range.

(ii) Time taken to transmit the range tot eh clock.

(iii) Time taken to set the sights and fire.

(iv) Time of flight.

69. Although the use of a correction equal to the rate in use was a convenient amount, it seemed to be excessive, observing that (iv) is 25 secs. at 12,000 yards and (i) (ii) and (iii) should be completed in 20 seconds. It was therefore proposed that the allowance should be reduced to an amount equal to three-quarters of the rate in use.

70. It was then pointed out that (iii) was not truly applicable, since by the time (i) and (ii) had occurred the rate should be on the clock, in which case (i) and (ii) should not amount to more than 40 secs., and in consequence an allowance equivalent to two-thirds the rate in use would suffice.

71. Experience in 1931 practices proved the suitability of this correction but it was finally decided, on the score of simplicity and the small difference between the two allowances, *to adhere to a correction equal to the rate in use.*

WORKING THE BRACKET

72. Prior to 1930 the standard method of working the 800-yard bracket was successive halving of the corrections, e.g., “Up 800,” “Down 400,” “Down 200.”

73. It was pointed out that, with rapid salvos in use, a considerable interval will elapse before salvos with the final correction commence to fall, particularly if is has not been possible to spot one or more salvos. During this interval the almost inevitable error in rate may well prevent the “Down 200” finding the target and at least a 400-yard regaining step will then be required.

74. It was proposed, and *finally adopted*, that a correction as small as 200 yards should only by used when it was ordered in the *reverse* direction to the preceding one.

ENGAGEMENT OF A TURNING POINT OF DESTROYERS

75. Practices were carried out during 1932 to exercise the engagement of a turning point of a division of destroyers when turning to fire torpedoes. The method employed was to set the enemy’s speed to zero as the leading ship passed through 0º or 180º and fire at the extreme wing ship until the rear ship came under fire, when normal enemy settings were used.

76. It was claimed that the firings were successful, and showed that a turning point can be engaged with a reasonable prospect of success; tough this success would diminish as the speed of the enemy increased, and also if the rear ships turned inside or outside the leading ship’s track.

77. Further firings carried out in 1933 brought out the following points:-

(a) The difficulty of keeping line when firing at the turning point.
(b) That even if the turning point is successfully engaged the destroyers will not necessarily be prevented from firing their torpedoes.

78. In opposition to this, it was suggested that it would be preferable to fire at each destroyer in turn before she reaches the turning point and fires her torpedoes. Each targe would then present a similar control problem, and shifting from one destroyer to another would not involve any great changes in the settings of the instruments.

79. *This system has the definite advantage* that the enemy is engaged before torpedoes are fired, and in consequence the attack is more likely to become disorganised and avoiding action more difficult.

SECTION 6. – AFFECTING CRUISERS ONLY

TRIPLE SALVO FOR DEFLECTION

80. Concurrently with the proposals to amend the rules for spreading the initial deflection salvo, remarks were called for during 1930, as to whether or not cruisers should fire a ~~*trend*~~ *third* [transcribers note – this was a pen amendment to the original document] deflection salvo with the calculated deflection when the time of flight is long enough to admit of more than two salvos being in the air.

81. As a result of experience the arguments for and against were summarised as follows:-

For. (*All classes of cruisers.*)

(i) Reduces the chance of initial salvos falling either side of the target when end on.
(ii) Utilisation of an additional opportunity to hit.
(iii) Productive of a more uniform rate of fire, and therefore regular loading intervals.
(iv) Spotting is simplified when calculated deflection is reverted to after completion of ladder.

Against. (*Certain 8-inch Cruisers.*)

(i) The time of flight does not permit of their use below effective gun range (16,000 yards approximate).
(ii) If used between ranges of 16,000 yards and 20,000 yards, and information for starting a ladder is obtained with the first salvo of the triple, the firing of this ladder is delayed as the guns will not be ready. (Assuming a rate of fire of four rounds per minute.)

(iii) Owing to the good deflection-finding qualities of the Admiralty fire control table, a deflection double will almost always suffice.

(iv) The only time when triple deflection salvos may prove advantageous is if the initial range is correct. This rarely occurs at the ranges when triple deflection salvos can be used.

(v) Triple deflection salvos are liable to be wasteful of ammunition at a stage in an action when the conservation of ammunition is of importance, i.e., outside effective gun range.

82. *The advantages were considered to be of a more concrete nature than the disadvantages* and it was decided to accept the latter, and issue instructions authorising the use of a triple deflection salvo when the time of flight permits.

8-INCH CRUISERS – THE USE OF AN ARTIFICIAL SPREAD FOR LINE AT RANGES ABOVE 10,000 YARDS

83. During 1932 a Cruiser Squadron investigated, and favourably reported upon, the use of an artificial line spread, an investigation which was carried out owing to the small line spread experienced with 8-gun salvos, which made individual shots difficult to observe.

This artificial spread was achieved by setting convergence in "A" turret to 20,000 yards, and in "B" to infinity.

84. It was pointed out that one objection to this proposal was the possibility of the enemy altering course and presenting a narrow target.

85. Further experience was against this proposal, and *the decision was given that it was not to be used.*

CRUISERS – NUMBER OF GUNS IN A SALVO WHEN RANGING

"Hawkins" Class (6-7.5 *inch on a broadside)*

86. In 1925, after a long succession of trials, the use of half-broadside salvos was definitely decided against. It had been thought that by firing faster, the target would have been more quickly found. Experience showed, however, that a 3-gun salvo was unreliable, and therefore liable to mislead, the critical salvo possibly being incorrectly spotted.

The matter was kept in mind in the event of ships being give a larger number of guns on a broadside.

"Kent" and "London" Classes (8-8-*in.. on a broadside*)

87. When these classes came into service in 1928 the matter was again raised. It appeared desirable that broadsides should be fired in order that the full use could be made of the rate of fire obtainable with these guns.

88. On the other hand it seemed that there might be occasions when the four-gun salvo would suffice, such as testing "splash visibility", or finding the range at very long ranges when effective fire is unlikely. Further, the long range and limited outfit of ammunition necessitates economical use outside effective range.

89. Initial experience suggested the advantages and disadvantages to be-

Advantages:-

(i) Reduction in the time required for deflection and ladder salvos.
(ii) Greater output of salvos per minute, making dodging fall-of-shot more difficult.

Disadvantages:-

(iii) Less chance of early straddles due to smaller spread of salvo.
(iv) Less chance of hitting with straddling salvos, due to less density of rounds.
(v) Increased to rangefinders and control.
(vi) Effective of loss of output is much greater than in broadsides.
(vii) Does not develop full output of which the guns are capable.

90. *The final conclusions were-*

(i) Spotting four-gun salvos is practicable under average conditions up to 18,000 yards, but spotting half broadsides, at twice the rate of fire of broadsides would be less certain due mainly to cordite smoke interference.
(ii) With loading intervals varying between 11 seconds and 16 seconds, and "time on aim" between 3 and 6 seconds, it was possible to fire broadsides every 14 to 22 seconds. It was not considered possible to fire half broadsides every 7 to 11 seconds, except under exceptional conditions, and in consequence half broadsides resulted in reduced output.
(iii) The fewer the guns fired in a salvo, the less the probability of hits in a salvo.
(iv) The effect on the output of failures at guns increases if half broadsides are fired.

91. In consequence of these conclusions *it was decided that* 8-*inch cruisers are normally to fire full broadsides.*

CRUISERS – ACTION TO BE TAKEN IF A REGAINING LADDER CROSSES THE TARGET WITHOUT STRADDLING

92. In 1931 the instructions laid down that if a regaining ladder (then of 200-yard steps) should cross the target without straddling, further salvos were to be fired to confirm the fall of the salvos which fell on opposite sides of the target.

It was pointed out that this procedure delayed going into rapid salvos after the target had been located, which was not acceptable in cruiser gunnery.

93. *The instructions were therefore deleted.*

8-INCH CRUISERS – LOCAL CONTROL – NATURE OF FIRE

94. The "Firing Manual" directed initially that turrets were to fire broadsides in "rapid salvos", but this was subsequently amended to *direct 8-inch turrets to fire "salvos."*

95. Before this amendment had been promulgated, proposals had been received that 8-inch turrets should be allowed to use Cruiser Spotting Rules. It was pointed out that considerations of the firing interval and time of flight show that range ladders are impracticable at all ranges at which local control firings would be justified, and that the same argument applies to rapid salvos.

CRUISERS – SPOTTING RULES FOR INDIRECT FIRE

96. In 1929 the suggestion was made that rapid salvos and an 800-yard bracket should be employed if the target *had not* been found on turning over to indirect fire, and rapid salvos and single step corrections of 400 yards if it had been found.

97. At this time it was laid down that, in the event of indirect fire being resorted to when no aircraft was available, and the target was being held before its disappearance, a short burst of rapid salvos could be fired.

The proposal was not agreed to, it being considered preferable to use normal cruiser spotting rules based on reports of a consort or aircraft.

SECTION 7. – AFFECTING AIRCRAFT CARRIERS ONLY

WHETHER DESTROYER OR SECONDARY ARMAMENT SPOTTING RULES ARE PREFERABLE

98. Prior to 1926 the ships armed with 6-inch and 5.5-inch guns used the Cruiser Spotting Rules and the *Argus,* with 4-inch guns, used the Destroyer Rules. The proposal was made that all

should employ a single step system, on the grounds that the gun armament is provided for a defensive purpose and chiefly against destroyers. The conditions are therefore similar to those for the secondary armament of a battleship.

99. Approval for these to be adopted by all carriers was given in 1927. The desirability of opening fire in rapid salvos was questioned, however, after the *Glorious* and *Courageous* came forward for service, it being pointed out that when shooting up to the target at extreme range, it was possible to have six salvos in the air. Against this however, it was pointed out that a deliberate reduction in the rate of fire might result in an increase in the chances of the target being crossed without being straddled, and that furthermore, in most conditions of weather, the splash visibility would be less than the extreme range of the guns. This will influence the range at which fire is opened and so the number of rounds in the air will be correspondingly reduced.

100. It was not proposed, therefore, to make any change in the rules.

101. In 1929 it was represented that the Secondary Armament Rules were not entirely suitable. The point of view was advanced that these rules were designed to suit conditions of high closing rate during a limited period, consequent on the limited range of the secondary armament of battleships, and the long range of modern torpedoes. Such an argument was not really applicable to aircraft carriers, who would normally turn from an adversary, thereby precluding a high rate.

102. One carrier was detailed to test the Destroyer Spotting Rules. In 1931 the indications were that these would be preferable, and they were adopted finally in 1933.

103. The decision was questioned in 1934 on the grounds that the Secondary Armament Rules produced earlier hitting, though admittedly with greater expenditure of ammunition. An important factor is the ability of the ammunition supply arrangements to compete with the high rates of fire.

104. After further firing, when the actual results were compared with results which would probably have been obtained with Secondary Armament Spotting Rules, the conclusion was reached that the latter might, on an average, find the target earlier, though the balance in their favour was very small. On the other hand, the increase in ammunition expenditure might be considerable.

105. The possible and only slight balance in favour of the Secondary Armament Rules was held to be overweighted by the inadequacy of the ammunition supply under these conditions, and *it was decided to adhere to the Destroyer Spotting Rules.*

SECTION 8. – AFFECTING SUBMARINES ONLY

REVERSE CORRECTIONS

106. It is directed that when the target has been crossed by a step of the range ladder if the reverse correction of 200 yards produces a short, it is to be taken off and hitting may be assumed. If it produces an over, hitting may be assumed.

107. The proposal was put forward in 1932 that a correction of 200 yards should always be given in the direction of the target as a result of the fall of the first round affected by the reverse correction, on the grounds that, even if laddering had been carried out correctly, it was not difficult for the range to be as much as 300 yards in error. It was therefore considered desirable to confirm the accuracy of the range selected at the earliest possible moment.

108. Reports have been called for and the *evidence to date is inconclusive. Further information is required.*

CHAPTER III

Compensation for Own and Enemy Alterations of Course

Section 1. – Compensation for Own Ship's Movements.

15-inch ships	.. ..	Dreyer Tables.
Cruisers	.. ..	General.
		Turret Dreyer Tables.
		Mark III* Table.
		A.F.C. Tables.

Section 2. – Compensation for Enemy Alteration of Course.

15-inch ships	.. ..	Dreyer Tables.
15-inch ships	.. ..	Secondary Armament.

CHAPTER III

Compensation for Own and Enemy Alterations Of Course

SECTION 1. – COMPENSATION FOR OWN SHIP'S MOVEMENT

15-INCH SHIPS – DREYER TABLES

1. This problem was set in 1928, with the following foreword:-

"Action experience and the results of fleet exercises show that it may be necessary to accept the torpedo menace in order to obtain decisive results. This may entail a large turn towards the enemy, and subsequently individual avoiding action when the torpedo zone is reached. It may be anticipated that under these circumstances the enemy will maintain comparatively steady course so as to develop maximum gunfire and take advantage of possible confusion in our line."

2. The first opinions formed were -

Deflection.- Provided the calculating instruments are trusted, and care is taken not to spot on occasional erratic salvos, there should be no difficulty in keeping correct for line.

Range.- To maintain hitting, the Dreyer calculator requires constant resetting, which can best be achieved by good drill rather than by additional gear.

3. Further consideration gave rise to the following statements:-

With Dreyer tables the change of bearing due to alteration of own ship is applied automatically. Provided, therefore, that due allowance is made for loss of speed during the turn the change in rate and deflection will also be allowed for accurately.

4. Other factors affecting hitting:-

Deflection.- Errors in training will not be enough to cause misses for line unless drill is bad.

Canted trunnions.- Since no cross levelling gear is fitted the heel resulting from alteration of course must be allowed for by a spotting

correction, which is not anticipated to be difficult to assess and order if the hell is steady. If rolling, salvos must only be fired with the ship upright or in same position on each roll.

Range.- (i) Change in Dreyer correction due to change in component of own ship's speed along the line of fire.

(ii) Error in range produced by the lateral transfer of the ship, or slip, i.e. the ship does not follow the theoretical track traced out on the Dreyer table.

5. With regard to (i), for a turn towards, this correction is "Down" and is not large. In a 15-inch ship, speed 20 knots and alteration of course of 90º:-

At 20,000 yards, correction is "Down 210 yards."
At 15,000 yards, correction is "Down 170 yards."

With regard to (ii), for a turn towards, this correction is "Up," the actual track being outside the theoretical track. The exact amount is difficult to assess, but is of the nature of 100-200 yards according to the speed and rudder used.

6. It will therefore be seen that (i) and (ii) tend to cancel each other, and that the actual change in range due to an alteration of own ship is not likely to exceed 100 yards.

7. From an examination of a number of analysis charts, it appeared that the change in Dreyer correction was frequently wrongly calculated and almost always over-estimated. The reason for this was believed to be that change in rate is applied to the calculator, but the alteration in "wing you feel" along the line of fire is not applied at the same time. This would result in over-estimating the change in Dreyer correction. It is obvious that the change in rate is much easier to apply, being read directly off the auto-Dumaresq, whereas the change in "wind you feel" is less likely to be obtained quickly and accurately.

8. It was therefore considered that, as the maximum change of Dreyer correction likely to be required (100 yards) was well within the spread of a salvo and also, that by leaving the correction unaltered, the risk of applying a wrong correction due to neglecting the alteration of wind was eliminated, it would be better to make no alteration to the Dreyer correction for an alteration of own course.

9. Opinion in both Fleets in 1930 was unanimous that no range correction should be made when own ship alters course as the correction is small, and *it was decided that* the Dreyer calculator was only to be used before opening fire and when tuning to rangefinders.

CRUISERS

General

10. This problem was set for all cruisers in 1928, as follows:-

"To investigate the effect on own ship's fire when frequent and large alterations of course have to be made, and to discover the best method of compensating for own ship's movements with Dreyer Fire Control Tables."

For Range

11. The factors to be considered are-

(i) Effect of lateral transfer or slip of the ship while turning.
(ii) Effect of errors in calculation and lag in application of rate.
(iii) Effect of change in component of own ship's speed, resolved along the line of fire, on ballistics

For Deflection

(iv) Effect of error in calculation and application of correct deflection
(v) Effect for firing with ship heeled.

12. It can be shown that the effects of (i) and (iii) are opposite and cancel each other, leaving (ii) as the chief source of error. Provided that lag in resetting rate and Dreyer correction is not excessive, for small alterations of course no spotting correction is necessary to gun range. For alterations over 50º at high speed the resultant effects may be appreciable and a correction may be required.

13. Item (iv) is dependent on accurate assessment of the loss in speed and on the bearing. If the loss of speed is correctly assessed, the major error will be due to lag in resetting the calculating instruments. The effect of this lag will be appreciable if the bearing is on the bow.

14. To counteract item (v) the director layer should endeavour to fire when the horizontal cross wire indicates the ship is approximately upright, informing the Control Officer if a salve was fired with the ship listed. With a ship target, salvos may still be in line; but in target firings, when the danger space is small, Control Officers are liable to order corrections when they are not really necessary.

Cruisers with Turret Dreyer Tables

15. The T.S. and control positions were cramped, and it seemed that it might be impracticable to use the Dreyer calculator except initially.

16. It was therefore proposed to investigate the use of the following scale of corrections for speeds over 18 knots.

Up to 30º	..	No correction.
30º to 60º	..	200 yards.
Over 60º	..	A further 200 yards correction after 60 degrees.

The correction to be *up* or *down* according to whether the turn is away or towards, and to be applied in the middle of the turn.

17. For further consideration *see* "Cruisers equipped with Mark III* Tables."

Cruisers equipped with Mark III* Tables

18. It was considered that if the correct drill was carried out with the existing fire control installations, no correction would be required to range. The ideal to be aimed at was for the T.S. to apply all corrections necessary to allow for own-ship alterations without reference to the control, and thus enable Control Officers to concentrate on observation of fire and enemy movements.

19. As regards deflection, it was considered that quick and accurate working of the calculator would give good results, except perhaps during large alterations of course. Under these circumstances, which involve a large change in deflection, spotting to anticipate the change was recommended, though it was pointed out that care must be taken not to increase the total change in calculated deflection.

20. Experience during 1929 confirmed the suitability of relying on the quick and accurate working of the deflection calculator, but reports were strongly against reliance on the Dreyer calculator. Little information was received as to the suitability of the scale of corrections laid down in para. 16.

21. No definite recommendations were received as the result of experience during 1930, but it was suggested that the proposed corrections were unsound on account of the complication involved in applying such corrections in ships which should maintain a rate of fire of four to five salvos per minute. It appeared more practical to absorb the correction either in a regaining ladder or in a spread either side of the straddling range. This proposal was not concurred in, and attention was called to the Battleship procedure (*see* paragraphs 8 and 9).

22. Opinion during 1931 hardened in favour of the use of the Dumaresq, course being set ahead as the wheel was put over, and opinion was generally against the use of the Dreyer calculator (except when opening fire or when tuning to rangefinders), it being accepted that the effects on M.V. and of slip are approximately opposite and equal.

23. *The final decision* reached was-

(a) Keep the Dumaresq set 20º ahead of the turn until the wheel is put amidships.
(b) Alter own speed settings at the rate indicated by the Forbes log.

Cruisers fitted with A.F.C. Tables

24. No definite information was obtained during 1930, but opinion tended towards the use of 10º of slip angle when using 25º of rudder.

25. A difficulty was pointed out in connection with the speed settings. Forbes logs were fitted which were not very accurate regards actual speed, but could be relied upon to indicate correctly the change in speed. It was considered that the *change* in speed [..] shown was the best means available.

(This difficulty does not apply with Pitometer logs, which accurately record the speed through the water.)

26. Experience during 1931 favoured the use of the Forbes log as indicated above. The allowance for slip had proved less easy, the moment of application and removal was considered to be of importance, and mistakes were easy to make. What evidence there was tended to indicate that slip error was small up to turns of about 40º and, in view of the possibility of making mistakes, it was questioned whether it was really necessary to apply it.

Such information tended to show that a standard slip angle of from 5º to 8º appeared suitable.

27. Information from trials carried out later showed that the magnitude of the slip angle is variable, being chiefly influenced by the tendency of the ship's head at the moment the rudder is put over.

28. *It was directed that* the following procedure was to be adopted:-

(a) Apply a slip angle of 3º when rudder is put over.
(b) Reduce own speed settings at the rate indicated by the Forbes log.

SECTION 2. – COMPENSATION FOR ENEMY ALTERATIONS OF COURSE

15-INCH SHIPS – DREYER TABLES

29. In this case the "wind you feel" does not alter and the change in rate can be applied easily and quickly to the Dreyer calculator.

30. It was suggested that change in range correction consequent on an alteration of course by the enemy should also be ignored because-

(i) The change is partially offset by enemy "slip," though to a less extent than is the case with own ship.
(ii) The occasions on which the alterations of the enemy are seen in time to apply the correction are not frequent, and the drill at the calculator is at present complicated.

31. As a result of the above remarks it was proposed that the Dreyer calculator should only be used before opening fire, or when tuning to rangefinders. While this proposal was concurred in the trial, it was pointed out that the change in

range correction for an alteration of course on the part of the enemy is considerably greater

than that for a similar alteration on the part of own ship and, if no correction is applied by the calculator, allowance should be made by means of a spotting correction, the amount of which must depend on the speed of the enemy and the size of the alteration, when this alteration is observed.

If the enemy is *seen* to alter course, an appropriate spotting correction should at once be given The application of the correction by means of the Dreyer calculator is far too slow.

32. *It was therefore approved that* the change in range correction when the enemy is *seen* to alter course is to be applied in the form of a spotting correction, the size of which must depend on the amount of the alteration and the speed of the enemy.

CAPITAL SHIP – SECONDARY ARMAMENT.- CORRECTION WHEN ENEMY ALTERS COURSE

33. In some firings carried out during 1931it was found that although line was held during a large alteration of course by the enemy range was lost. It was therefore proposed that the Control Officer should make an arbitrary correction for range to allow for change of range in time of flight during the turn.

34. Experience in 1932 was insufficient to justify a definite opinion being given on this point, but one report was that the use of such a correction was liable to confuse the Control Officer and that it was not, in consequence, recommended. It was suggested that if the enemy is seen to be making a large alteration of course, the rate should be forecast.

35. The matter was further investigated during 1933 but no consensus of opinion was reached, although it was agreed that the degree of forecasting will be difficult to estimate. Nevertheless, it was recommended that-

(a) An attempt should be made to forecast the inclination, even if it could only be done approximately to counteract the lag in the effect of change of rate.

(b) That for deflection, the deflection calculator should be ignored and the line kept by estimated spotting corrections. tions. [sic]

36. *Opinion in* 1934 *was generally in favour* of the foregoing proposal.

CHAPTER IV

Defence Against D.C.B.s and C.M.B.s

Section 1.- Repulse of Daylight C.M.B. Attack by Destroyer Screen.

Section 2.- Repulse of C.M.B. Attacks by other classes of Ships.

CHAPTER IV

Defence against D.C.B.s and C.M.B.s

SECTION 1. – REPULSE OF A DAYLIGHT C.M.B. ATTACK BY DESTROYER SCREEN

1. Trials were carried out in 1922 and 1923 to evolve suitable spotting rules for use against these very high-speed targes. A series of practices was arranged to compare the relative merits of "rapid salvos" and single step spotting against a "creeping barrage."

2. The results of the trials showed the former to be infinitely preferable. The latter system involved an error of principle, because data which are known with accuracy, sufficient to make the barrage creep at a proper speed, and in the right direction, should be utilised to hit rather than to miss the target.

3. *The general principles to be followed* are laid down in the "Destroyer Firing Manual."

SECTION 2. – REPULSE OF C.M.B. ATTACKYS BY OTHER CLASSES OF SHIPS

4. Trials were carried out in the latter part of 1921 and 1922 to compare the effectiveness of Pom-poms with a splash barrage from 6-inch guns.

5. The object of the splash barrage was to put down a zone of fire through which the attacking craft would have to pass, and which did not rely for its effectiveness entirely on direct hits. It was hoped to provide sensitively fuzed shell which would burst on impact with the water, setting up a barrage of flying splinters.

6. *The conclusions reached* at this date were –

(a) Single or Mark "M" pom-poms are expected to prove the most effective weapons.
(b) The splash barrage cannot be relied upon to defeat the attack.

CHAPTER V

Aircraft Spotting

CHAPTER V

Aircraft Spotting

SECTION 1. – GENERAL

1. The best method of employing aircraft for observing gunfire and reporting enemy course and speed, has been under investigation since 1918. It was initially a Capital Ship problem, since the number of aircraft available, and the W/T equipment of cruisers, did not permit of their employment, other than experimentally, by the latter type of vessel.

2. The experimental aspect as regards the employment of aircraft reports by cruisers was annulled in 1934, when modified W/T and V/S arrangements for gunnery purposes in cruisers had been decided upon.

SECTION 2.- POSITION TO BE TAKEN UP BY SPOTTING AIRCRAFT

3. Up till 1925 little or no control was exercised over the position taken up by spotting aircraft. It was then found that it had become the habit to fly over the target while spotting fall of shot. As a results the first instructions were laid down, limiting the aircraft to a position approximately over the firing ships, and not nearer than half-way to the target.

4. In 1926 these instructions were elaborated, both as regards position and height as follows:-

(a) Aircraft should fly as high as possible.
(b) As a general rule the height in feet should be not less than half the range in yards.
(c) Consistent with (*b*) above, the spotting aircraft should take up a position about one mile on the lee side of the battle line.
(d) If due to clouds it is not possible to attain the height as in (*b*), aircraft should close the target line well to a flank.

5. These instructions have been subsequently modified on broader lines, which give greater freedom of choice to the aircraft.

(a) The normal position for spotting is on the line of fire, and nearer the firing line than the enemy.
(b) If due to smoke or other reasons the fall of shot cannot be seen by the observer from the normal position, the aircraft is to proceed to a position from which spotting can be carried out.

Experience shows that the nearer the observer is to the target, the greater is his accuracy in reporting fall of shot for range. It is considered that the spotting aircraft should take up the best position attainable at the time for the type of firing being carried out, and it is undesirable to lay down anything more definite.

6. The advantages of the normal position are that a particular target can be more easily identified, and that the upper works of enemy ships may provide a scale on which to base fall of shot reports.

The disadvantage is that it militates against accuracy and, to some extent, speed in course reporting.

SECTION 3. – METHOD OF REPORTING FALL OF SHOT

7. The difficulty of producing an instrument for measuring fall of shot led to consideration as to the possibility of employing clock code for fleet spotting, partly with a view to assisting the observer in course reporting, in opposition to the method then in use which was direct spotting.

8. These trials were carried out in 1925, and it was decided that direct spotting was to be used on all occasions except-

(i) Bombardment.
(ii) When aircraft cannot see both firing ships and target ships at the same time.

9. Subsequent experience showed that although the aircraft had on occasions lost sight of the firing ships, it had never been necessary to revert to clock spotting, no difficulty having been experienced in determining the approximate line of fire.

10. In view of the great advantages of direct spotting in saving of time, the foregoing decision was amended and now stands as follows:-

(i) Against a ship target direct spotting should always be employed, if this is practicable.
(ii) If clock code is to be used, ru north is to be taken as the datum point for 12 o’clock.

SECTION 4. – ACCURACY OF AIRCRAFT REPORTS OF FALL OF SHOT

11. As experience has been gained, the accuracy of reports has steadily improved. In the early stages of the investigation, attention was directed towards the design of an instrument for measuring the distance between the splash and the target, but this project was not successful. Estimation of the distance is now made by judgement based on the height of the mast or upper works as a scale. The […] of the probable spread of salvos as a scale is to be avoided, since these are very variable.

12. It was remarked in 1926 and 1928 that the reports of the initial salvos were considerably less accurate than those of subsequent salvos, and that the error was primarily in the direction of underestimating the distance. This fault seems largely to have been overcome, and the magnitude of errors in estimation now seems to be only dependent on the distance of the fall of shot from the target.

13. Nevertheless, the tendency to underestimate on all occasions which has been frequently remarked upon in the past, still persists.

SECTION 4. – AIRCRAFT SPOTTING RULES

14. The spotting rules to be employed when aircraft observation is available must be largely dependent, of course, on the anticipated accuracy of aircraft reports.

15. Spotting rules to be used when aircraft reports were available have been continuously under revision from quite early in the investigation, and various codes have from time to time been issued. So far, complete agreement has not been reached as to the corrections to be used under various circumstances.

16. As the accuracy of aircraft reports increased, control officers came to place more and more reliance on them, almost to the extent of neglecting the evidence f direct observation. In 1929 it was necessary to issue a caution pointing out that control frequently delayed giving spotting corrections which could have been made on the results of direct observation.

17. The policy regarding control with air observation is that-

(i) If the fall of shot cannot be seen, rely entirely upon the reports from aircraft.
(ii) If the fall of shot is visible, accept the guidance of air reports but do not neglect the evidence of your own eyes.

Furthermore, in all cases the method of control should be such that no change of procedure is entailed if air reports are not available or suddenly cease.

SECTION 6. – RELATIVE IMPORTANE OF FALL OF SHOT AND COURSE REPORTS

18. The relative importance of these two reports has always been a matter of great importance, and the requirements in this respect have been coloured to a large extent by the ability of the ship to estimate these two factors. When aircraft spotting was first considered, ships had no accurate instrumental means of estimating an enemy's course, and in consequence for some years course reporting was given a very high order of priority.

19. Experience in 1926 with the inclinometers then afloat was that the expected of these instruments to detect alterations of course was not confirmed.

Since that date, however, considerable improvements have been made in these instruments, and statistics indicate that they are capable of measuring the course more accurately than an aircraft can estimate it.

20. In 1934, Home Fleet experience during *Centurion* practices indicated that fall of shot reports should normally take precedence over course reports, but that it was necessary continually to impress on observers that ships need an early and accurate course report to assist them in judging the side of 90º, and derive great help from good and rapid course reports, especially when the enemy alters course.

21. Further experience during 1935 in the Home Fleet led to the conclusion that-

> "While fall of shots reports are normally of greater value than enemy course reports, occasions arise when the latter assume greater importance. Missing an alteration of course takes salvos progressively further from the target, while missing one or two spotting reports merely leave the fall of shot where it was, subject, of course, to errors in rate."

22. The consensus of opinion in the Home Fleet was that, in direct fire, it is easier in reasonable visibility to observe inclination from a ship than fall of shot, and that the aircraft's piror task should be to assist the spotter rather than the inclination officer.

23. Mediterranean Fleet opinion generally confirmed the foregoing, and both fleets pointed out the necessity of the ship being able to reverse the order of priority.

SECTION 7. – RANGE AND BEARING FINDING BY AIRCRAFT

24. The necessity for aircraft to be able to provide ranges and bearings of a target invisible to the firing ship has been recognised for many years, the first investigations into suitable instruments being made in 1920-21. Much, of course, depended on the accuracy and reliability of the compass.

25. At the time, a system of measuring the angles of depression from the aircraft, of the firing ship and target, and the angle between them was in use. The instruments were rude, and the lag was considerable, because these data had to be transmitted to the firing ship for computation of the range. No reliance could be placed on the accuracy of the result. It also called for a high degree of co-operation between pilot and observer, since simultaneous observations were necessary.

26. It was promising, however, and development proceeded slowly to 1926, when the same system with improved instruments was still in use, but computation could be made in the aircraft. Development was taking place along the lines of making the system more automatic, and it was also under consideration to investigate the possibilities of evolving a single observer instrument.

27. Opinion in the Fleet gradually hardened against the gear employed – for various reasons such as weight and complication – and attempts were made to evolve a simpler and lighter instrument. A combined horizon and bubble rangefinder came into supply in 1931. A further type, Plan Rangefinder, Mark II, was issued to certain units in 1932.

28. It is now normal for aircraft to estimate both range and bearing from a position immediately over the firing ships.

CHAPTER VI

The Value of Long Range Fire

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The Value of Long Range Fire

1. In order to collect date with regard to the effectiveness of fire at long ranges, *Nelson, Rodney, Hood,* and 8inch cruisers commenced in 1934, carrying out a certain number of practices at ranges of 23,000 yards and upwards. The problem is primarily a capital ship one, but the 8-inch cruisers were associated with the investigation in order to provide more data.

2. To date, these practices have necessarily been confined to target and throw-off firings, from both types of which there is a danger of drawing false conclusions. In throw-of firings the spotting is unrealistic; in target firings, "enemy" movement is not comparable with that of an enemy ship.

3. The problem is still under investigation. Opinion appears to be trending towards-

(i) That aircraft spotting will be a requirement whether or not the target is visible to the firing ship(s).
(ii) That the difficulty will be to keep salvos on the target, both for range and line, in view of the greater effectiveness of avoiding action at long range.
(iii) Nevertheless, the expenditure of a limited amount of ammunition may be justified in view of the serious damage which may be inflicted by one or two hits from "plunging" fire.

CHAPTER VII

Concentration of Fire in Capital Ships

Section 1.- War Experience.

Section 2.- Master Ship Control v. Individual Ship Control.

Section 3.- Position of Master Ship and Datum Ship.

Section 4.- Method of obtaining the best Rate of Hitting.

Section 5.- The Firing Signal.

Section 6.- Breakdowns in Communication in Master Ship Control.

Section 7.- Concentration on Enemy Turning Point.

CHAPTER VII

Concentration of Fire in Capital Ships

SECTION 1. – WAR EXPERIENCE

1. In the earlier days of the War, 1914-1918, little was known about fire concentration, although ships had on occasions fired in company.

2. The primary object in view in target practices in 1915 was to develop single ship efficiency to the highest attainable point, based partly on the factor that the British Fleet was numerically not greatly superior to the German High Seas Fleet. Because of the results of the Dogger Bank action, renewed attention was given to pair-ship concentration, and the, up till then, accepted maxim that "no enemy ship must remain unfired at" was thrown open to doubt.

3. Later, as the relative numerical strength of the British to the German battle fleet increased, still more attention was given to the question, and the problem became one of reliable intercommunication.

The Battle of Jutland then intervened and showed that-

(i) *Apart from numerical superiority, the conditions of battle may offer good opportunities for fire concentration.*
(ii) *That to be effective, a strictly disciplined system of fire distribution is essential to success.*

4. The new system of control regulated by standardised rules was a big step towards simplifying concentration. This was further facilitated by the provision of W/T sets for gunnery purposes during 1917.

5. After a period during which each division investigated the problem according to its own ideas, rules for concentration were drawn up in the autumn of 1917, based on what is now known as Individual Ship Control.

6. Considerable attention has since been paid to this problem and the various major items are summarised under their separate headings.

SECTION 6. – MASTER SHIP CONTROL (GMS) AND INDIVIDUAL SHIP CONTROL (GIC)

7. When concentration was introduced for Capital Ships, a reliable and rapid line of intercommunication was not available, since W/T for this purpose had not been sufficiently developed. Doubt existed as to whether intercommunication could be depended upon in battle, and the funnel smoke in coal burning ships was too dense to allow of visual methods being employed with any certainty.

"GMS" was tried, but, partly owing to the dislike of placing the control of the fire of a number of ships in the hands of one man, and also to the above defects, it was held to be impracticable.

Individual control, firing double salvos, was therefore developed. Mutual interference to spotting by each others fall of shot led tot eh adoption of time sectors, which were allocated to individual ships, and during each one of which only one shp might fire. Intercommunication of results was arranged for. It was decided that the cycle of sectors should be completed every minute and in a four-ship concentration the individual sectors were of 15 seconds duration, in a three-ship 20 seconds and in pair-ship concentration 30 seconds.

8. Confusion of fall of shot still occurred with sectors in use, as a ship which fired towards the end other sector was apt to clash with the ext ship to fire. Improvement in "fall of shot" devices, though helping the identification of each ship's salvos, did not render spotting, either from the air or direct, any easier if two salvos fell nearly simultaneously.

None of the foregoing sectors allowed a 15-inch gun ship to develop her full output – 3 salvos per ship per minute – and efforts were directed towards improvement in this respect. The two methods tried were neglect of sectors and shortening the sectors. In both cases confusion of fall of shot occurred sooner or later, and, under action conditions this confusion would almost certainly be more frequent and have more severe effects. Moreover, although shortened sectors allow of the full potential output being obtained they limited the maximum range at which this form of firing could effectively be used. For instance, in a pair-ship concentration using 30-second sectors, and allowing 10-15 seconds for observation of fall of shot of both salvos of a double, application of corrections and firing of a double salvo in the next sector some 35-40 seconds remained available for time of flight. This fixed the maximum 15-inch range at about 22,000 yards. Any longer time of flight encroached on the next sector, and soon led to a sector being missed, or to only one salvo of a double being fired in it. With the same conditions, but with 20-second sectors, pair-ship concentration could not effectively be used much above 14,000 yards.

10. It was then suggested that broadsides would solve the difficulty, but, after trial, this was abandoned, owing to the heavy strain thrown on the hydraulic machinery, and to the fact that a broadside could bot be spread on either side of a snap R.F. reading, or of an aircraft report, and that salvos indicated more quickly an error in rate, or served better to confirm a doubtful fall of shot.

11. Trials of master ship control having been dropped in 1917, were re-opened in 1918, and improvements in W/T communication permitted their continuance. It was stated in 1921 that this was the most successful system so far evolved for the concentration of three or more ships on one target.

12. The master ship signalled the range for each salvo, and gave the order to fire whilst consorts corrected the signalled range for P.I.L. and applied and corrected their own deflection.

At first P.I.L. difficulties caused large spreads to be obtained, but the supply of modern and accurate gear for calculating this correction brought spreads down to a reasonable figure.

13. It was found that confusion of fall of shot caused deflection mistakes, and, after considerable experimenting with the firing signal, it was proved to be practicable for the master ship to control both the range and deflection, and still achieve a divisional output of one salvo every 20 seconds. This is superior to any result that can be obtained by "GIC" and, so long as the divisional spread can be kept small, "GMS gives the better chance of hitting since the density of shots in a straddling salvo is greater than that obtained in "GIC."

14. The principle drawbacks to "GMS" are the difficulty of direct spotting on a salvo which may contain as many as sixteen 15-inch splashes, and the delays that may occur owing to any failure of communications in master ship or consorts.

With regard to the latter, a satisfactory procedure has been evolved which minimises the delay to be expected.

As regards the former, the difficulty is largely overcome if air spotting is available, and, since heavy concentrations will normally be employed at the commencement of an action, it is reasonable to suppose that this will be the case.

15. When H.M. ships *Nelson* and *Rodney* began concentration practices, it was found that the difficulties of direct spotting in "GMS" on nine 16-inch splashes were so great that control of fire was badly handicapped, and was impracticable without aircraft spotting. Moreover, the design of the 16-inch mounting rendered it necessary to fire a double salvo before re-loading could be commenced, and the use of divisional double salvos, with the consequent delay between successive salvos reduced the rate of fire to an extent that

was unacceptable. These ships therefore have developed "GIC" as their normal method. This has the further advantage that in the event of a 15-inch ship being ordered to join in their concentration, the difficulties inherent in using two different natures of gun are minimised.

Conclusion

16. "GMS" is the only method of concentration under which the full output of a number of ships can efficiently be used. It suffers from the difficulty of applying such a large number of shots effectively, but this can be overcome by aircraft spotting. It also has the disadvantage that a mistake by one officer or rating in the master ship may have a disastrous effect. Mistakes in any type of firing will have bad effects, and the chances of mistakes should not be allowed to outweigh the enhanced efficiency obtained by "GMS" if mistakes do not occur.

17. Should errors during "GMS" be such as to cause the Admiral or Master Control Officer to doubt the effectiveness of the concentration its degree can be reduced of "GIC" reverted to.

SECTION 3. – POSITION OF MASTER AND DATUM SHIPS

18. In 1920, when "GMS" was being developed, it was considered that one of the middle ships of the concentration should act as datum ship, the master ship being the Senior Officer who would usually be leading.

19. This was elaborated in 1921 as under:-

Master Ship.- The Senior Officer, but a ship other than the former would be detailed if necessary.

Datum Ship in "GMS" was to be the centre ship of the concentration, or that ship of the senior subdivision nearest to the junior subdivision.

At this time when in "GIC" there was no datum ship, and all signals were corrected for P.I.L. by the recipient, according to the relative position from her of their originator.

20. In 1928 the position had become-

Master Ship.- Divisional or Subdivisional leaders depended upon the degree of concentration. In event of breakdowns the net ship in the line was to take over. All ships were to be equally capable of carrying out Master Ship duties.

Datum Ship to be the Master Ship, or, in "GIC" the leading ship of the division, irrespective of the degree of concentration.

21. In 1930 it was pointed out that it was our policy to concentrate fire on the leading ships of enemy division, and that there was little reason to doubt that an enemy would adopt the same

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policy. It would probably occur, therefore, that the leading ship of a division would be unfavourably situated for controlling and observing the fire of her division, owing to the enemy fire directed at her, whereas the second ship might be unfired at. There were many advantages in a flagship leading her division, but no real necessity for her to be Master Ship.

22. It therefore appeared sounder for the second ship to be Master Ship, and this would have the additional advantage of reducing the datum distance from the rear ship thus conducing to more accurate P.I.L. correction.

It was appreciated that the necessity for being able to obtain P.I.L. correction abaft the beam would entail alterations and possibly an increase in complement.

At the same time it was pointed out that, in the event of a division engaging two targets by pair-ship concentrations in "GMS" the datum ship of the rear subdivision must be changed to the leading ship of the division if this subdivision has to revert to "GIC." It was therefore decided that datum ship in "GIC" was to be the leading ship of the concentration.

23. Trials with the second ship acting as Master Ship showed that no difficulties arose, and that under normal condition the concentration was very nearly as efficient as when the leading ship was Master Ship. It was held, however, that experience pointed to the desirability of the leading ship in action being Master Ship, but that the second ship take over this duty if the leading ship was more heavily engaged than the remainder.

24. Differences in construction between battleships and battle cruisers led to the following decisions as to the position of the datum ship.

Battleships.- The leading ship of the concentration.

Battle cruisers.- The Master Ship.

SECTION 4.- METHOD OF OBTAINING BEST RATE OF HITTING

25. Neglecting the question of spotting rules, which are considered separately, various methods of achieving the best rate of hitting in Master Ship concentration have been put forward.

26. At the end of the war it was thought that, when the target had been found, all ships should fire salvos at their maximum rate, regardless of attaining simultaneous divisional salvos. This method of firing was termed Master Ship Independent, "AFR," and it led

to a more or less continuous fall of salvos. This, although it might produce the highest possible output from the firing ships, suffered from the following disadvantages:-

(i) Direct and Indirect spotting was rendered difficult owing to the continuous fall of salvos with no definite intervals.
(ii) It was difficult to control the fire effectively since there was no silent period.
(iii) The possibility existed of confusion to the control, owing to the uncertainty as to whether a given salvo carried a spotting correction or not.

The Divisional spread would also be thereby increase and false straddles resulted.

27. Trials confirmed that the total output in Divisional Rapid Salvos was equal to that obtained in "AFT" and that the former had the additional merit of obviating the disadvantages given in (i) to (iii) above.

In Divisional Rapid Salvos with 15-inch mountings, it was found that a salve fired every 20 seconds gave the maximum output possible from the guns, and the advantages of this regular 20-second salve interval were:-

(a) It allowed of regular and disciplined firing.
(b) As all salvos from the concentration unit fell at nearly the same time, the tasks of the Master Ship spotting officer and of the aircraft observer were much simpler.
(c) The regular fall of divisional salvos at short intervals made it difficult for the enemy to take avoiding action by snaking the line.

SECTION 5. – THE FIRING SIGNAL

28. When "GMS" first came into use the maximum rate of fire ("AFR") was obtained without regard to the speed of signalling, and the length of the firing signal was not of vital importance, although it increased the normal interval between the salvos of Deflection and Range doubles.

29. In 1924 the position was that the Master Ship could order either of two methods of firing which depended on an executive signal from her:-

Divisional Salvos.- Signal "OSF," 3-figure range group.
M.S. Independent.- Signal "AFT," 3-figure range group every 15 seconds.

30. Following the *Monarch* firing in January, 1925, the introduction of Divisional Rapid Salvos, and of Master Ship control of deflection as well as range, led to the length of the firing signal assuming great importance. The firing signal in tis present form emerged:-

> Deflection and range are made, followed by the "OSF" signal; a pause is then made to allow consorts to apply these data, and an exceutive [sic] dash is made. On the receipt of the latter, all ship's rig their fire gongs. This method gives latitude to the Master Ship to fire slightly early if it is required to test the fall of the Master Ship salvos alone.

31. In 1927 the following methods for shortening the firing signal were tried:-

(a) Either Range of Deflection could be made first at the discretion of the Master T.S. officer.
(b) Deflection could be omitted if it had not altered since the last signal. Range was always to be included, even if it had not changed, as otherwise confusion might result owing to the receiving ship being doubtful whether or not a complete signal had been taken in.
(c) The Master T.S. officer was to work the firing intervals from the Transmitting Station, ordering the firing signal to be made at regular intervals when firing Divisional Rapid Salvos. The Control officer could order both steps of a ladder at the same time.

32. In the Firing Manual issued in December, 1928, the firing signal was definitely laid down. It consisted of four components:-

(i) Range. 3 figures, e.g.: 090, 138, 210.
(ii) Deflection. e.g.: L03L, R27R, L00L.
(iii) Master Ship identification letter.
(iv) Executive sign.

(i) and (ii) were employed as laid down in (*a*) and (*b*) above.

(iii) was a single letter designating the ship originating the signal, and (iv) was a long dash of four seconds' duration. The length f this dash was designed to allow for sigh setting in consorts, and its termination was to be accepted by all ships as the exact instant for ringing their fire gongs. Ships might fire at any time up to five seconds after the termination of the Executive sign.

33. In 1929 the Divisional Call sign had been added to the firing signal and criticism was again directed to the length of the signal.

It was proposed to omit the Divisional Call sign, and the 4-second Executive sign, and to make the end of the Master ship's identification letter the executive signal for ringing fire gongs. The interval

between the Range of Deflection and the letter would be adjusted according to the degree of efficiency which had been reached by the ships taking part.

34. In 1931 the preliminary nought in single fire deflections was omitted for trial, and "T" was used for nought in ranges of less than 10,000 yards. These modifications were adopted in 1932, the "T" being used for all noughts in the range component.

35. The present state of the firing signal is as follows:-

The firing signal consists of:-

(1) Range.
(2) Deflection, if required.
(3) Self-evident letter of master ship.

If both range and deflection are passed, the order in which they are placed in the signal is optional; when the deflection changes it should be included in the firing signal following that in which the new deflection was made, as a precaution against incomplete reception when first transmitted.

The self-evident letter is to be preceded by a pause of about 3 seconds for sight setting, and the termination of this letter is the executive signal for all ships to ring their fire gongs.

The extent of the firing time is not exactly defined.

SECTION 6. – BREAKDOWNS IN COMMUNICATION IN "GMS"

36. The conclusions set out below were arrived at after trial in capital ships, but are applicable also to other classes of vessels.

37. In 1924 investigation was directed to the solution of the following problems:-

(a) Procedure to be adopted by a division in "GMS" if all communications with the Master Ship fail.
(b) As in (*a*) if a consort fails to receive any information from the Master Ship.

38. Preliminary investigation was directed to the trial of some visual device, such as a cone worked from the control position, to denote the failure of communications. It was considered, however, that this was not a sufficiently reliable or evident method, and that so long as the free Aldis lamp remained available in the control it was the most effective channel.

39. "GIC" was felt to be the solution of a general failure of communication from the Master Ship pending the taking over of control by her next astern.

40. Any failure to receive by a consort could be met by that ship engaging another target or attempting to fit in her salvos on the original target between those of the division. It was considered that such interposition would cause confusion sooner or later, and that, failing another available target, the ship affected should withhold her fire.

41. Trials carried out in 1927 enabled the following conclusions to be arrived at:-

> "A consort whose G.C. W/T fails should remain in the concentration using V/S, provided that the master ship dials or lamp can be read direct. Any ship withdrawing from the concentration for any cause should open fire at the nearest disengaged target, or withhold her fire should such not be available.
>
> N.B.- This points to the desirability of allotting at least two targets to each division in the original distribution of fire signal.
>
> "A ship quitting the concentration and engaging a fresh target should not limit her ire to her "GIC" sector.
>
> "Should no signal be received from the Master Ship for 40 seconds and the remainder of the division are withholding their fire, the second ship should at once assume master ship.
>
> "Further failures should entail "GIC" throughout the division."

42. If the concentrating unit consisted of two ships the situation would naturally best be met by a resort to "GIC" whether the failure at 37 (*a*) or (*b*) had occurred, since it would probably be difficult to decide which of the two ships was responsible for the failure. Further experience resulted in the following instructions being embodied in the "Firing Manual, 1933":-

> "If W/T communications fail, it is not desirable to attempt to continue 'GMS,' using the visual alternatives.
>
> In a concentration of 3 or more ships, a consort experiencing a failure in communication must shift her fire to a disengaged target, or, if one is not available, must withhold her fire until the situation is cleared up.
>
> In a concentration of 3 or more ships, if the Master Ship's transmission fails, the next astern is to assume Master Ship. If the original Master Ship is still able to receive she will act as a controlled ship, otherwise she must proceed as for a consort whose communication has failed.
>
> In a pair-ship concentration, should the consort fail to receive signals she should inform the Master Ship by all available means, and should reopen fire in "GIC," endeavouring to fire her salvos as far out of synchronization with those of the Master Ship as possible.

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SECTION 7. – CONCENTRATION ON ENEMY TURNING POINT

43. Investigation of this problem was carried out by capital ships between 1925 and 1929.

After the initial firings it was considered that two methods could be used:-

(a) *In good visibility*.- Fire at each individual ship in turn as she reaches the turning point. Assuming air spotting is available, this should be carried out in the normal manner, the aircraft being informed each time target is shifted.

(b) *In bad visibility*.- Fire at the end ship visible at any moment. Air spotting should be confined to spotting on to the mid-point of the turn, paying particular attention to line.

44. At the end of 1928 the conclusions were summed up as follows:-

There are three possible methods of attacking the problem:-

(i) To concentrate on one enemy ship throughout, either the leading or rear ship being the most suitable.

(ii) To concentrate of each individual ship in turn as she reaches the turning point.

(iii) To direct the concentration against the geographical spot on the turning circle through which enemy ships will have to pass.

Method (iii) has been more generally used to date. It has the advantage of simplicity; spotting is unnecessary and full rate of fire can be developed. It does suffer, however, from the disadvantage that only a proportion of salvos fired can be effective.

Methods (i) and (ii) should theoretically give better hitting results, as fire is aimed at one particular ship. The procedure is more complicated, however, and successful results will depend to a large extent on visibility, ability to spot, and also t keep the correct point of aim under difficult conditions.

45. It has been pointed out that it will probably be a rare occurrence for the enemy to cay out a large turn in succession, and therefore that no elaborate organisation is justified in order to deal with an improbable tactical situation. Further, any organisation should satisfy requirements for both goo and bad weather conditions.

46. Taking all the above points into consideration, *it was considered that* method (iii) was the most likely to meet requirements under all conditions.

CHAPTER VIII

Concentration of Fire in Cruisers

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SECTION 1. – WAR EXPERIENCE AND POST WAR DEVELOPMENT

1. It was generally accepted that cruisers were normally spread, and were therefore unlikely to be called upon to fight more than a single-ship action. During the period May, 1916, to November, 1917, cruisers squadrons were used more frequently in subsidiary operations in which they were manoeuvred in close order, and the problem of concentration (which had hitherto been mainly considered from the point of view of two ships *not* in company engaging the same target when intercommunication was valueless) began to be seriously considered and intercommunication studied.

2. On 17th November, 1917, a cruiser action was fought in which our ships greatly outnumbered the enemy, and heavy concentrations were necessary.

Progress

3. As a result of this action, the problem of concentration was vigorously pursued. With a maximum output o six salvos per minute, it was obvious that any form of sector firing was too unwieldy, and would restrict the rate of fire to a extent that was unacceptable. The alternatives were “GMS” or neglect of sectors in “GIC.” The latter was tried, but, even with only two ships, and against B.P. targets in clear weather, it caused the expected confusion in fall of shot, and, for a heavier concentration, was quite impracticable. It was therefore abandoned. “GMS” as developed, and, although the short salvo interval puts a very high premium on effective intercommunication, it has proved efficient. In 8-inch cruisers the rate of fire is also sufficiently high to render “GIC” with time sectors impracticable.

4. *It is therefore considered* that, for cruisers in close order, or at distances from each other where P.I.L. correction can be calculated and applied, “GMS” will give the best results when concentration of fire is required.

5. The foregoing remarks cover the broad aspect of cruiser concentration, irrespective of the numbers concerned, but they suppose homogeneity of a squadron, both in armament and fire control equipment.

6. Post-war construction has resulted in the cruiser forces of the Navy being composed on 8-inch gun cruisers having the same type of fire control equipment, cruisers with modern 6-inch guns, but not homogenous as regards fire control, and older 6-inch cruisers with old 6-inch guns and fire control arrangements.

Further, cruisers are frequently separated yet so placed as to enable two or more to engage simultaneously a single target, under conditions beyond the scope of P.I.L. arrangements.

7. The present problem of cruisers acting in mutual support thus divides itself into three circumstances:-

(a) In close formation, with normal concentration procedure, namely, Master Ship control.
(b) In close formation in close order under conditions when normal concentration procedure is not possible. (*See Section 2.*)
(c) Widely separated, i.e., lines of fire differing by 30º or more. (*See Section 3.*)

8. (*a*) Calls for no special comment since it is covered by the remarks in paragraphs 3 and 4.

SECTION 2. – CONCENTRATION IN CLOSE FORMATION WHEN NORMAL PROCEDURE IS NOT SUITABLE

9. It may be said now that this situation might arise from:-

(i) Failure in communications.
(ii) Smoke interference.
(iii) Ships fitted with different types of fire control apparatus.
(iv) Ships mounting different calibres of guns.

10. In the initial stages (1926) of this problem, the matter was solely on of concentrating with 7.5-inch and 6-inch guns. "GMS" was used, but varying success was obtained, owing to the difficulty of making the two range together. The differences in ranging were attributed mainly to unknown ballistic and range table errors, and to differences in range correction. Further difficulties were foreseen when the 8-inch cruisers, with their very different fire control tables, came into commission.

11. In 1930 the problem was reviewed in the light of experience gained 1926-1929 and was withdrawn. The situation was summarised as follows, but it should be noted that I covers only 7.5-inch and 6-inch guns which had the same fire control tables :-

(i) No reliance can be placed on distinguishing between 7.5-inch and 6-inch splashes

(ii) It is unsound to develop a system of concentration dependent on ability to do so.
(iii) It is unsatisfactory to develop a second method of concentration for use in special circumstances.
(iv) Provided arrangements are made for known ballistic differences to be applied, a reasonable spread is probable.

12. The decision was given that Master Ship Control is to be used where ships armed with different natures of guns are required to concentrate.

13. This closed the question as regards the old 7.5-inch and 6-inch cruisers, and, as such, the situation no longer arises, with the re-armament of the 7.5-inch cruisers.

The problem was re-opened in 1933 with respect to 8-inch and 6-inch guns. Here the problem is still more complicated since both guns and fire control tables differ.

It was pointed out that firings of this type necessitate the intercommunication of true range, for which neither tables are equipped. After enumerating the difficulties to be met, it was stated that the use of "GMS" concentration by ships armed with different natures of gun had been definitely abandoned.

14. Experience from 1933-35 tends to show:-

(i) That accurately calibrated time of flight instruments are not of sufficient assistance to prevent confusion arising.
(ii) No reliance can be placed on differentiating between 8-inch and 6-inch splashes, though when the two natures are concentrating it may be possible to distinguish the 8-inch which themselves are liable to obscure the 6-inch.

15. *The problem has thus become:-*

"If two cruisers in close order simultaneously engage the same target under conditions when normal concentration is not possible, what form of fire discipline, to avoid confusion of fall of shot, will cause the least reduction in output?"

It is suggested that consideration be given to a form of individual ship control without time sectors, in which the leading ship develops the maximum volume of fire, and the second ship endeavours to fire a few seconds after the leading ship. (cf procedure for O.O.Q. firing in destroyers.)

It is also desired to try intercommunication of ranges and deflections between 8-inch and new 6-inch cruisers, i.e., those with modern types of fire control equipment.

SECTION 3. – CONCENTRATION BY CRUISERS WIDELY SEPARATED

16. This subject is bound up with flank marking and investigation was commenced after the war with the object of providing an organisation whereby-

(i) A cruiser could report the fall of shot on an enemy engaged by other of our forces.
(ii) Cruisers when not in formation could develop an effective fire against a common target, aided by mutual fall of shot reports.

17. Preliminary investigations tended to show that the results obtained from flank marking were generally so unreliable that the deliberate weakening of a squadron by the employment of one ship for this duty was not advocated.

As, however, a ship might find herself in a suitable position, the organisation for flank marking must exist.

Flank marking was to be regarded as outside observation, and the W/T procedure for aircraft was to be used.

18. Certain principles were held to have been established as a result of the 1925 practices:-

(a) The utility of flank marking by a ship conveniently placed is unquestionable, and therefore a simple organisation for the purpose should exist in all cruisers.
(b) A ship in action must devote all her efforts to beating her immediate opponent, and the flank-marking organisation must therefore be kept separate from the main and H.A. controls.
(c) Ships attacking the same target should not flank mark once both flanks are in action, unless it is quite clear that the other ship's fall of shot is much in error. The reason for this is the confusion that is bound to result in identifying signalled fall of shot. Flank marking is likely to be the most useful at the commencement of an action, when it is probable that the fall of shot is not near the target.
(d) The principle that a ship within range of the enemy should withhold her fire is unacceptable. Cases where it is undesirable for a detached ship to interfere with a very superior concentration against a weak enemy are best met by the Senior Officer ordering that ship to withhold her fire and flank mark.
(e) Flank-marking reports should not be made unless the observation is certain.

(f) Communication of flank-marking signals should normally be by W/T, with S/P as a second line.

(g) Flank marking should not be employed where air spotting is available, and precautions are necessary that aircraft signals are not interefered [sic] with.

19. It was then suggested that, where only two ships were concerned, it would be preferable for them to separate and flank mark for each other rather than to concentrate in "GMS." The fallibility of the communications for the latter method was put forward as the reason. Subsequent experience has shown that better results are much more probable when "GMS" is used, but that the tactical situation must govern the action taken.

20. A summary of the conclusions reached was embodied in the "Firing Manual, 1928," and was as follows:-

(i) The tactical situation may require two or more cruisers who are widely separated to concentrate their fire on one enemy ship.

(ii) Experience has shown that when the lines of fire of two cruisers are separated by an angel of about 30º or more, both ships are able to develop an effective fire, notwithstanding the occasional confusion in identification of fall of shot which is bound to occur. Moreover, they may be able to give each other valuable assistance by reporting their consort's fall of shot.

(iii) Although flank marking may be of considerable value, the performance of this duty is on no account to interfere with a cruiser using her own armament to its full effect against the enemy, or suing her W/T or V/S equipment for making "enemy" or other important reports.

(iv) A cruiser may also be in a position to give valuable assistance to any unit of the fleet by flank marking for them on an enemy ship which she herself is not engaging.

(v) An organisation for giving effect to the above is to be prepared and practised in all cruisers. The concentration personnel should be employed for flank marking as far as possible, using the fore bridge or after control position. The observing officer must necessarily be one who has some other duty and flank marking must not interfere with his performance of this duty.

(vi) W/T communication will not usually be available, and V./S must therefore be looked on as the normal method, suing a searchlight; with W/T occasionally available as a better method.

(vii) The following instructions for concentration by cruisers when widely separated are to be complied with:- A cruiser within effective range of the enemy is not to withhold her

fire in order to facilitate flank marking, or to avoid temporary confusion in the fall of shot unless ordered to do so by the Senior officer. A situation in which the Senior Officer would be justified in ordering a detached ship to withhold her fire and flank mark, is where a very superior concentration is engaged against a weak enemy.

(viii) A cruiser, who is herself engaging the enemy on whom she is flank marking, is only to make a report when she is certain of correctly identifying the fall of shot. Reports which are not absolutely reliable are of negative value.

(ix) Reports of the enemy's course should not be made unless in a position to measure them accurately, such as when the enemy is end on or nearly so.

(x) Flank marking should not be carried out when aircraft observation is available, and precautions are necessary that aircraft signals are not interfered with.

21. Experience to date led to the conclusion that the after control is the most suitable position for carrying out flank marking for the following reasons.

(i) The existing secondary control personnel and after concentration party can be utilised.

(ii) The flank-marking officer is in close touch with the searchlight used for passing reports.

(iii) Communications already exist between the primary and after control position, and these are adequate.

(iv) Interference, except from cordite and funnel smoke, is at a minimum as compared with a position on the fore bridge.

Experience had shown, however, that an alternative line of communication might be necessary due to the limited effective arc of view of the after searchlights on extreme forward bearings. G/C W/T should be used for flank marking reports if this is not already in use by other ships.

22. After review of the practices carried out in 1931, the problem was considered to have been investigated to a sufficient extent, and final conclusions were drawn and inserted in the "Firing Manual, 1933." These conclusions agreed with those given in paragraph 20 (i), (ii). (iii), and (iv).

23. As regards paragraph 10 (v) and (vi), the revised conclusions read:-

"In most cases it will be found advantageous to employ the after control personnel for the observation of consorts' fire; transmission of reports should be made by the Fire Control W/T set when available, and, when not available by signalling projector. The latter method is subject to interference by gun blast."

24. Paragraph 20 (vii) to (x) inclusive were re-drafted as follows:-

Instructions governing the transmission of flank reports-

(a) Not to be made if aircraft spotting is in use.
(b) No report should be made unless it is certain that the salvo has been correctly spotted and identified.
(c) Delayed reports are of negative value and should be withheld.
(d) If more than two units are engaging the same target signals should be addressed, and bear their source of origin.
(e) Enemy course reports should be made only when the reporting ship is in a position to make an accurate observation.

In order that delays shall not occur, the communications, particularly when V/S is being employed, need to be highly organised.

General Considerations

25. If the tactical situation admits a choice, and definite instructions are not received from the Senior Officer of the unit, a detached cruiser, when practicable, should avoid the maintenance of a position unfavourable alike for cross-fire or concentration. Whilst recognition is to be accorded to the general principle that a ship within range of the enemy should not withhold her fire, circumstances will arise in which such action may be desirable; a detached ship, for example, might withhold her fire and mark, in place of joining a superior concentration against one enemy vessel.

26. *The general conclusions reached* are as follows:-

(a) Cross-fire by cruisers widely separated and the use of flank-marking signals to assist in establishing early hitting, presents no great difficulty provided that-
  (i) The necessary communications are organised and have been exercised.
  (ii) Ships go into “GMS” or “GIC” when the angle separating them, as measured at the target, falls below 30º.

(b) Situations may be expected to arise, such as when cruisers are engaged in a sweep, or are stationed on the A-K line, when this form of firing may be effectively used.

(c) The decision as to whether they should close and concentrate in “GMS” must naturally rest with the Senior Officer. Should he decide to do so, however, it should be realised that whilst closing, when the angle separating the ships has fallen below 30º, the effectiveness of cross-fire, and the value of flank reports will rapidly diminish.

(d) Communications for passing flank reports should be by G/C sets with a secondary visual line.

(e) The value of the angle separating the ships is indicated by the bearing P.I.L. correction, which is obtainable up to 30º.

(f) Flank signals should be regarded as a secondary aid, to be used with discretion.

SECTION 4. – POSITION OF MASTER SHIP AND DATUM SHIP

27. The condition under which concentration of fire by these vessels may take place differ considerably from capital ships. The situation may be expected to change more rapidly, and the ships may be joining or quitting the concentration unit at undefined moments.

28. The Master Ship has always been the datum ship for the above reasons, and also because restriction of space and of personnel in cruisers makes the complication of having the datum ship other than the Master Ship undesirable.

29. In 1919 the leading ship of the concentration unit took Master Ship. If another ship joined one already engaging the enemy, the latter remained Master Ship until a further signal was made.

This was amended in 1924 as follows:-

(1) If a group of ships is ordered to engage the same target the Senior Officer will assume Master Ship unless otherwise ordered.

(2) When a group of ships is engaging an enemy, the Master Ship of that group retains the duty irrespective of what ships join subsequently.

(3) When a single ship is engaging a target that ship becomes Master Ship if any other ships join in.

(4) A ship that has assumed master ship does not relinquish the duty on alteration of course, unless ordered to do so by the Senior Officer, or because she wishes to turn over the duty to another ship who is in a better position to observe.

30. In 1933 the above arrangement was amended as regards (1) as follows:-

The senior ship of the concentration will normally be Master Ship. The organisation must be so flexible, however, that this duty can be taken over by the ship that is most favourably situated, taking into consideration the distribution of enemy gunfire and other circumstances.

31. It is probably that the leading ship of a division will be more heavily engaged by the enemy than the remainder; it may therefore be preferable to arrange previously for the second ship to act initially as Master Ship for the division.

SECTION 5. – METHOD OF OBTAINING THE BEST RATE OF HITTING

32. Master Ship Independent ("AFR") was, as in capital ships the accepted solution at the end of the war. Ships were not to check fire because their own salvos could not be distinguished. The fact that any range corrections applied during "AFR" might increase the spread was at that time looked on as an advantage rather than otherwise, since the target would thereby be more easily retained. At this time, 1922, it was widely held that Independent was the most effective form of fire for cruisers firing as single ships and desiring to obtain the maximum output. Trials in the case with Rapid Salvos showed, however, that the regular and disciplined fire obtain by their use more than offset any slight loss in total output. Rapid Salvos were therefore adopted for single ships, and the procedure became one in which the Transmitting Station rang the fire gongs at a fixed time interval, after the previous rapid salvo had been fired, irrespective of the number of guns then at the "Ready." This time interval was to vary with individual degrees of efficiency, an done of eight seconds was accepted as the standard for an efficient 6-inch cruiser under good conditions.

33. Master Ship Independent continued to be the method in concentrations when the target was found, each ship firing Rapid Salvos. The confusion in range which was found to result after the reverse correction, if any, at the end of a range ladder, due to consorts commencing "AFR" before receiving this reverse correction from the Master Ship, was to be avoided by the Master Ship not making the signal "AFR" until she had fired her first salvo with the corrected range.

34. Cases of this confusion in range over the initial salvos in "AFR" continued to occur, and in 1930, destroyers having already abandoned "AFR" in favour of Divisional Rapid Salvos, a trial was given to the latter method.

As might be expected the gain in steadiness and fire discipline was so marked that they were immediately adopted and, rather than a loss of output being the result, a gain was obtained.

SECTION 6. – FIRING SIGNAL

35. Until W/T in cruisers was sufficiently developed to be available for Gun Control purposes, reliance had to be placed on visual methods, and little progress could be made with any definite form of firing signal.

36. In 1928 W/T was available generally, and it was laid down that the Master Ship was to make a Gun Control signal (F.D.S., D.E.F., et.) with range and deflection for each salvo before the target was found. Consorts were to fire the Deflection and Range salvos with the astern Ship, being careful not to fire unless they could do so before the Master Ship fired her next step. At this time visual means such as semaphores were in use for passing the Gun Control signals, and it was questioned whether it was necessary to overload the G/C. W/T line with these signals. Without them Range and Deflection, plus the call sign in a signal were not long enough to slow up ladders unduly.

37. With the adoption of Divisional Rapid Salvos a firing signal for every salvo became necessary whether in deliberate or Rapid, and consideration was given as to the form it should take.

Gun Control signals were to be omitted, as was also the divisional call sign, and the signal became that in use by capital ships, Chapter VII, paragraph 35, the 0 being omitted in single figure deflections.

SECTION 7. – CONCENTRATION OF FIRE AGAINST ENEMY DESTROYER FLOTILLAS

38. Investigations were initiated in 1920 into the best method of cruisers dealing by gunfire with a flotilla of destroyers attacking the battle fleet. (Cruisers were armed with four, five, or six 6-inch guns – destroyers with four 4-inch or 4.7-inch guns.)

39. Experience gained in 1921 pointed to the fact that concentration of gunfire against attacking destroyers was necessary, and that as a general rule ships should concentrate in pairs. Any larger degree rendered the spread liable to increase without increase in the density of the fall of shot. On the other hand, it was said that the large spread of four ships might envelope ore than one destroyer.

40. A conclusion was also drawn, that, unless the tactical situation precluded it, the range should not be closed below 10,000 yards. If, at any time, the range was below this, single sip action should be the rule. The relatively powerful armament of the modern destroyer was a factor in reaching this conclusion.

41. As a result of further experience in 1923 *the following conclusions were considered to be a reliable guide*, but it was pointed out that conditions were so varied that they could be no more than a guide:-

(a) If a flotilla offers several targets, it is better to *destroy some* than *engage many* in the hope of moral effect frustrating the attack.

(b) Concentrate outside 10,000 yards range, but it should not be continued below this range.

(c) Normal concentration should be by pairs, and in a 5-ship squadron should be 2, 2, 1 at nearer flank, centre and further flank respectively. Heavier concentrations could be used at long range.

CHAPTER IX

Concentration of Fire in Destroyers

Section 1. – War Experience.

Section 2. – Position of Master Ship and Datum Ship.

Section 3. – Method of obtaining Best Rate of Hitting.

Section 4. – Firing Signal.

CHAPTER IX

Concentration of Fire in Destroyers

SECTION 1. – WAR EXPERIENCE

1. As in the case of cruisers, the action of 17th November, 1917 showed the necessity for an organised system for concentration of fire, since ships had been unable to identify their own shot. The increase in the rate of fire had already shown that identification was improbable when two destroyers only were firing.

2. The first system employed was a form of "Barrage Fire," when two or more destroyers were engaging a single target or a group of enemy destroyers.

3. This system soon gave way to the principle of "Master Ship" control, but the question of intercommunication was a pressing one. As an interim measure the main W/T set was made available in practices, in order not to retard progress. All destroyers were now fitted with a second W/T set primarily for gunnery purposes during day action.

SECTION 2. – POSITION OF MASTER AND DATUM SHIPS

4. *Datum Ship*. – For the same reasons as in cruisers, which reasons are even more accentuated in destroyers, the Master Ship has always been datum ship.

5. *Master Ship.* – Concentration of fire in destroyers was developed on the assumption that the normal concentration unit was to be the division. A higher degree – flotilla concentration – was allowed form. In divisional concentration the flotilla leader was to engage a separate target. In flotilla concentration she took Master Ship, unless otherwise ordered.

In divisional concentration the divisional leaders were Master Ships for their respective divisions.

It was not considered that allowance of practice ammunition and of opportunities for training would be sufficient to admit of other ships in addition to the above being trained to take Master Ship duties.

6. In 1929 it was decided that, as the occasions on which flotilla concentration was likely to be required were few, and that on those rare occasions experience tended o show that the expenditure of ammunition entailed would not be commensurate with the results obtained, flotilla concentration was no longer to be carried out.

7. In 1930 changes in the attack formations of flotillas led to the flotilla leader becoming divisional leader for the odd umbered division of her flotilla. She therefore became Master Ship for that division.

It was laid down that the next Senior Officer to the divisional leader was to be trained as Stand-by Master Ship in each division.

At the same time the use of the line ahead formation for torpedo attack was given a trial, thus involving alterations of course in succession.

8. The tactical conditions under which concentration of fire by destroyer flotillas may be required are such that frequently a torpedo attack will be in progress at the same time as concentration of gunfire is wanted.

9. Bearing in mind the limited signal and other personnel available, and the fact that one rangefinder must serve both torpedo and gunnery purposes, it is desirable to hamper Captain D as little as possible with gunfire distribution and details, if he has at the same time to control the execution of a torpedo attack by the whole flotilla.

10. Moreover, it was suggested that in line ahead the leading ship in any formation is likely to suffer more severely from enemy fire than will her consorts.

11. For these reasons it was decided to test the suitability of making No. 2 (i.e. ship with the next higher fleet number to the divisional leader) in each division the master Ship. This Master Ship was to be nominated beforehand and trained as such regardless of the varying formations that might be assumed by a division during an attack.

No. 3 in each division was to be Stand-by Master Ship.

12. Whilst these tests were proceeding, the trials with line ahead attack formations showed that these latter were unsuited to quick development of maximum gunpower against counter attacking flotillas, and that alterations of course in succession caused a considerable falling off in accuracy in divisional gunfire.

13. It was considered that no one formation was suitable for all occasions, and that both line ahead and line of bearing formations must be practised and that for gunfire the important point was for the line of bearing of the division to be roughly at right angles to the bearing of the gun-target and for alterations of course to be made together.

14. The tests as to the position of the Master Ship, however, were held to confirm that, under normal conditions it is satisfactory for the second ship to act as Master Ship, and the third ship as Stand-by Master Ship. As the ability of the Master Control Officer must be the deciding factor the choice must be left to Captain D.

15. The question was re-opened in 1934. Captain D had now been detached from the leadership of the odd numbered division, thus restoring control of both divisions to the proper divisional leaders. Captain D was left free to control the torpedo attack, and to manoeuvre the flotilla as a whole, engaging his own target, or joining as consort in one of the divisional concentrations as might be most convenient.

16. One of the reasons for divorcing the leading ship from Master Ship duties had therefore been removed, and doubt was expressed as to whether the argument that the leading ship should not take Master Ship on account of the probability of her being the first to suffer damage was sound.

As the line of bearing formation for a division might result in either flank being more advanced towards the enemy the Master Ship might find herself in No. 3 position, which, on account of funnel and cordite smoke might well be unsuitable.

17. *The problem is still under consideration.*

SECTION 3. – METHOD OF OBTAINING THE BEST RATE OF HITTING

18. The arguments for Divisional Rapid Salvos are the same as advanced in the case of cruisers, the higher rate of fire in destroyers placing a still greater premium on the value of disciplined and regular salvos.

SECTION 4. – FIRING SIGNAL

19. Before reliable G/C, W/T became available the use of Master Ship Independent in destroyers had meant that several salvos would be fired by consorts between signalled ranges from the Master Ship. The principle was therefore accepted that the range clocks in consorts should be kept in tune with the clock in the Master Ship by dint of using the same rate.

Rate therefore required to be signalled.

20. With the advent of a G/C. W/T set, and the sue of divisional rapid salvos, the length of the firing signal became important. The 4.7-inch Q.R. gun was coming into service at the same time, and it was decided that under good conditions, a maximum output of

8 salvos per minute was practicable. This only leaves 7½ seconds for the transmission of each firing signal. At this time the signal was composed as follows:-

(i) Range.
(ii) Deflection.
(iii) Letter F.
(iv) Executive Sign.

The latter was a long dash of about 3 seconds' duration. Its termination was to be the exact instant of ringing the fire gongs in consorts, and its length was to vary with local requirements. Deflection might be omitted during range ladders, provided that it did not change.

Rate was to be signalled after the initial deflection double and subsequently at intervals.

1. For divisional rapid salvos the firing signal was therefore amended for trial as follows:-

(a) One of the following – range, deflection, or rate.
(b) Letter F.
(c) Executive sign.

As regards (*a*) these items are made in turn in successive signals, the executive sign being made at intervals of 7½ seconds. Should spotting corrections or alteration of rate change any one item, the sequence is to be broken, and the item that has changed is to be made for the next firing signal, the sequence being then continued as before.

22. Should two items change at once they must both be made in the next firing signal, the temporary lengthening of the firing interval being accepted. The range must invariably be included in the first firing signal in divisional rapid salvos as otherwise there is no certainty that the reverse correction, if any, is applied before divisional rapid salvos are started. Experience shows that the W/T operator is forced to forecast in his mind to such an extent that, once a salvo is fired there is no time for him to apply a spotting correction, in divisional rapid salvos, before the next salvo is fired. Care must therefore be taken that the Master Ship does not get on her correction one salvo before the remainder of the division. This can be avoided by a standing order in the Master Ship that no correction is ever applied in divisional rapid salvos until the next salvo has been fired.

23. Opinion was divided as to the value of signalling the rate. It was claimed to be preferable to signal the range each time it changed, the necessary forecast being made by the clock-worker to allow for the rate in use. Consorts then set their rate to zero and tuned the clock to ranges as received from the Master hip.

24. This method was, after trial, adopted and rate was no longer signalled. The orders for the firing signal in divisional rapid salvos were therefore amended as under:-

Passing of rate to be discontinued.
Range and deflection to be signalled on commencing divisional rapid salvos.
Range and/or deflection should be omitted if they have not changed, but in no case for more than four successive salvos.
Range and deflection should be signalled if they both change in the same salvos.

25. At the same time the general amendments whereby the preliminary nought in single-figure deflection signals was omitted, and the nought in range signals was passed as “T,” were adopted.

26. The A.F.C. clock was now coming into service, and certain modifications were made to the procedure. Since this clock allows automatically for the movements of own ship, the generated rate is correct if the enemy course and speed is known. The master ship signals the enemy course and speed settings in use whenever this can be done without interference with the firing signal, which remains as before.

CHAPTER X

Night Action – General

Section 1. – General.

Section 2. – War Experience.

Section 3. - Nature of Fire.

Section 4. – Value of Tracers.

CHAPTER X

Night Action – General

SECTION 1. - GENERAL

1. Night action is a large subject and requires treatment under several headings. First of all, however, the conditions governing fighting at night must be recognised. These are-

(a) Initial difficulty in locating and identifying the target.
(b) The short period during which an engagement at close range will last.
(c) Close range, high rate of change of range and bearing, and drastic alterations of course.
(d) General necessity for the use of illuminants.

SECTION 2. – WAR EXPERIENCE

2. Such practices as were carried out before the war were largely hampered by the lack of efficient illuminants. Searchlights were not fitted with any reliable methods of operation or of control, and star shell were non-existent. Somewhat naturally the results obtained were so poor as to engender a marked distaste for this form of battle, which was in fact unsuitable for capital ships in our then superiority, and its thorough investigation was to some extent delayed.

3. In the War the Germans were noticeably our superiors at night both in material, and, with the exception of the torpedo, it its use, and further consideration was urgently directed to the problem.

4. Our war experience showed that a searchlight could be a very two-edged weapon, and the conclusion was reached that, on the whole it was more of a danger to the ship using it than the enemy. This was based on rather isolated experiences. At the same time the German star shell appeared to be very efficient, and it was not perhaps sufficiently realised that the enemy were able to make good use of their searchlights as well, owing to good drill and to instant development of the full fire power at the commencement of an engagement.

5. The German identification procedure was efficient, and they enjoyed the advantage that they were seldom in doubt that nay object sighted was an enemy.

6. The war conclusions may be summarised as follows:-

Policy

Owing to the usual visibility conditions it may be practicable to avoid action if desired. In this case naturally every effort must be directed to concealment and evasion. On the other hand, if successful action is to be sought the following conditions must be fulfilled:-

(i) An efficient look-out must be kept, using the best glasses available, and whoever sight an object must be able accurately to direct the armament and illuminants upon it.
(ii) Quick and effective means must be available for identifying the object.
(iii) Own presence must not be disclosed until completely ready for immediate action.
(iv) Once committed to an engagement all efforts must be directed to the immediate development of the maximum volume of gun and torpedo fire and no other consideration must be allowed to interfere.
(v) Sufficient illumination must be provided to allow of a point of aim and of spotting. Since to initiate an action at night, the enemy must be sufficiently visible fore someone to locate her before illuminants are used, the latter must not be allowed to dominate the use f the armament or to interfere with it.
(vi) Action must only be joined at a range, and under conditions, where fire will be effective. (This last conclusion is more applicable to post-war experience.)

SECTION 3. – NATURE OF FIRE

7. An ordered fire is of even more value at night than by day, as good fire discipline and regularity is thereby maintained. With heavy guns it is advisable to fire broadsides, since this causes less interference to the fire of the secondary armament and star shell guns, and also to searchlight. It is not necessary, however, to delay the firing of the initial broadside until all guns will bear, nor of subsequent broadsides to ensure that all guns are ready.

SECTION 4. – VALUE OF TRACERS

8. Tracers have proved of great assistance in spotting fall of shot for line. Their use for elevation is less marked, owing to the eye being prone to prolong the flight from the highest point of the trajectory, instead of allowing for the fall of the projectile from this point to the water. It has been found that tracers are of most

assistance when fired from guns in the vicinity of the line of sight of the control officer, and that from guns more remote the tracers are apt to mistaken for those from a consort. The effective range of tracers is only about 2,000 yards. Outside that range they are not sufficiently visible to be of use in distinguishing own fall of shot.

9. Tracers fired from Lewis guns cause confusion, as they go out after about 500 yards, and their use from these weapons at night has been discontinued.

10. Tracers fitted in star shell can be seen from the moment of firing from a position anywhere on the disengaged side, and from the engaged side, except within approximately 60º of the line of fire, in which conditions they will not be seen until a few seconds after firing. They should not therefore be used until the ship is committed to action. When in company, however, it is unlikely that individual ships will be able to recognise and control their bursts without the use of a proportion of tracers.

11. As at present tracers can only be used in nose-fuzed shell their use is limited.

CHAPTER XI

Night Action – Illuminants

Section 1. – Development and Use of Illuminants

Section 2. – Silhouetting Effect of Illuminants on Ships using them.

Section 3. – Searching an Area with Star Shell.

CHAPTER XI

Night Action – Illuminants

SECTION 1. – DEVELOPMENT AND USE OF ILLUMINANTS

1. Star shell came into supply at the end of the War, and were at first used from the then H.A. armament of 3-inch guns. Star shell of this size were not very effective, and, as a general rule, there was only one gun available at a time to fire them. Star shell for 6-inch guns, i.e. the secondary armament of capital ships, and the main armament of cruisers – were therefore developed.

2. At the same time Iris shutters were fitted for searchlights and more efficient remote control arrangements were supplied.

3. Bearing indicators to ensure adequate direction fo the searchlights and star shell guns on to the required target were evolved.

4. Trials were then carried out to determine the relative merits of searchlights and star shell:-

Searchlights

A selective and direct illuminant of great power. Its maximum range against targets of the order of a cruiser and above is about 5,000 yards, destroyers 2,000 yards.

Advantages

Good illuminating effect and considerable glare effect on enemy at short ranges.

Immediately available when required, and can be stopped at once.

Neutralises enemy star shell

Disadvantages

Difficult to ensure that the light is directed on to the desired target when the shutters are first opened.

Difficult to keep continuously laid and trained, except under favourable conditions.

Much affected by blast and their illuminating effect spoilt by own funnel and cordite smoke, or enemy splashes.

Provides a good point of aim and ranging mark for the enemy.

Reduces the effect of own star shell.

Silhouettes own ship on the disengaged side and gives away her exact position to other craft in the vicinity.

Star Shell

A non-selective and indirect illuminant of less power than a searchlight. The maximum range about 9,000 and 5,000 yards against cruisers and above and destroyers respectively.

Advantages

Provides adequate illumination of a fairly large area.

Bad direction is not necessarily a disadvantage as regards own ship.

Not affected by blast or own smoke.

Control easier in heavy weather.

Flashes of star shell guns do not provide a reliable point of aim nor can they be ranged on.

Does not disclose exact position.

Disadvantages

Illumination inferior to searchlight and difficult to identify another vessel by means of star shell.

Not immediately available nor can they at once be stopped.

Silhouette own ship on disengaged side, but not to so large an extent as to searchlights.

Gives away the general position over a much larger area.

May illuminate hull of own ship at the shorter ranges.

5. As a result of all these trials it was held that both forms of illumination had their uses, but that star shell were definitely less dangerous to our own side This rather put defence at a premium, as opposed to effective offence.

The general conclusions drawn were that star shell formed the main method of illumination, and that the use of searchlights should be reduced to a minimum. An exception was against destroyers where the dazzling effect of a searchlight at short range combined with the difficulty of keeping star shell aligned with small, fast moving craft was in favour of the former under reasonable conditions.

6. There still remained the necessity of using a searchlight in the time which elapsed between firing a star shell gun and the shell bursting (about 20 seconds). It was found that until a searchlight beam had been exposed for some 25 seconds, reliable ranges on it could not be obtained by an enemy not already fully aware of own ships' presence. Consideration was therefore given to the intermittent display of the searchlight. This was found to be impracticable as it was difficult to produce the beam exactly as and when required, and this method did not disconcert the opponent to any marked extent, whilst it was apt to restrict own rate of fire.

7. Meanwhile, the following improvements in materiel were being made:-

4-inch star shell introduced as these guns came into general use as the H.A. armament.

More than one gun a side available for star shell.

8. The question of the use of the secondary armament in capital ships, and of the main armament in cruisers and destroyers, for firing star shell was investigated. The improvements in material mentioned above enhanced the effectiveness of star shell from

H.A. guns, and, although an initial salvo of 6-inch star shell produced good illumination, it was held that to use a gun which was required for service ammunition to fire star shell was wrong in principle. Moreover, in war, it was possible that the – inch guns would be loaded with service shell after a previous alarm or action, and so would not be available when required for star shell.

9. An exception had to be made in the case of destroyers as their main armaments constituted the only suitable guns for star shell, it was arranged therefore that these craft should consider the searchlight to be their primary method of illumination.

10. With the improvement of target indicating devices and gyro laying, and observing that to initiate action at night the suspicious object must be visible to somebody before any form of illumination is employed, it was held that it should be practicable to fire the first service salvo coincidently with the commencement of the illumination procedure, and that therefore a delay of some 20 seconds would be imposed on those 6-inch guns firing star shell before they began to use service. The above method of firing the first service salvo, although not normally practicable at towed targets for reasons of safety can be, and has been, used at moored targets, and should be still more feasible at the larger target presented by a ship.

11. Further improvements in material have:-

Stabilised searchlights for elevation.

Provided a reliable and long burning searchlight.

Introduced power control for searchlights giving much greater accuracy of direction.

Produced brighter star shell.

Introduced flashless propellant for star shell.

12. With these searchlight improvements the immediate and clear effect of a good searchlight became more obvious, and under *suitable* conditions its beneficial effect in the immediate development of the maximum offensive power was marked. It was also found that identification of the class and course of the enemy was fairly certain with a searchlight, but doubtful with star shell. Moreover, the latter for the best effect must burst only some 1,500 yards beyond the target, and the uncertainty as to the initial range may modify their effect considerable especially in the case of small, fast craft at short ranges.

13. With the advent of flashless charges for star shell, it becomes possible for a ship to provide illumination by this means without necessarily disclosing her exact position, and it has been proposed that the initial rounds of star shell could be allowed to burst before the first service salvo was fired, thus obviating the use of a

searchlight during their time of flight. This method is not considered sound, as, assuming the enemy has not taken the initiative, nothing should be

done which might disclose own ship's position before all the armament is ready for action, and, secondly that at the instant the armament is ready, offensive action should be taken. It may well happen that the enemy may take offensive action during this 20-second or longer time of flight. It therefore appears that no change in initial procedure should follow the introduction of flashless propellant for star shell, and it principal advantage is likely to be restricted to occasions where the firing ship is searching an area, rather than identifying a ship which has already been sighted. In destroyers where "B" gun is the normal star shell gun the absence of disturbance to the bridge when flashless charges are used makes this improvement of marked benefit in all cases.

14. Improvements in look-out glasses have led to a wider range of sighting an enemy at night, and to the possibility of this sighting taking place outside the effective range of illuminants, and where control of fire and spotting may not be practicable. Trials have shown that, under good conditions, 15-inch splashes may be spotted up to a range of 8,000 yards and 6-inch splashes up to 6,000 yards.

Conclusions as regards illuminants

15. Strategical and tactical considerations will govern the employment of searchlights and star shell, and it may be necessary for these reasons to restrict their use. Subject to this, illuminants are a means to an end, and searchlights and star shell should not be regarded as rival forms of illumination. The limitations of each have been discussed in the foregoing pages. Either or both will normally be required for-

(a) Identification.
(b) To provide a point of aim.
(c) To facilitate observation of fall of shot.
(d) To defeat enemy's illumination.

(*d*) Can only be done by searchlight.

Procedure when action is sought:

Where the initiative is ours

16. If a point of aim is obtainable without illumination, open fire coincidently with the opening of the searchlight shutter, and the firing of the first round of star shell.

If no point of aim is available without illumination, expose the searchlight beam simultaneously with opening fire with star shell.

In both cases obscure the searchlight beam as soon as the star shell becomes effective, and maintain illumination with star shell so long as circumstances are favourable. The exception is against destroyers at lose ranges where the dazzling effect of a searchlight should be exploited to the full, and in destroyers themselves where star shell should only be used if searchlights are ineffective.

17. Once a searchlight beam is exposed, and fire is opened, the advertisement of the firing ship's position is complete and further searchlights from the same source will add little to the disclosure.

Where the initiative lies with the enemy

18. If the enemy uses star shell, the use of own searchlight will neutralise their effect, but it is probable that a searchlight will not be necessary for obtaining on point of aim or for spotting.

19. The opening of a searchlight by the enemy does not necessarily mean that it is being used effectively, and, if he uses a searchlight he gives us a perfect point of aim and ranging mark, at the same time gaining for himself what may be doubtful aiming, ranging and spotting. He may of course in addition be obtaining information as to identity, class and movements of our ship. If we use a searchlight in reply, we deny the enemy any advantages in identification and knowledge of our movements but give him definite advantages in gun control that previously were ours alone.

Neglecting weather conditions the use therefore of a searchlight depends on the relative importance of denial of identification and of gun control

20. Assuming that this denial is not the primary requirement, the best procedure in action between heavy ships or cruisers is considered to be:-

(i) Open fire with star shell without waiting for the remainder of the armament, so as to have star shell illumination ready when required.
(ii) If the enemy uses a searchlight do not reply with one so long as his searchlight enables effective gunfire to be maintained on our part.
(iii) Against destroyers at close ranges searchlights should be used in any weather where they can be employed effectively.
(iv) In destroyers when discovered the use of searchlight against enemy heavy ships may have considerable blinding effect, and may help to neutralise his searchlight.

SECTION 2. – SILHOUETTING EFFECT OF ILLUMINANTS

21. Instructions that this point should be the subject of investigation were issued to capital ships and cruisers early in 1929.

CAPITAL SHIPS

22. The following conclusions were drawn as the results of the 1929 practices:-

Searchlights

(i) When used on the engaged side only, under ordinary circumstances give a perfect silhoueting [sic] effect of the ship using them to an observer on the disengaged side.
(ii) When used on both sides they do not silhouette the ship using them to any appreciable extent.

(iii) Searchlights burned ahead by the leading ship of a division make it very difficult of destroyers attacking from ahead to estimate inclination and also assist materially in preventing silhouetting.

Star Shell

(iv) Star shell are more apt to silhouette ships than searchlights burnt on both sides simultaneously.

23. These conclusions were generally confirmed during 1930.

24. In a divisional night firing under conditions of full moon the firing ships did not require to use illuminants, but both types were used against destroyers which attacked them on the disengaged side. It was stated tat, owing to the moon, the inclination of the battleships was easy to judge, and they were well silhouetted by the gunfire of the engaged battery.

25. In another squadron a continuous searchlight sweep on both sides was found to be very effective in preventing silhouetting.

CRUISERS

26. At the end of 1929, only one report had been received, which referred to conditions on a dark and clear night. The summary was as follows:-

Star Shell

Star shell have little or no silhouetting effect when burst at 5,000 yards, except to an observer on the disengaged side who is within 15º of the direct line between the ship and star shell. The distance from the firing ship on the disengaged side up to which this silhouetting effect is obtained was not stated; and further, since the date of this report the brilliancy of star shell has been increased.

Searchlights

On the disengaged side a ship is well silhouetted by her own searchlights particularly when the observer is more than 20º from the line of the beam of light.

Point of Aim and Observation of Fire

When under the above conditions, ships are silhouetted, although a good point of aim was provided, it was remarked that observation of fire would be difficult.

27. In 1930 these conclusions were confirmed. It was pointed out that a searchlight, being a beam of light, was more likely to silhouette ships in the immediate vicinity of the ship of origin as was a star shell, which was a point of light.

28. The question was then withdrawn, since it was considered unlikely that further information would be obtained in the course of normal practices.

SECTION 3. – SEARCHING AN AREA WITH STAR SHELL

29. In 1923 it was considered that an organisation should exist whereby an area could be searched quickly with star shell. Investigation of the problem was confined to destroyers as presumably this class of vessel would be the most likely to carry out the duty.

30. The conditions laid down were:-

(a) Ships to be ready for immediate action.
(b) It is undesirable to introduce complicated procedures which differ largely from normal night action procedure.
(c) Normal star shell and stand-by star shell guns only are to be used, with normal fuze-setting of 5,000 yards.
(d) Bearing ordered was to be a relative one.

31. The slewing dials of star shell guns were at that time marked with stars at 6º intervals from the black pointers, and it was therefore feasible for the star shell gun to be kept trained by director at 6º or multiples thereof, away from the director's line of sight.

Arrangements for the trial were therefore to spread the star shell in increments of 6º, the guns using gunlayers' firing.

32. The problem was further divided into two portions:-

(1) Search of a limited area by a division.
(2) All round search by a flotilla.

33. The first trials showed that an arc of 4 points could rapidly be illuminated by a division, illumination becoming effective over this area at 5,000 yards in about 80 seconds after commencing the procedure. Four salvos of two star shell each per ship were used, and this was found to be adequate to cover the four-point area.

34. It was found, however, that 5,000 yards was too short a fuze range, as firing ships became self-illuminated. 7,000 yards was tried, using the same procedure as before, and the following conclusions were reached:-

(a) An arc of 45º was sufficiently illuminated to reveal any ship in it, and though certain dark spots occurred at various times and on various bearings, no one portion of the 45º sector was never illuminated.
(b) Ships disclosed could be seen sufficiently well through glasses for fire to be opened (the range was between 2,000 and 3,500 yards).
(c) Firing ships were self-illuminated sufficiently to reveal their type number and course to the targets, but not well enough for these to open fire.

35. It was considered that with a flotilla, extension of the divisional search to one by both divisions was the most practical method of solving paragraph 32(2). It was decided, therefore, to restrict the whole problem to a divisional search covering an arc of 45º on any relative bearing, and from any formation. Illumination to be produced as the result of a preparatory signal by the divisional leader followed by an executive signal.

36. A gyro bearing was introduced instead of a relative one, and subject to the fact that if the signalled bearing or its reciprocal was that on which the division was formed, blank spots must occur, it was found that the following procedure was effective, and that it did not interfere with the handling the division by W/T concurrently with the search:-

(i) The divisional leader orders a search on a gyro bearing. All ships prepare to fire with star shell and stand-by star shell guns using 7,000 yard setting.

(ii) The executive order to commence is the firing of the first round by the divisional leader. This should not be more than 30 seconds after the search signal.

(iii) Each ship fires four salvos of two star shell each as follows:-

First salvo	..	On bearing ordered.
Second salvo	..	6º outwards from bearing ordered.
Third salvo	..	12º outwards from bearing ordered.
Fourth salvo	..	18º outwards from bearing ordered.

(iv) "Outwards" means away from the ships of the other sub-division. Bearings right ahead or astern in line-ahead, or abeam in-line-abreast should not be ordered for a search as the foregoing definition breaks down in these circumstances.

(v) If any ships are seen at the edge of the illuminated area, the end ship affected continues to spread star shell to complete identification.

37. Further trials of the above procedure in the Mediterranean fleet gave rise to the following report:-

(1) It is impossible to forecast the exact tactical situations in which a division of destroyers may be required to search an area, but they would appear to be very infrequent. Such situations may vary from the division being alone in an area in which no enemy is expected, to one in which the division is in company with own heavy ships and in which the enemy is known to be in the vicinity.

(2) For the above reasons it is held to be unsound to use any organisation which does not leave the division ready to engage the enemy immediately the first star shell is fired.

(3) To search an area with star shell pre-supposes that the initiative lies with our own ships. In order to engage an enemy effectively, all guns must bear. Therefore should the area to be searched lie outside the "A" arc, or in a line through the line of bearing of the division it should be the policy to dispose the ships of the division as required before commencing the search.

(4) It is considered that "B" gun should be the only gun used for firing star shell, and that "X" gun is not needed as a stand-by gun, nor for assisting in the search. This will avoid both the sacrifice of 50 per cent. of the ship's armament to star shell, and also the complications of control when using an after gun for this purpose.

(5) It is therefore proposed to modify the rules given in paragraph 36 as follows:-

(a) Double rounds to be fired from "B" gun, and "X" gun no longer to be considered as a star shell gun.

(b) When ordering the bearing on which a search is to take place the divisional leader must make due allowance for the rate of change of bearing should he have any knowledge of the probable enemy movements.

On the other hand the Atlantic Fleet reported that one gun firing double rounds was too slow to produce the required illumination.

38. Further trials affirmed that "B" gun only was necessary, and the present system is as shown in paragraph 36, but using "B" gun only.

CHAPTER XII

Night Action – Procedure when in Company

Section 1. – General.

Section 2. – A Division of Capital Ships.

Section 3. – A Cruiser Squadron.

Section 4. – A Division of Destroyers.

CHAPTER XII

Night Action – Procedure when in Company

SECTION 1. – GENERAL

1. This differs from single ship procedure in that co-ordinated action is required, and that the functions and peculiarities of different classes of ships are liable to require greater difference in treatment. In all cases some definite arrangement is required for the handling of illuminants of the ships in company.

The subject is considered below for a normal unit of a division of capital ships or destroyers and a squadron of cruisers.

SECTION 2. – A DIVISION OF CAPITAL SHIPS

2. When the problem was first reconsidered after the war, it was apparent that the Admiral should promulgate the policy for the night by signal before dark. This policy signal should include-

(1) Degree of readiness for action to be assumed.
(2) Expectation or otherwise of being attacked.
(3) Range for the night (to be altered as necessary).
(4) Intended action if enemy is encountered.
(5) Position of own ships on the screen.
(6) Challenge procedure to be adopted.
(7) Any special orders as to the use of star shell and searchlights.

3. At this time the use of searchlights from capital ships was as limited as possible. The intention normally was that the secondary armament would be loaded with star shell, and it was considered that a salvo of star shell from these guns would illuminate at least one, and perhaps more ships on either side of the one sighted.

A searchlight was to be used initially to illuminate the enemy before star shell became effective, and for the purpose of indicating the direction of attack to ships in company, but in neither case was the beam to be exposed for more than 25 seconds.

4. Subject to the Admiral's intentions the illumination procedure was-

The sighting ship exposed a searchlight, and opened fire with star shell, at the same time opening fire with service.

The remainder opened fire with service, and star shell on the target first sighted.

Star shell should be stopped if the enemy was identified as destroyers at close range, otherwise sighting ship obscured her searchlight when star shell became effective, or after 20 seconds, whichever was the shorter.

5. Opinion was divided as to the merits of a searchlight sweep to disclose any further enemy. The searchlight would have to be used for this purpose, as ships engaging a target would already be employing their H.A. armament for star shell as well as all the secondary armament that could be spared.

6. The Atlantic Fleet held that any further enemy would almost certainly reveal their presence by the flash of their own guns or the use of searchlights (this seems to leave out of account attacks by destroyers), whilst the Mediterranean Fleet considered that this sweep was necessary; but it was restricted to the end ships of the division sweeping about 30º outwards from the enemy already illuminated; the centre ship (third ship if more than 3 in a division) taking over the responsibility for illumination on the initial enemy. This sweep might be repeated at the discretion of the end ships.

As regards further illumination of the target the Atlantic Fleet laid down that all ships were to use star shell, reinforced by their own searchlight, whenever star shell became ineffective. Only one ship's searchlight was to be on any particular target at one time, the ship to burn it being the leading one of those suffering from poor star shell illumination. In the Mediterranean Fleet the centre ship became responsible for the illumination of the first target. A second target was to be taken over by the second searchlight in the centre ship, and further targets by ships on either side of the centre ship in turn, each ship being responsible for a maximum of two targets.

8. Further experience led to the adoption by both fleets of the centre ship as being the one to take over the responsibility for the first target if any searchlight was required, thus leaving the end ships free for further identification sweeping by searchlights.

9. Consideration was now directed to the question of whether a different procedure to the foregoing was required to deal with attacks by light craft. It was decided that a searchlight sweep on the engaged side was desirable to ensure disclosing the extent of the attack. Trials disclosed the fact that, with ships whose searchlights were all situated abaft the bridge, the sweep ahead by the leading ship was apt to interfere with the control of gunfire, and might have to be undertaken in this case by star shell.

10. As regards the disengaged side opinion was not unanimous.

The greater silhouetting effect of searchlights over star shell or gun flashes was a reason for not employing searchlights more than necessary as this silhouetting would help attacking craft whether

on the original engaged or disengaged side. On the other hand, star shell are not so reliable for illuminating small fast craft at close ranges, and the dazzling effect of a searchlight under these conditions is great.

Furthermore, searchlights used simultaneously on both sides will tend to neutralise each other's silhouetting effects, and once fire is opened the additional disclosure of the general position by using plenty of searchlights is of little consequence.

11. The deciding argument is held to be, that when once committed to an action, all efforts must be directed to the immediate development of the maximum offensive power, and no other considerations should intervene.

12. Since, therefore, the searchlight helps the offensive by its dazzling effect at close ranges, and is also normally more suitable than star shell against light craft, its use on the engaged side is sound, and the silhouetting effect must be accepted. As regards the disengaged side, a star shell sweep may be successful, but if searchlights are in use on the engaged side, no disadvantage attends their use on the disengaged side also, and this will neutralise the silhouetting effect. To ensure this, searchlights should therefore always be used on both sides if at all.

13. The present position in both fleets is as follows:- Subject to the policy signal, to the suspicious vessel being with effective range of illuminants and to captains retaining full discretion to acta as circumstances may require:-

On sighting a suspicious Ship.

(i) Sighting ship is at once to make the squadron alarm (Mediterranean only.)
(ii) When ready to take offensive action, the sighting ship is to establish the identify of the stranger; if hostile, a searchlight is to be switched on, and fire opened with star shell and armament.
(iii) Should the enemy sigh first, and successfully illuminate a ship, that ship is to act as sighting ship (HF only).

If the Vessel is Identified as a Capital Ship

(iv) Sighting ship is to obscure her searchlight when star shell becomes effective.
(v) All ships are to use star shell to illuminate their selected target reinforced by searchlights as necessary.

If the vessel is identified as a cruiser or destroyer

(vi) All ships are to commence star shell (*Mediterranean only*).
(vii) The division nearest the attack provides searchlight illumination as follows:-

Engaged side

(a) The two centre ships, if possible, are to take over the illumination of the target or targets first sighted.
(b) The end ships are then to sweep outwards continuously between the target and their own fore and aft line (or extreme searchlight bearings).
(c) Any further target disclosed must be held by one searchlight of the sweeping ship until taken over by a centre ship, while the second searchlight continues the sweep.
(d) It is important to illuminate continuously all torpedo craft, and also small cruisers, in order to dazzle them.

Disengaged side

(e) The senior officer present or the senior officer of the division may initiate a sweep on the disengaged side with searchlights or star shell.
(f) This sweep is then to be carried out by the end ships, sweeping outwards from the beam allowing an overlap.
(g) If this sweep discloses a target the procedure for the engaged side is to be carried out.

Precautions whilst Sweeping

(viii) As large alterations of course are likely during a night engagement, special vigilance is necessary to avoid lighting up a friendly ship.

Control of Gunfire

14. Some difference of opinion existed between the two fleets on this question, and the original opinions are here given separately.

Atlantic Fleet

15. Range for the night should be the same for all ships.

Both W/T and V/S lines of communication should be available as in day action.

An alarm gyro bearing is useful, and should be passed, but once fire has been opened intercommunication of range and bearing appears to be of little value, owing to the very raped sequence of events, and to the large P.I.L. corrections required.

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Mediterranean Fleet

16. Doubtful if intercommunication of bearing is of much use. The risk of warning the enemy, if W/T is used before disclosure, could not be accepted, and the lag of communication is then too great for any useful purpose to be served. Intercommunication of range, however, is recommended.

Both Fleets

17. Both fleets were agreed that whilst normally all ships should open fire at the enemy first sighted, captains of ships had complete discretion to shift on to any other enemy who was heavily engaging them, who was unfired at, or who was in a menacing torpedo position.

18. Subsequent experience has not modified the views expressed above as to the undesirability of any organised form of concentration of fire at night. The arguments for and against concentration are discussed more fully in the section on cruisers and destroyers.

19. Further trials, however, have shown that it is inadvisable to signal the range for the night at intervals during the dark hours, since it is not desired to use V/S for this purpose, and W/T silence is likely to be in force. It has been decided, therefore, to omit any reference to the range for the night in the policy signal.

When contact or probable contact has been gained with the enemy, however, the advantages of a squadron gyro alarm bearing are held to be sufficient to justify its immediate transmission by W/T by the sighting ship. This signal serves chiefly as an alarm, and the rough bearing is all that is practicable or necessary.

SECTION 3. - A CRUISER SQUADRON

20. In this case definite trials were carried out in 1924 with a view to evolving a common procedure. It was held that, as the transmission of information about the enemy is just as much the duty of cruisers by night as it is by day, it may often be more necessary for cruisers to ensure passing their information than to become closely engaged.

Subject to the above, and to the policy signal, the illumination procedure evolved was the same as for capital ships, with the exception that the second ship took over the initial target.

Control of Gunfire

21. When more than one enemy is disclosed initially, or at short intervals after the first alarm, it is extremely difficult for individual ships to distinguish which of their consorts is firing at which target. The intercommunication of ranges and deflections is therefore merely confusing, since there is no certainty as to what target they apply. A bearing signal will not clear up the difficulty owing to the short range

and rapid change of bearing, combined with the inherent lag in transmission and reception.

22. Cases will arise, however, in which only one enemy is present. If this target is to be engaged with decisive effect by several ships it is necessary that these ships shall all use the same range (corrected for P.I.L.). There is therefore a strong argument for an organised concentration procedure, and, since by day GMS has been proved to be the most effective form of concentration, the same should hold good by night.

23. The range at which the action takes place, however, is a modifying feature. Up to about 2,000 yards the fixed sight procedure is suitable, i.e., ships using fixed sight range will in any case be using the most effective range, and this range does not require signalling. Moreover, in ships whose outfit includes tracer fitted projectiles, it has been found generally feasibly to distinguish own fall of shot up to 2,000 yards when several ships are engaging the same target.

24. With careful training of the personnel, rangefinder ranges may often be obtained at moderate ranges, and, in this case, bearing in mind the difficulty of assessing accurately the P.I.L. correction, rangefinder control by individual ships will probably be more effective than any form of concentration procedure. Care is necessary that ranges are not taken of own star shell.

25. In addition the rapid change of range and of bearing, at these short ranges, may not give time for an organised form of concentration to be initiated before the action is over.

The conclusion, therefore, is that inside about 2,000 yards such concentration is unnecessary.

26. With the extension of effective range of star shell, improvements in illuminating power, and control of searchlights, the advent of better night glasses, and the possibility of illumination by flares or by other ships not in formation, the practicability of engaging enemy ships at medium ranges by night is becoming more marked.

When more than one enemy is present the arguments against concentration still hold good, but with only a single enemy, decisive results are unlikely to be obtained by indiscriminate firing by ships in company.

27. GMS concentration has been practised by night, and has given good results at target firings. Its use has so far been considered undesirable, however, mainly owing to:-

(a) Difficulty of accurate assessment of P.I.L.
(b) The need for flexibility.
(c) Difficulty experienced by the master control officer in spotting consort's salvos, their line of fire at short ranges differing considerably from that of master ship.

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(*a*) *Difficulty of accurate assessment of P.I.L.*

28. This is still unsolved, as an accurate knowledge of the distance of the master ship from a consort is not at present determinable. An approximation is practicable, however, if it is assumed that the consort is in station, or if it is known that she is outside.

(*b*) *The need for flexibility*

This is merely a matter of drill. As already stated, if one enemy only is present no confusion will arise. Emphasis is only required on the fact that *immediately* more enemy are disclosed organised concentration is at once at an end, and each commanding officer is perfectly free to take what action the situation demands.

(*c*) *Difficulty experienced by Master Control Officer in spotting consorts salvos*

At ranges outside 2,000 yards this is not so marked. In any case it has often been advocated that by day the master control officer should attempt to pot on his own salvos, rather than on the general fall of shot, and this procedure at night should be effective.

29. It is considered, therefore, that under the stated conditions, i.e., only one enemy present and outside 2,000 yards, GMS concentration should give better results than indiscriminate firing. It is questionable, however, whether, owing to rapid changes of course and differences of bearing, it is of any advantage to signal the master ship's deflection. It should be sufficient for the master ship to use divisional rapid salvos, and for the firing signal merely to contain the range and her self-evident letter.

Should any other enemy be disclosed, or the range fall below 2,000 yards, GIC is at once signalled and organised concentration ceases.

SECTION 4. – A DIVISION OF DESTROYERS

30. In this case, the large number of flotillas who are normally investigating the same problem at any one time, has given rise to a great variety of opinion, and the co-ordination of ideas has been more difficult.

Illumination Procedure

31. The previously discussed advantages and disadvantages respectively of searchlights and star shell hold good with the following modifications:-

Searchlights

Only one fitted per destroyer and that of low power. Mechanically controlled, and of little use except in moderately smooth water.

Star Shell

Must be fired from guns of the main armament.

32. The illumination procedure evolved in the cruiser trials of 1923 enabled considerable progress to be made by destroyers in 1924, and the following conclusions were arrived at:-

Searchlights

Under suitable weather conditions, one searchlight provides illumination for one target for a whole division, and this searchlight should be shown by the sighting ship, subsequent illumination being maintained by her. A stand-by searchlight is required, and should be in one of the centre ships (Nos. 2 and 3).

Star Shell

"B" gun should be the star shell gun with "X" as a stand-by.

Disadvantages of "B" gun are: Loss of service fire on ahead bearings and the effect of flash on the bridge personnel in the early stages of an encounter.

The advantages are: As a destroyer searchlight will not bear ahead, it is very advantageous to be able to fire star shell on these bearings. Ease of control of a gun near the bridge.

It was considered that two ships were sufficient to produce illumination. They were to be the centre ships, thus leaving the end ships free to shift their fire to another target as required.

The rate of fire for star shell remained undecided, and opinion on this point, differed between the maximum rate of fire of the gun, or with, or directly after, the main armament salvos.

33. Practices in 1925 still disclosed many differences of opinion but the following points were held to have been established:-

Searchlights

One was not always sufficient to enable all ships of the division to spot their fall of shot. It could not be done with certainty by a ship more than one station in the line away from the searchlight ship. If any concentration of fire was to be used, the divisional leader, as master ship, would require efficient illumination, and therefore at lease one of the searchlight ships should be her next astern. It was undesirable to draw enemy fire on to the master ship.

It was also clear that the sighting ship must initiate the searchlight procedure, since she must not delay offensive action.

34. The following instructions were therefore laid down for trial:-

(a) Sighting ship switches on her searchlight.
(b) The two ships next astern of the Senior Officer switch on and provide the illumination for the whole unit. If the sighting ship is not one of these two, she is then to switch off.

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(c) If either of the illuminating ships fails, the nearest ship is to take over.
(d) Nothing above precludes the Senior Officer from opening his shutter at any time should he so desire.

Star Shell

35, The balance of opinion confirmed that these should be fired from the centre ships, leaving the end ships free to shift their fire as required. This procedure implied that, if not the sighting ships, the centre ships were to take over from her as soon as possible.

If the division were a 5-ship on, i.e., flotilla leader present, her 3-inch H.A. gun might be used to improve the illumination from her own point of view.

The rate of fire should not be restricted, but should be the maximum.

36. The following instructions were laid down for trial:-

(a) Sighting ship opens fire with star shell.
(b) Nos. 2 and 3 open fire and take over. If sighting ship is not one of these she stops firing star shell when Nos. 2 and 3 become effective.
(c) Star shell rate of fire is to be the maximum.
(d) Two groups of fuzes, 5,000 yards and 3,000 yards, are to be kept set. Sighting ship is to use 5,000 yards setting. Nos. 2 and 3 are to use the group which will give the nearer bursts to the target, but not less than 1,500 yards beyond it.
(e) Nothing in the foregoing prevents the Senior Officer taking independent illuminating action.

37. The results in 1926 confirmed these instructions, and the searchlight and star shell instructions were combined as under:-

(a) Sighting ship opens searchlight shutter and begins firing star shell at the maximum rate.
(b) Searchlight is obscured when star shell becomes effective.
(c) Nos. 2 and 3 are the illuminating ships for the division. They assume duty as soon as they can, and if the sighting ship is not one of these, she then ceases to illuminate.
(d) If Nos. 2 or 3 fail, the nearest ship takes on.
(e) The Master Control officer (normally the Senior Officer) may use independent illumination.
(f) Any ship shifting fire to a new target must provide her own illumination.

38. The question of which was to be the star shell gun was re-opened. The flash from "B" gun with an unrestricted rate of fire was found to be disturbing to the bridge personnel, and the director's crew. It was also suggested that, if the target sighted were abaft the beam, the limited training of "B" gun might make the standard procedure unworkable, and it was suggested that "X" gun should be the normal star shell gun for the rear ships.

The introduction of flashless star shell propellant was expected to, and in fact has settled, the flash problem in favour of "B" gun, and the limited arc of training is not considered of sufficient importance to justify departure from the present arrangements. All modern destroyers have increased arc of training for "B" gun. Fuzes set to 5,000 yards were found on occasions to illuminate the firing ship and new settings were introduced:-

Long setting, 7,000 yards.
Short setting, 5,000 yards.

39. Experience in the following years was confirmatory, but in 1928 it was thought that the illumination instructions were too rigid, and that the sighting ship should act initially as if she were alone, the choice of illuminants, if any were required, being decided by her commanding officer, subject to the policy signal.

40. The question of a sweep for disclosing further enemy was raised, and it was decided, subject to the policy, that the end ships should sweep up to 45º outwards from the target. This sweep to be carried out once only. No decision was given as to what illuminants should be used for the sweep.

41. In 1929 the following modification to the illumination procedure was included in the instructions-

(a) The sighting ship should act as if she were alone and be guided by the policy signal.
(b) Consorts must not rely on illumination from others, but may withhold illumination if from other sources they have a satisfactory point of aim.

42. Concentration practices have tended to show that a searchlight provides too directional a light for the spotting officer to see more than a few of his splashes. This may necessitate the use of star shell when concentrating.

In this event it has been suggested that star shell fired by ships other than the master ship and her next astern, are of no value to the master control officer, by reason of their being on a different bearing from the target as viewed by the master ship.

43. Occasional difficulty has been caused by the star shell gun to the control of the main armament. It has been seen that the maximum rate of star shell fire is disturbing to bridge personnel.

With the improved star shell now available, an unrestricted rate of fire after the first burst is not so necessary, and one commensurate with that in use by the main armament is found to be sufficient. If the star shell gun, which is normally in gunlayer's firing, fires on hearing the main armament fire gong, any delay in the director firing may be taken by other guns to indicate a director miss-fire. This may be avoided if the star shell gun fires directly after each main armament salvo, being prepared to fire by order of the star-shell control officer should the target be lost or there be an undue delay with the main armaments.

Control of Gunfire

44. The practicability of concentration of fire at night has been remarked upon in the cruiser section. It has powerful arguments in addition for destroyers.

(a) The closer station keeping in destroyers lessens the P.I.L. correction required.
(b) No modern destroyer at present carries tracer fitted shell.
(c) With their rapid firing guns it is even more difficult to distinguish individual fall of shot.

45. The question of organised concentration was considered after the war. At that time the method of day concentration was a barrage fire, requiring comparatively infrequent signals, which was partly necessitated by the meagre control and communication fittings available. Opinion was in favour of master ship control at night (no ship then carried night tracers) and it was held:-

(a) It is impossible for individual G.C.O.s to spot their own fall of shot, therefore some system of Master ship control is essential.
(b) All signals – gunnery, torpedo and manoeuvring – can be more efficiently passed through the common line of communication ,i.e. W/T via the transmitting station.

Emphasis was laid on the necessity of simple and flexible organisation, and consideration was directed to whether or not the sighting ship should become master ship.

46. By 1926 sufficient progress had been made to enable rules for the conduct of practices in 1927 to be laid down. It was still considered that all gunnery, torpedo and manoeuvring signals could be passed through the transmitting station.

The following is a summary of these rules:-

(i) Senior Officer is to signal the range for the night keeping it corrected as necessary.
(ii) No signalled orders for distribution of fire will be given.

(iii) Sighting ship proceeds exactly as if she were alone, except that she immediately signals the relative bearing of the enemy by W/T, and may also signal her gun range after the first spotting correction for information of consorts.
(iv) All ships open fire without delay in individual control on the target first sighted, using the range for the night or sighting ship's gun range as desired, reverting to "GMS" if and when the signal "GMS" is made by the Senior Officer, who will take the duty of master ship.
(v) Concentration is not desirable below 1,000 yards.
(vi) Range only will be signalled. (A.F.R. was in use.)
(vii) All ships firing at master ship's target are to use his ranges corrected for P.I.L, but concentration is permissive and the selection of targets in all cases rests with individual commanding officers.

Instructions were also given about engaging another target. If this appeared abaft the original one, the rear ship broke off and engaged it, and vice versa.

Should the master ship shift target, the fact was to be indicated by the signal SOB, and the concentration (still permissive) might continue.

47. It should be noted that these rules appear to have been drawn up without thorough investigation of the difficulty of distinguishing each ship's target at night, or of the confusion that is likely to arise if concentration is attempted when several targets present themselves. The *relative* alarm bearing was employed partly owing to all ships not being fitted with gyro compasses.

48. In 1928 it was confirmed that the flotilla leader if present, should act as a consort, and that the divisional fire control organisation, with the divisional leader as master ship, should remain unaltered. The "Senior Officer" if the foregoing summary therefore became the "Divisional Leader."

Coloured light procedure was also to be used for the alarm bearing in addition to W/T, and the bearing so signalled was to be a gyro one.

49. By 1929, a considerable amount of trial had been given to the foregoing procedure, and the opinion had been formed that it was becoming too complicated to stand the test of war.

The 1927 procedure (paragraph 46) was therefore modified as follows:-

(i) If one enemy is sighted and illuminated, all ships should at once concentrate upon her. The cardinal rule by night, however, is that no enemy must be left unfired at.
(ii) At close range, independent control is essential and no order ACY need be made or expected.

(iii) At longer ranges, if the enemy is inferior in numbers, and concentration of fire is therefore possible, the maximum hitting power can only be produced if the ships concentrating use the same ranges. The divisional leader or sighting ship under these conditions may use MSC procedure, but the signal MSC is *not* to be taken as an order, but as an indication that the ranges being transmitted are those that must be used if fire is directed upon his target.

(iv) In exceptional conditions, where the visibility is greater than about 6,000 yards, it may be desirable to employ concentration, and, in these circumstances day procedure should be used.

(v) A special night concentration procedure is only required, therefore, between roughly 2,000 and 6,000 yards, and not always even then. When used it should be in accordance with (iii) above.

50. Further and more realistic trials led to the discovery of the practical impossibility, when more than one target was presented, of distinguishing which ship was firing at which target. It appeared therefore that, in this case, no form of concentration was practicable.

Opinion between the two main fleets now diverged.

51. In the Mediterranean Fleet it was considered that decisive results outside about 2,000 yards could only be obtained against a single enemy if concentration was employed. If this was to be done the most effective form of concentration – MSC – should be used, and, if MSC was to be used, it should be done by a definite order. At the same time, it should be made perfectly clear what was to happen if and when another target presented itself.

52. The Mediterranean procedure therefore became as follows:-

Range 2,000 yards and under

Concentration is not to be used. If the range decreases to 2,000 yards during concentration, the master ship is to make the signal ACY.

Above 2,000 yards

Concentration is not to be employed unless only one enemy ship appears to be present. If, while concentrating, a fresh enemy is disclosed, consorts are free to take independent action at once, and the master ship is immediately to make the signal ACY.

Subject to the above the Senior Officer of any formation will decide if and when concentration is to be employed. If it is employed, the signals made by the master ship will indicate to consorts that it is an order to concentrate which is being signalled and not merely permission.

The flotilla leader will normally be the Senior Officer of the leading division, and will take duty as master ship for that division.

When concentrating day procedure is to be sued except that:-

(a) Divisional rapid salvos are to be fired throughout.
(b) No distribution of fire signals are to made or awaited. The master ship merely making MSC followed by the usual firing signal. (N.B.- This included deflection.)

P.I.L. Correction

It is to be assumed, unless obviously incorrect, that ships are in station. The G.C.O. should memorise the corrections for various bearings, and pass them to the Transmitting Station as necessary.

53. The remainder of the procedure, e.g., action by sighting ship, remained as before.

This system received a thorough trial, and was found to be efficient if limited to the conditions laid down for its use.

54. In the Atlantic fleet, on the other hand, it was considered that the previous instructions (paragraph 49) met the requirements.

55. The situation was complicated by the fact that at this time (1930) there were conflicting opinions as to the use to be made at night of the gun control W/T set. Owing to its value for manoeuvring purposes, it was normally so used by most flotillas, though it was officially available for gun control, and the foregoing procedures had been worked out on the assumption that this was the case.

An Admiralty decision (November 1932) was given as follows:-

"Gun control W/T set need not be regarded as immediately available for fire control purposes at night."

The position was now modified considerably. Since the essence of master ship control lies in quick and reliable inter-communication, the interruption caused by the intrusion of a manoeuvring signal may be disastrous. Against this must be balanced the confusion that is likely to arise if several ships engaging the same target are using different ranges.

56. The procedure outlined in paragraph 49 is now considered to be the correct one. It is uncertain, however,

(a) Whether or not the Divisional Commander should have more control of the fire distribution.
(b) Whether it is suitable for the sighting ship to act as master ship.

CHAPTER XIII

Trend Spotting

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Trend spotting

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1. In 1930, certain "C" class cruisers investigated the employment of reverse ladder after the target had been crossed, instead of using a single reverse correction. The object was to ensure straddling with at least one of the first three salvos fired in rapid.

2. The Admiralty view was that the system had the following disadvantages:-

(i) The potential rate of hitting is reduced by two-thirds.
(ii) The rate of fire is affected by the necessity for spotting corrections.
(iii) Added complication, and therefore increased liability to error. This is greatly increased in the event of one of the salvos of the ladder falling out for line.
(iv) Introduction of rules applicable to one class of cruiser only;

and it was directed that no further trials were to be carried out.

3. This proposed system did not embody the principle of spotting according tot eh trend of the fall of shot but did recognise the probability of the rate in use being in error.

4. In 1934, proposals, similar to each other in principle, were received at the Admiralty in which a radical change in the existing spotting rules were suggested. These proposals came from an 8-inch cruiser squadron, a destroyer command and H.M.S. *Excellent.* Generally speaking, each proposal was based on the essential factor that, in actions between high speed ships, the rate would be in error to an extent which would result in the burst of rapid salvos, following a reverse correction after a ladder had located that target, being fired at an incorrect range, even if the enemy took no avoiding action.

5. The proposed rules aimed at the employment of a method which would cover the error in rate assumed to be present.

6. It was proposed to achieve this by firing groups of salvos which contain salvos fired at the best known range, at a specified amount above this range and at a similar amount below this range (the cruiser squadron and *Excellent* suggested that a group should contain three salvos – the destroyer command suggested that the number of salvos fired should depend on the time of flight), rapid salvos never being employed.

1859

H.M.S. Hood Association

7. By this means it was hoped that at least one salvo in each group would straddle in spite of errors in rate, and that straddle would provide information on which to base a further group.

8. The obvious criticism was that the proposed systems were too complicated, but nevertheless authority was given for them to be tried by an 8-inch cruiser, some 6-inch cruisers, and certain destroyers.

Cruiser Report, 1935

1st Cruiser Squadron (8-inch)

9. "As regards the results obtained, the prolonged firing carried out by one cruiser at *Centurion* provided a searching test. Whilst it is not easy to obtain an exact comparison with the normal spotting rules solely by conjecture, it is probably that three ore straddles would have been secured by the trial rules in the time under fire, with a saving of about 36 rounds of ammunition. This saving of ammunition was due to the firing of four-gun salvos* until the target was found, and to an assumed higher rate of fire with the old rules firing rapid broadsides.

"It is not contended on the other hand, that the rate of fire will necessarily be slower with the new rules. On this occasion, the Control and Spotting Officers had not used them previously, and although no difficulty was found in applying them, unfamiliarity naturally led to a slowing down of the control. Even if experience shows that a slightly reduced rate of fire must be accepted, this appears to be amply justified if a higher rate of hitting can be obtained on a smaller output of ammunition.

"It is considered that the results obtained with the new rules are exceedingly promising, and that trials should continue. It is further recommended strongly that all ships should be authorised to use these rules against high-speed targets in time of war."

3rd Cruiser Squadron (new and old 6-inch)

10. Target and throw-off full calibre firings, carried out by ships of the 3rd Cruiser Squadron have created an unfavourable impression as to the ability of the ships, not only to obtain early hitting, but also to hold the target once it has been found.

"One 'D' class cruiser has stated that it is harder to hold the target for range and line with a 'D' class cruiser fire control equipment than in more modern classes of cruisers, and considered that the adoption of the spotting proposed by *Excellent* would enable a 'D' class cruiser to maintain good hitting results once the target has been found."

**The firing of four-gun salvos when opening fire is prejudicial to early hitting and is not authorised. In any case it is not a feature of "trend" spotting, since it applies to the salvos before the target is "found."*

(C23461) F

C.-in-C. Mediterranean

11. "It will be seen that whereas the Rear-Admiral Commanding, 1st Cruiser Squadron is much in favour of the principle of 'Trend' spotting, the Rear-Admiral Commanding, 3rd Cruiser Squadron, recommended the retention of the normal rules. The difference of opinion is probably due to the different main armament of the two squadrons.

I am not entirely convinced that 'Trend' spotting should be abandoned by 6-inch cruisers.

Summarise cruisers as a whole, it appears that-

(a) The new rules are better for single-ship firings.
(b) The new rules are slightly more difficult to apply.
(c) No advantage will be gained by using the new rules in concentration or night firings."

General

12. Results up-to-date are not conclusive enough to warrant a recommendation that the principle of 'Trend' spotting should definitely be adopted by any one type of ship, and slow speed peace time practices will frequently show that better results would be obtained by using the normal rules. I am convinced, however, that with the high speeds that will be used during action conditions, better hitting results will be obtained by using the 'Trend' principle, provided that the slightly greater difficulties of application can be overcome."

2nd Cruiser Squadron

13. "These spotting rules have been found difficult to manipulate, but the requisite percentage of straddles has invariably been obtained."

C.-in-C. East Indies

14. "The spotting rules have been tried in one 8-inch cruiser during full and sub-calibre throw-off practices. It appears that the rules give good results, but there is a considerable chance of the spotting officer mistaking the fall of one salvo for that of another. This is probably more likely to occur in a thro-off practice than when firing at a target or a ship. The need for very careful drill by the rating operating the fall of shot hooter is evident.

The rules under trial made it somewhat difficult for the Control officer to keep in touch with the situation. For example, if he has been in consultation with the rate officer and then turns his attention to the spotting, it is not easy for him to appreciate what happened while his attention was elsewhere. On

the other hand, if rapid salvos were being fired, it would be comparatively easy to grasp the situation immediately."

Destroyers

Admiralty remarks

15. Of these firings, there are sufficient *Centurion* and throw-off practices to enable comparisons to be made with the results obtained when using the standard code under similar conditions.

Curves of rates of hitting have been computed from the results of these firings. The results are interesting in that, while by the standard rules the rate of hitting steadily diminishes as the range increases, the "Trend" rules appear to give a regular rate of hitting at all ranges 7,000 yards and upwards. On the other hand below 6,000 yards the rate of hitting due to the standard rules tends to rise sharply. Evidence as to the results to be expected from the "Trend" rules at these lower ranges is lacking.

The formula employed for calculating the rate of hitting embodies the overall rate of fire. For 1935 the average rates of fire are 5.0 (standard) and 4.4 ("Trend). At what may be termed the likely range of 8,000 yards, where the rate of hitting by the two sets is the same, the corollary is that the "Trend" rules are producing a higher percentage of hits to rounds fired.

Another aspect to be considered is the certainty of hitting. From a comparison of the minima, it appears that there is a greater certainty of hitting with the "Trend" rules. On the other hand there cannot be a "lucky" shoot producing an unusually high rate of hitting.

The original spotting rules for destroyers, introduced during the war, were based on keeping as many salvos in the air as the time of flight allowed. Experience, however, showed that this was beyond the capacity of the control officers then available, and the rules had to be modified to keeping a maximum of two salvos in the air except when in rapid salvos. The control officers of that period had done no gunnery courses as Sub-Lieutenants, and so had had less preliminary training than the present G.C.O.s Further, modern fire control gear relieves the present day G.C.O. of many of the distractions which beset his predecessor during a firing. At the same time it must be borne in mind that, in seniority and experience, destroyer G.C.O.s in a future war will not vary greatly from those of the past. Unless therefore some "control officers' aid" (as suggested by Rear-Admiral (D)) can be made effective, it may be unwise to accept as standard, spotting rules which contain the same principle – the maximum umber of salvos in the air – as those rejected on wartime experience.

Commodore D

16. "It appears that these rules provide distinct possibility of increasing hitting results at high speed targets particularly in single-ship action."

Rear-Admiral D

17. "Taking into consideration the experience so far gained in the Seventh Division, and the various arguments that have been put forward during the last year, the following is my view of the problem.

In theory the new rules are greatly superior.

In practice this is equally true provided the control officer is efficient in the application of the rules.

The new rules therefore stand or fall not on their own merits, but in the ability of the control officer to apply them correctly and quickly.

In most of the firings during the year this has been done with sufficient measure of success to uphold their superiority.

This measure of success, however, is bound to be reduced under war conditions. The crux of the problem appears to be therefore:-

> "Will the embarrassment of war conditions neutralise the superiority which the new rules undoubtedly possess in peace practices?"

Viewed in this light, the case for the new type of rules cannot by any means be considered definitely proved without some aid to overcome a formidable array of obstacles.

To summarise it is considered that-

(a) The advantages to be obtained from the new rules are very considerable.
(b) To ensure them being realised their application must be facilitated.

General

18. Experience in all classes of ships indicate that the "trend" spotting rules are unsuitable for use in concentration, at night, and at very short ranges.

CHAPTER XIV

Anti-Aircraft Gunnery – Long Range

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Anti-Aircraft Gunnery – Long Range

SECTION 1. – RATE OF FIRE

1. Fleet firing with H.A.C.S. commenced in 1930, and the progress made in increasing the rate of fire and reducing the dead time can be judged from the following table:-

Year.	4.7 in.			4 in.		
	Rate of Fire.		Dead Time.*	Rate of Fire.		Dead Time.*
	Normal	Best		Normal	Best	
			Secs.			Secs.
1930	6	7-8	15	6	7-8	15
1931	6	-	12	8	10	11
1932	6.3 (Av.)	-	-	7.7 (Av.)	12	8-12
1933	-	13	11	-	20	5½-8
1934	12-14	15	-	15-20	20	5½-8
1935	12-12½	-	10	15-20	24	5½-8

* With hand fuze-setters.

2. In 1934 views began to crystallise as to the most satisfactory rate of fire to be used from the point of view of steadiness and accuracy, taking into account probably weather conditions, possibility of fatigue, etc., and opinion began to form as follows:-

(a) 4.7 *inch*. – 12-12½ rounds per minute with a dead time of about 10 seconds, except when continuous prediction gear and automatic fuze setters are fitted, when a dead time of 5½ seconds can be used.

(b) 4 *inch*. – 16-18 rounds per minute with a dead time of from 5 to 7 seconds, though there was doubt whether 15 rounds per minute could be exceeded if there was motion of the ship or respirators were being worn.

4-*inch Guns*

3. In 1935 opinion began to harden in favour of the adoption of a standard rate of fire of 16 rounds per minute. (One ship achieved 24 rounds per minute.)

4. This great increase in the rate of fire brought other difficulties in its train:-

(1) The need for increasing outfits of ammunition. It was approved to increase outfits from 150 to 250 rounds per gun.
(2) This rate of fire could only be maintained between certain limits of elevation. Below and above these limits both the rate of fire and dead time must be altered (*see* Section 2).
(3) When two or more ships are engaging one target, difficulty may be experienced in identifying own burst (*see* Section 3).

SECTION 2. – REDUCTION OF RATE OF FIRE AND INCREASE OF DEAD TIME WHEN LOADING DIFFICULTIES INREASE – 4-INCH GUNS

5. The rates of fire and dead time commented on in Section 1 can only be adhered to between certain elevations, and investigations are being carried out as to the best method of reducing the rate of fire and increasing the dead time when loading difficulties increase.

This problem is not simple and there are various factors to be considered in seeking a solution, some of which are discussed hereunder.

Dead Time

6. Dead time is made up from:-

(a) Time to predict and transmit a new fuze by voice – say 1½ seconds.
(b) Time to receive and set this fuze at the fuze setting position – say 1½ seconds.
(c) Time to load, lay the gun from loading elevation and fire it.

Notes. – (*a*) and (*b*) are fixed factors which, with hand fuze setters, cannot be reduced and may be exceeded.

(*c*) is a variable factor depending on the firing elevation. At the easier loading elevations from 2 to 3 seconds is the minimum.

7. There is some minimum figure for 4-inch H.A. guns, of the order of 5 seconds, below which the total dead time cannot at present be reduced, which will require perfect drill to achieve, and which will not be easy to maintain for any but a short firing period.

8. If the minimum possible dead time is used at the easier loading elevations, some increase will be necessary as loading difficulties increase.

9. There is some evidence to show that, whatever the firing elevation may be, a total dead time of 8 seconds (i.e., 5 seconds for factor 6(*c*)) can be used provided that the rate of fire is not too high.

Rate of Fire

10. Rate of fire is governed by factor 6(*c*) above and in addition by:-

(x) Time of recoil and run out.
(*y*) Time to come to the loading elevation (if necessary).
(*z*) Fatigue and physical capability of the gun's crew.

11. Factor 6(*c*) directly affects the dead time : factors 10 (*x*), (*y*) and (*z*) affect it only indirectly, and become of importance only at the difficult loading elevations.

12. If, at the difficult loading elevations the guns are fired in alternate salvos, or if provision can be made by other means for the effect of 10 (*x*), (*y*) and (*z*), it should be possible to assess an upper limit of time for factor 6(*c*) which represents the lowest figure that an be achieved under all conditions. Experience indicates that this time is about 5 seconds, as stated in paragraph 9.

Drill and Fuze Prediction

13. A rate of fire of 20 rounds per minute has been reached by several ships. The drill to achieve this rate has not been standardised, and varies in different ships. The drill used has an important bearing upon the method of changing the rate of fire.

14. A factor to be considered in drill is whether a single or a double overlap is used. This is determined by the rate of fire and dead time settings used.

Single Overlap

15. With a rate of fire of 20 rounds per minute, to secure a single overlap, the dead time must not be more than 6 seconds.

Double Overlap

16. With a rate of fire of 20 rounds per minute a double overlap results when the dead time is above 6 seconds and less than 9 seconds.

Prediction Sequence

17. The moment in the drill sequence at which the prediction fuze is passed by telaupad to the fuzesetters is important. With a ship using a dead time of 5½ seconds and 20 rounds per minute, the fire gong will commence to ring 0.5 seconds after the moment when prediction is made. The gun is therefore likely to fire

at the moment the fuzesetters are receiving the new fuze by teleupad. With a ship using a dead time of 8 seconds and 20 rounds per minute, the fuze is received immediately after the fire gong has ceased ringing and the gun has fired.

Change from Single to Double Overlap

18. If, when the change from normal to slow rate of fire is made, the settings on the fuze and firing interval clock are altered, a change from single to double overlap may result, depending upon the new settings used. The drill is simplified if the same overlap is maintained, but the change is feasible.

Details of Drill in use in the Fleet

19. The following different methods of solving the problem of reducing the rate of fire, and increasing the dead time, when loading difficulties increase, are typical of those which were used with success in the Fleet during 1934.

Method A

20. Settings of 20 rounds per minute with dead time 8 seconds are used under all conditions. At difficult loading elevations the guns fire alternate salvos.

21. The advantage of this method is its extreme simplicity and flexibility. No change of settings is necessary in the T.S., and there is no risk of confusion to the control. Moreover, the change can be effected ad any elevation which experience, or the conditions of the moment, show to be desirable.

22, There are two disadvantages:-

(1) A loss of output occurs at the reduced rate of fire. Twenty one-gun salvos per minute are in effect fired, whereas, it may be possible to fire up to 15 two-gun salvos per minute, if certain disadvantages are accepted.
(2) A dead time higher than the minimum that has been shown possible is used at the easier loading elevations. This is done deliberately for the reason given in paragraph 12, and to avoid the need for a change of settings and a change of overlap. It does, however, allow a margin for action conditions.

Method B

23. A rate of fire of 18 rounds per minute with a dead time of 6.3 seconds is normally used. This gives a single overlap. The slow rte of fire is 18 rounds per minute, but guns fire alternate salvos, with a dead time of 9 seconds. This gives a double overlap.

24. The change is effected by a definite drill in the T.S. and at the guns. In the T.S. the change from normal to slow rate of fire is ordered when the gun elevation reaches 43º increasing, and 15º decreasing; the change from slow to normal rate when the gun elevation reaches 50º decreasing and 13º increasing.

25. The change at the guns, necessary on account of the change in overlap, is ordered in all circumstances when the elevation is 48º or 15º.

26. These conditions are selected to satisfy requirements in a "direct attack" run, with an aircraft speed 100 knots at a height of 5,000 ft. The T.S. has latitude to alter the moment of change should the angle of presentation and height of the target indicate that the aircraft is carrying out some manoeuvre other than a "direct attack."

27. The effect on the fuze and firing interval clock is to cause an extended interval between fire gongs, when changing from normal to slow rate, and a reduced interval when changing from slow to normal rate. Prediction is undisturbed.

28. This method is criticised because of its rigidity. Perfect drill, and a difficult drill, is required if no confusion to the control is to result. Moreover it does not develop the maximum output at the reduced rate of fire.

Method C

29. A normal rate of fire of 20 rounds per minute with dead time 6 seconds, and a slow rate of fire of 12 rounds per minute with dead time 10 seconds are used. Each of these settings is on the exact border line between single and double overlap, i.e., prediction and gunfire occur simultaneously. No difficulty is reported with this procedure.

30. The change is effected in the T.S., at predetermined elevations, by altering the settings on the fuze and firing interval clock. The resulting disturbance to the prediction and fire gong sequence is not stated to cause difficulty.

31. The disadvantage of this method is that the two rounds fired immediately after the change over, are fire with incorrect fuzes. They are unlikely to be effective, and may embarrass the control.

32. The method does have the advantages of employing the highest rate of fire possible under most conditions, the lowest possible dead time at the easy elevations, and a margin of 2 extra seconds of dead time at the difficult elevations.

Method D

33. At the easy elevations, the highest rate of fire and lowest dead time with which the guns crews can compete, are used. On reaching the difficult loading elevations, the rate of fire and dead time settings on the fuze and firing interval clock are altered gradually, but by a definite amount, after each salvo, until the desired settings are reached.

34. This method has the advantage that the highest rate of fire and lowest dead time possible are used under all conditions. When the change in settings is being made, it introduces the disadvantage that the rounds will be fired at a different dead time from that for which the fuzes were predicted. Provided the change in settings is small after each salvo, the error should not be great and may prove acceptable.

35. Unanimity was not reached as a result of experience during 1935. One view held was that a reduction in rate of fire might be necessary for reasons other than difficult loading elevations, *e.g.* fatigue, casualties or breakdowns. The suggestion may, therefore be expected to come from the gun which likelihood makes Method A preferable. On the other hand, another view was that Methods A, B and C were insufficiently flexible to meet war requirements and therefore Method D was preferable.

Conclusions

36. It is not desired to restrict the lines upon which further investigation of this problem should proceed, but it should be noted that, in war, the majority of salvos will be fired at the easy elevations. A method which employs, at the easy elevations, a longer dead time or a slower rate of fire than is necessary, would therefore appear to be undesirable.

SECTION 3. – CONCENTRATION – IDENTIFICATION OF OWN BURSTS

37. With the slow rates of fire achieved in 1931, no difficulty was experienced in identification of won bursts during simultaneous firings with two, three and four ships.

38. As the rates of fire increased difficulties began to be experienced when two or more ships were firing at the same target. It was considered unsound to restrict the output and possible solutions appeared to be-

(a) Tracers.
(b) Coloured bursts.

It seems probable that in war, concentration would be required at long ranges, and identification must be effective at extreme range. Tracers would not meet this requirement, and investigations into the possibility of producing a coloured burst were put in hand.

39. At the same time the fleets were instructed to test the principle by firing H.A. practice projectiles as “identifies” during H.E. practices and *vice versa.*

40. During 1935 experience of the difficulty of distinguishing own ship's bursts was variable. Generally, with only two ships firing, no difficulty was found, provided that one ship had had time to make initial adjustments to speed and angle of presentation to establish line, before the other ship opened fire.

41. Experience showed that while H.E. "identifiers" employed in a firing with practice ammunition are entirely effective, the same is not always true under service conditions, viz, firing with H.E. using practice shell as "identifiers," since the large burst of the H.E. may obscure the bursts of the "identifier" rounds.

Trials are to be carried out with H.E. shell filled powder. Meanwhile, every endeavour is being made to produce H.E. shell giving different coloured bursts.

42. In commenting on "Queen Be" firings one report suggested that as it is more than likely that each ship's normal individual errors will cause such a pattern in the sky as will ensure aircraft being thoroughly harassed, a suitable general rule for control officers might be:-

> If while engaging enemy aircraft at long or medium range it is observed from the number of bursts that other ships are also firing at the same targe, identifier shell should not normally be fired unless some of the burst indicate an obvious error in vertical and lateral deflection applied in one or more of the ships firing at that target.

SECTION . – USE OF GUESSED DATA FOR OPENING FIRE

43. In 1931, when the normal dead time in use was of the order of 15 seconds, it was customary to open fire using a guessed height in order to cut down the time from enemy in sight to first round.

44. The suitability of this policy was questioned. The desirability of shooting to instrument was recognised, but it was considered essential to open fire on a menacing target as early as possible. In some cases a delay of a few seconds could be justified while waiting for an observed height, but it was considered that such a procedure should not normally be employed and it was held that proper liaison between the control officer and range-taker would enable the former to determine the right course of action.

45. This opinion was reiterated in 1933 after further representations from sea as a result of 1932 practices.

46. The considerable advance in the efficiency of A.A. gunnery in 1933 led to a slight revision of this policy. Experience clearly indicated that no useful purpose was served in opening fire with guessed data, unless the target is immediately threatening. It is also extremely wasteful of ammunition.

47. With ships able to open fire with properly predicted rounds within 25-30 seconds of the "Alarm" (if good conditions less than 20 seconds) it is considered that the question of whether fire should be opened on guessed data is dependent on the circumstances at the time, and the standard of the A.A. armament.

SECTION 5. – POSSIBILITY OF SPOTTING FOR FUZE LENGTH OR HEIGHT

Direct Observation

48. When firing at sleeve targets it is quite impracticable to spot the position of bursts for range in relation to the target, but the advent of wireless controlled aircraft led to a suggestion that against actual aircraft this might be possible. Opinion is not unanimous, but the general trend appears to be that spotting for range may be possible under certain conditions.

10x Stereo Spotting Glasses

49. Full investigation during "Queen Bee" firings indicates that no reliance can be placed on the results of observations with these instruments.

Long Base (12 ft.) Stereo Spotting Telescope

50. Consideration was first given to the possibility of stereo spotting in 1931 in combination with stereo height finding. Trials carried out in 1934 brought out the following points:-

(*a*) The importance of the observer being experienced in stereo-observation.
(*b*) For successful observation, bursts must be close to the target for line. Observation of bursts not close for line may be misleading.
(*c*) Reliability of results increases as the range decreases.

51. Trials of a long base instrument in 1935 gave rise to the following remarks:-

> "It was found that the position of bursts relative to the target could be assessed with reasonable accuracy up to ranges of approximately 6,000 yards, provided bursts were within one degree for line, and in certain cases beyond that range. Some difficulty arose, however, in making full use at the time of the information obtained since an alteration to the ballistic height correction in use was considered to be unjustifiable unless the burst reported happened to have been predicted exactly on the true prediction line, or the report was contradictory to that expected from the error in prediction. Even then it is doubtful if it is desirable to make an alteration on the evidence of an isolated salvo, observing that a report is generally based on the observation of only one burst of each salvo. There is little

doubt that the instrument would be of value in affording a means of correcting a consistent error during one firing before engaging another target; the possibility of determining the ballistic height correction for the day, prior to engaging a target, also appears worthy of investigation.

From the limited experience gained, the results obtained were promising."

Further trials will be carried out and four more instruments are being manufactured, two of which will have fixed wander marks.

52. Arrangements are being made in most H.A.C.S. directors now on order to accommodate a duplex rangefinder, one band of which, if results with the trial instruments are successful, could be used for spotting.

SECTION 6. – VALUE OF FLANK OBSERVATION REPORTS

53. The possibility of making use of flank observation reports has continuously been under consideration. It is held that it would be unsound for a ship to take immediate action on flank observations because:-

(a) The flank observations refer only to past errors, which will not necessarily recur.
(b) Of the difficulties of communication at the necessary speed.

54. Such observation, however, may be of value in eliminating a consistent error before the next target is engaged, and it is under consideration to adopt the following policy:-

(a) If a consistent error throughout an engagement of one target is apparent, it is justifiable for an arbitrary correction to be made since the most probably cause of this consistent error is the heightfinder being out of adjustment.
(b) Any ship in a suitable position to observe the position of the burst for range of another ship should communicate the general trend of the burst of the firing ship immediately on conclusion of a run or engagement of one target.
(c) For this purpose the bursts are to be divided into groups of about five or six, and the M.P.I. of each group signalled. The distances of the bursts over or short should be measured in degrees, and converted approximately into hundreds of yards, allowance being made for the range of the target from the marking ship and the direction of the line of fire.

CHAPTER XV

Anti-Aircraft Gunnery – Close Range

Value of tracers in observation of fire and proportion to be used.

CHAPTER XV

Anti-Aircraft Gunnery – Close Range

VALUE OF TRACERS IN OBSERVATION OF FIRE AND PROPORTION TO BE USED

Value of Tracers

1. The problem of observation of fire from the "M" Pom-Pom is a difficult one, and continuous investigations have been carried out since 1930. The first conclusions reached as a result of trials carried out in that year with *single* pom-poms were:-

(i) Observation of fire by means of tracers is only 100 per cent. definite when no part of the trajectory crosses the target, as seen from the firing ship.
(ii) Tracers are only of value for indicating the existence of *large* errors in line and relatively *very large* errors in elevation.

2. The reports of firings carried out at sea between that date and 1935 were conflicting, but the general view appeared to be that tracers were of little value, except at very short ranges, and to indicate very large errors.

3. Further extensive trials were carried out in 1935, and the following conclusions were reached:-

(a) Accurate observation of tracer against a target at any range over about 1,000 yards is almost impossible to obtain. At shorter ranges the accuracy may be expected to improve provided the observer is near the gun.
(b) It is not possible to make any use of deductions resulting from the observation of tracer without affecting the accuracy of aiming.
(c) In any case the deductions made are inevitably stale by the amount of the time of flight, and are generally misleading except at very short ranges.
(d) The only value of tracer for pom-poms and 0.5-inch machine guns is to show up large errors (errors of 2^{o} and less will not be shown up), and to indicate at what targets the various guns are firing. For the latter purpose, tracer should be fired in bunches from all barrels separated by an interval from the next bunch.

Proportion of Tracer to be used

4. It is an important factor that tracer fitted shell (of small calibres) are less effective than non-tracer since some of the explosive is displaced. It is necessary that the loss of effective fire in such weapons as the "M" pom-pom must be reduced to the minimum, consistent with the meeting of requirements. It is a question, therefore, of correlating this requirement with that for observation of fire.

5. As a result of trials carried out in 1931, instructions were given to reduce the number of tracers to the supply to *two barrels only*, the number being 5 to each belt of 28 rounds or 3 to each belt of 14. It was hoped that practices in 1932 would enable some decision to be reached, but such was not the case, and it was necessary to allow Commander-in-Chief a free hand in investigating the proportion.

6. After the 1933 practices the Home Fleet reported that no improvement could be made on the proportion indicated in paragraph 4 above, but the Mediterranean Fleet opinion favoured one tracer in five from all barrels.

7. The Home Fleet, after 1934, favoured the firing of tracers from all barrels in order to portray a complete pattern, but in order to reduce the number of barrels in which tracer were fired, and thereby increase the effective density of the pattern, a trial was also made of firing tracers (first and eighth rounds) from the barrels covering the four corners of the pattern and this was favourably reported on.

The Mediterranean Fleet established that tracers from two barrels were insufficient, while China suggested that the minimum acceptable was one in five from two barrels.

8. Further extensive trials were carried out during 1935, and the recommendation made to continue to use tracer for the purposes mention in paragraph 3(*d*) in the following manner:-

2-pdr. Mark "M," pom-pom ..	1 night tracer every 7 rounds from all barrels.
0.5-in. machine gun	3 consecutive tracers every 20 rounds.

9. The Admiralty remarked:-

> It is possible that the proportion recommended (1 in 7) will be sufficient if fired from the four wing barrels of the pattern only. Further information is required on this point. Pending further reports from sea, arrangements are being made to supply tracer in the proportion of one tracer in 7 rounds for half the outfit only.

CHAPTER XVI

Anti-Aircraft Gunnery – Use of Guns primarily Mounted for Anti-Ship Purposes

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Section 1. – Long Range Fire.

Section 2. – Close Range Fire.

7. The following policy as to the employment against aircraft of guns primarily mounted for anti-ship use was approved in 1934:-

Class of Ship.	Armament.	Whether to be used for A.A. at		Fuzes to be used.
		Long Range.	Short Range.	
All Capital Ships	Main	No	No	-
All Capital Ships	Secondary	No	Yes	Short burning
"C," "D," and "E" cruisers	Main	No	No	
Later cruisers	Main	No	Yes	Short burning
Aircraft carriers with combined H.A. and L.A. armaments	Main	Yes	Yes	Time mechanical
Aircraft carriers with separate H.A. and L.A. armaments	Main	No	Yes	Short burning

(*See also* Sect. 2, para. 14.)

8. The provision of A.A. control arrangements for anti-ship guns was again urged in 1935, and the question is being reconsidered. Initial investigation is being directed towards a means of employing the geometric data provided by the H.A.C.S. of the main A.A. armament so as to enable the fire of anti-ship guns to augment that of the main A.A. armament – and, of course, to enable the anti-ship guns to open fire on the target of the main A.A. guns before it comes within range of the latter.

9. For destroyers and smaller craft not fitted with H.A.C.S., another system is being developed; and trials of the first set will be carried out during 1936. H.A. firing trials, designed solely to test the suitability of the 4.7-in. 40-degree mounting for H.A. fire, have been carried out.

10. Meanwhile, an opinion was expressed that there may be occasions on which it will be desirable to augment the fire of the A.A. guns of the fleet with fire from anti-ship guns – *e.g.*, before aircraft come within range of A.A. guns, or in the case of aircraft encountered only by destroyers with no A.A. guns – even though these anti-ship guns have no form of control. Briefly the method to be employed is as follows:-

> The ranges at which salvos are to be fired are predetermined, and fuzes set beforehand. The tangent elevations for these ranges are predetermined. The director lays on the aircraft, and, when the rangefinder indicates the appropriate range, rapid fire is opened for about 30 seconds. Lateral deflection is estimated, and vertical deflection included in the tangent elevation. This produces a series of bursts on the line of sight at different heights, rather than a barrage of bursts at one fixed point in the sky.

SECTION 2. – CLOSE RANGE FIRE

Use of Shrapnel from Turret Guns

11. Trials were carried out against a glider target during 1926, to try out the use of shrapnel from turret guns against close range air attack.

12. The conclusion drawn was that the use of shrapnel from main armament guns, in circumstances where a clear field of fire is available, is likely to cause considerable damage to attacking torpedo aircraft (but *see* Section 1, paragraph 7).

Splash and Splinter Barrage Trials

13. Trials were carried out in 1928 to investigate the possibility of using a splash and splinter barrage as a means of defence against torpedo aircraft attack. Anti-ship shell with a delay setting were used, and were fired to hit the water in the line of the attacking aircraft about 1,000 yards from the firing ship. It was hoped that in addition to the splash barrage put up, the shell would ricochet and burst at a considerable height, thus forming an additional splinter barrage. The shell used were anti-ship shell.

1. The information produced was:-

(a) A proportion of shell will be blind, particularly in smooth water.
(b) The burst will take place too low (8 ft. above water) to be really effective.
(c) The effect of setting fuzes to delay in order to get bursts at a greater height appears to be small.

Barrage with Time-fuzed Shell

(*See also Section* 1, *paragraph* 7.)

15. Concurrently with the Splash and Splinter Barrage, trials were also carried out using time-fuzed H.E. shell. The general conclusion reached was that the latter type of barrage is likely to prove more effective than the former.

16. Further trials carried out in 1930 confirmed the value of a time-fuzed H.E. barrage, but it was pointed out that the fleet would to be able to make use of this form of defence as suitable ammunition and fuzes were not in supply. Action was initiated to develop special fuzes with a maximum time of burning of the order of 5 seconds since the time of burning of No. 198 fuzes was too irregular at short ranges.

These fuzes (No. 400) became available in 1935, and, in 1936, some 6-inch innocuous shell for practice purposes.

17. At the same time, the supply of fuzes was extended to Q.F. 4.7-inch guns in destroyers in consequence of demands from sea.

CHAPTER XVII

Anti-Aircraft Gunnery – Night

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1. Prior to 1935 it was not the policy that night A.A. practices should be carried out. This policy was adopted at a time when concentration on the problem of day A.A. defence was of extreme importance. By this date ships had become considerably more efficient in day practices, and the ammunition allowance had been increased.

2. On this account it was considered that the time had arrived when more attention should be paid to night A.A. defence. Generally speaking, the policy was and is evasion, but it is obvious that there are some occasions on which gunfire must be employed as a defensive measure.

3. Reports indicated that the material supplied was not entirely suited to night firings, and information was asked for.

4. Night firings at "Queen Bees" were carried out by the Home Fleet during 1935. It was stated that little difficulty was found in obtaining a reasonably satisfactory plot, once the aircraft was well illuminated. Rangetaking was easier when the aircraft was in the edge, rather than in the centre, of the bear, and easier still when the aircraft was illuminated by the searchlights of another ship.

5. Night throw-off firings have been carried out by ships of the China Fleet. The conclusion reached from these practices is that little value is to be obtained from throw-off firings. Experience of A.A. defence at night can best be obtained from the control point of view by dummy runs and from the gun point of view by sleeve target firings.

6. In the first night throw-off firing carried out by the China Fleet, difficulty was experienced owing to the glare of the searchlight, which, in the *Kent* class, is close to the H.A. director, interfering with the H.A. control. In a later firing this was overcome by employing the next astern as illuminating ship; and under these conditions it was reported that the aircraft provided an ideal target on which to range.

7. The desirability of siting searchlights away from control positions has been noted.

8. The conclusions of the Commanders-in-Chief, Home Fleet and China, as to the ease of ranging on a target at night (paragraphs 4 and 6 above) are not endorsed by the Commander-in-Chief, Mediterranean, who considers that "at least three and sometimes six searchlights, depending on meteorological conditions and height of aircraft, are required to obtain the intensity of illumination necessary for heightfinders to get a clear cut."

Illumination

9. It was stated in 1935 that it had been proved that star shell, set to burst over and in the vicinity of a sleeve target, are capable of illuminating it so that it can be picked up and held in a searchlight beam.

10. Owing to the danger of illuminating the firing ship, this method of illumination is undesirable at short ranges.

11. Trials have been carried out in the Home and Mediterranean Fleets using Army sound locators. These confirmed conclusions reached in previous trials that the Army sound locator is not suitable for Naval purposes.

Experiments are now being made with another form of locator which is being designed for automatic control of searchlights. There appears to be little hope at present of producing a sound "detector" (as opposed to a directional "locator") which will be suitable for use on board.

12. Experience has shown that the possibility of picking up a target with a searchlight with no form of sound locating device is small. Further, it is, in general, undesirable to expose a searchlight beam from ships unless the light is trained on the target, since the attacking aircraft is assisted in locating its objective and is at once provided with a point of aim. It is concluded that for the defence of the fleet in harbour at night reliance must be placed in the first instance on shore searchlights, sound locators and guns, assisted by the guns of the fleet.

Considerable attention was directed to the problem of A.A. defence in consequence of the critical international situation arising

from the Italo-Abyssinian war, and the searchlight policy brought into force in the Mediterranean was, summarised, as follows:-

In Harbour

Policy No.	Night Condition.	Shore Lights.	Ship Lights		Remarks
			Main Body.	Selected Ship.	
		Defended Harbour.			
1	Dark	Yes	No	No	
2	Light	Yes	No	No	
		Undefended Harbour			
3	Dark	-	No	Yes*	* But only after fleet has been discovered
4	Light	-	Yes	Yes	
		Partially Defended Harbour			
5	Dark	Yes	No	Yes†	†But only to take over from shore lights
6	Light	Yes	Yes	Yes	
	Attention is called to "the possibility of craft in the air or on the surface being sent in to cause the Fleet to divulge its position to the air, or to illuminate the Fleet or base by flares, before the main attack is made.				
		At Sea			
7	Searchlights will not be used unless the Fleet's position has been disclosed by illuminating surface targets.				

14. Steps are being taken to remedy the known shortcomings of existing searchlight control for A.A. work, and consideration is being given to the fitting of large searchlights in future destroyers, the units of the fleet which, owing to their size, can perhaps best afford to betray their position.

CHAPTER XVIII

Bombardment

Section 1. – Spotting Rules.

Section 2. – F.O.O. v. Ship Control.

Section 3. – Orientation of the Clock when used for Ground Observation.

Section 4. – Accuracy, and Roll on which Salvos should be Fired.

CHAPTER XVIII

Bombardment

SECTION 1. – SPOTTING RULES

1. The Spotting Rules contained in the "Text Book of Naval Bombardment, 1935" have been recently evolved. They are the result of firings over land ranges, and are supported by Army experience and advice.

2. The suitability of the size of the corrections when verifying a hit or a contradiction while ranging, have been questioned, however, and further information is required on this point.

SECTION 2. – F.O.O. v. SHIP CONTROL

3. With ground observation the question as to whether the F.O.O. or the ship control officer should normally be in control of the fire has given rise to argument. The question was raised so long ago as the Chanak operations in 1922, but no record of it occurs in Progress in Naval Gunnery until 1932.

4. The conditions under which an alternative to ship control exists only arise when the ship is at anchor. When under way, the shoot must be considered as a normal naval practice at a fixed target, and observation from the ground is merely another line of information for the shi control officer, supplementing direct or air spotting.

When at anchor, however, the conditions are different, and the firing may be considered as being carried out by a rather inaccurately sited fixed gun.

5. The arguments for and against F.O.O. and ship control should only be influenced by those practices carried out against land targets.

Firings against moored targets are of no value as a guide to results which may be expected in war.

Moreover, if the conditions for observation are easy, there is probably little to choose between the two forms of control.

Thus until the Cape Wrath range became available, the last deductions of any real value were made after the practices at Gallipoli in 1923. These conclusions were:-

“When using ground observation, the advantages of ordering the actual spotting corrections from an O.P. which has any command over the ground are very marked, and this procedure

is definitely recommended. The F.O.O. is often able to form a good impression of the actual position of the fall of each round, but is unable to communicate this information to the ship to the full extent that he himself is able to appreciate it. The success of control from the O.P. naturally depends on an absence of mistakes in the firing ship, as the F.O.O. will not be able to realise when a mistake occurs. If the communications between the O.P. and the ship are bad, however, the ship must be prepared to take over the control, making the best use of whatever spotting reports are available; the extreme case of this would be a total failure of communications when, if firing is to be continued, it must be controlled from the ship.

"If the O.P. has command over the ground, the F.O.O. can tell with certainty when the shots are falling very far from the target, and so can save a further waste of rounds, whereas the tendency in such a case when controlling from the ship is to mistrust the report."

6. In "Progress in Naval Gunnery, 1932," the question is mentioned with the preliminary statement that -

"Experienced artillery officers were strongly of the opinion that F.O.O. control should be the normal procedure when the firing ship was at anchor. The chief argument adduced being the added safety to our own troops."

7. The following objections to this proposal were then given:-

(i) It can only be used when the ship is at anchor, and even then it is probable that the yaw of the ship would entail alterations to the range and line ordered being made in the ship.
(ii) The Control Officer in the ship is in direct touch with his director layer, and, under conditions where errors in laying may be expected, is able to discriminate between bad and good shots.
(iii) Good control by N.F.O.O. requires a considerable amount of practical experience.

8. As regards (i) it is quite agreed that it can only be used when the ship is at anchor, but this is no valid reason for not using the best method under those conditions. The fact that the corrections may have to be superimposed in the ship is no more an argument against F.O.O. control than are corrections for range due to rate imposed in the Transmitting Station, an argument against control from the fore top in normal naval firings. Such corrections will merely neutralise inaccuracies in the position of the gun, and should not affect the sequence of the observer's calculations.

As regards (ii), this close touch by no means ensures that director and gunlaying errors are immediately appreciated. In any event,

if a bad shot is made, the information that it is a bad shot can be conveyed to the F.O.O. almost as easily as it can be to the Control Officer in the ship.

As regards (iii), this is considered to be the kernel of the dispute. It was felt by commanding officers that it would be unwise to place the making or marring of the whole shoot in the hands of a comparatively untrained officer, and they were reluctant to admit that the F.O.O. could, with his command of the ground near the target, handle the armament better than could all the resources of the ship with information from the F.O.O. at their disposal.

9. Subsequent practices in which F.O.O. control has been employed have shown that the difficulties of this form of control have been over emphasised. The following good reasons exist for its adoption as the normal method of control when ground observation is used at anchor:-

> The Ship Control Officer can have little idea of the command of ground available from the O.P. On this command depends the method of controlling the fire, and good results are more probable when the person with this command (F.O.O.) has the handling of the fire control. This is especially the case where observation is difficult. The Ship Control Officer cannot know how much weight to attach to each report whereas F.O.O. knows that burst in certain sectors give more definite indications than in others. With F.O.O. control rounds can be placed in "good" sectors in order to obtain reliable spots.

SECTION 3. – ORIENTATION OF THE CLOCK WHEN USED FOR GROUND OBSERVATION

10. The first suggestion that the Clock Code method of reporting fall of shot could be used when employing shore single line observation was made as a result of experience in 1926 practices and authority was given for its use for amplifying reports as a result of 1927 practices. It was customary to orient the clock with 12 o'clock at True North.

11. The suitability of this orientation was question in 1932 and it was suggested that it would be preferable that the vi-xii line should be set along the line OT.

12. This, however, entails the position of the OP being accurately known in the firing ship. The chances of which, in war, re likely to be remote, since it is questionable whether the F.O.O. will himself be able accurately to fix his position.

13. It was considered more practicable for the clock to be oriented with xii at True North, and further experience in 1933 confirmed this.

SECTION 4. – ACCURACY, AND ROLL ON WHICH SALVOS SHOULD BE FIRED

14. Firing accurately laid salvos has always been recognised to be of importance, and in 1934 it was stated that it was preferable that all salvos should be fired on the upward roll, since any tendency to be late in firing will minimise the chances of danger to own troops.

15. This decision was questioned on the grounds that if an error was made to the extent of firing a round on the wrong roll, the danger to own troops would be increased.

16. From the point of view of safety to own troops, it would appear that the decision depends on whether the probable error will be

(a) To fire on the wrong roll, or
(b) To fire inaccurately on the selected one.

The possibility of a hang-fire, even with an accurately laid salvo must be considered.

17. No decision has been reached and further information is required.

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