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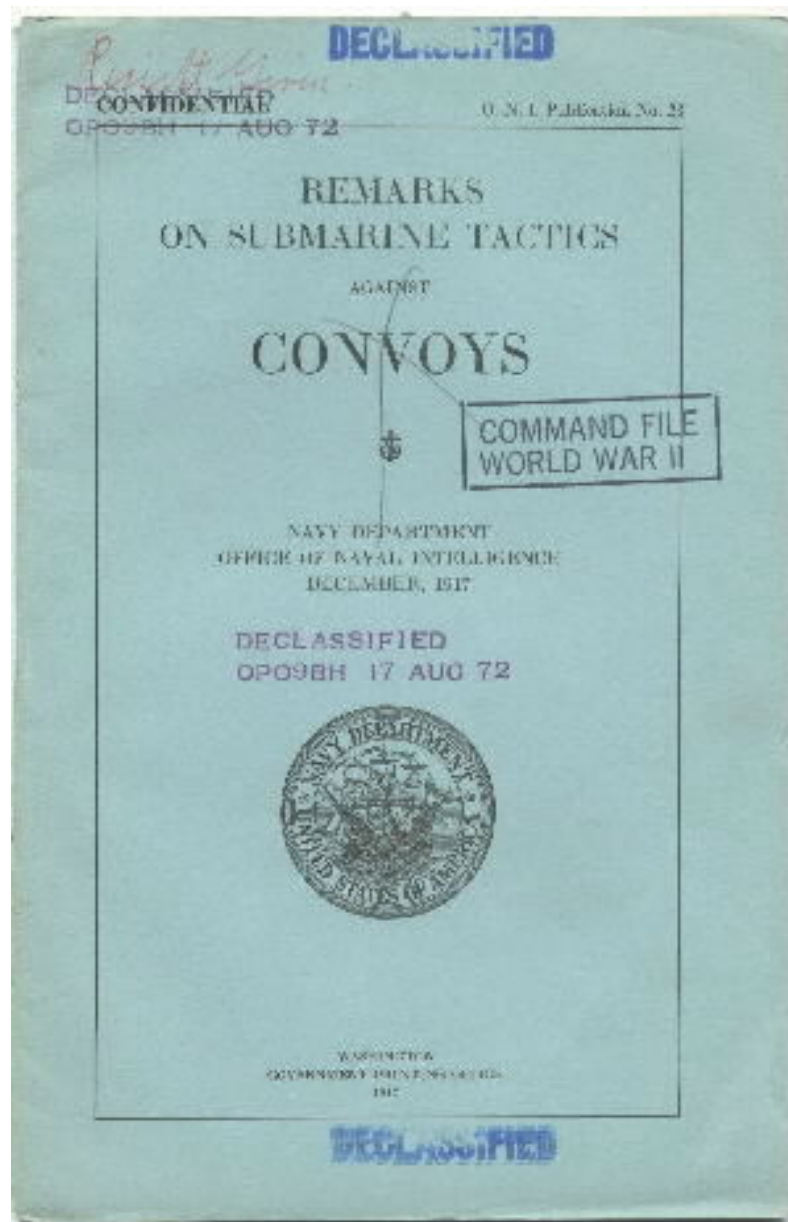
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**REMARKS
ON SUBMARINE TACTICS
AGAINST
CONVOYS**

NAVY DEPARTMENT
OFFICE OF NAVAL INTELLIGENCE
DECEMBER, 1917

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Image of cover.

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REMARKS ON SUBMARINE TACTICS

AGAINST

CONVOYS.

1917.

ADMIRALTY NAVAL STAFF
ANTI-SUBMARINE DIVISION
OCTOBER, 1917.

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NAVY DEPARTMENT,
OFFICE of NAVAL INTELLIGENCE,
Washington, December 1, 1917.

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ROGER WELLES,
Captain, U. S. Navy,
Director of Naval Intelligence.

--- 2 ---

CONTENTS.

	Page.
I. Under-water Speed	5
II. Effect of Bad Weather	6
III. Surface Speed	7
IV. Hearing Powers	7
V. Submarine operating by night	8
VI. Tactics of Submarine on sighting a Convoy	8
VII. Tactics of Submarine when attacking	9
VIII. Tactics of Submarine after an Attack	11
IX. Effect of Convoy zigzagging	11
X. Two or more Submarines co-operating	12
XI. Single Ship Escorts	12
XII. Convoy Escort	14
Diagrams.	

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REMARKS ON SUBMARINE TACTICS AGAINST CONVOYS GERMAN SUBMARINES.

Full details of German submarines, so far as is known, are contained in O. N. I. publication No. 13, German Navy (Submarines).

The following supplementary remarks are made from inferences drawn from a comparison between captured submarines and British submarines, and British general submarine experience.

I.--UNDER-WATER SPEED.

Full Speed probably less than stated.

Although complete records of surface trials and capacities of batteries have been obtained, definite data,

as to submerged speed is conspicuous by its absence.

Judging from their lines and the manner in which numerous external fittings have been added regardless of resistance, it is evident that the Germans do not aim at high under-water speed.

If a submarine is designed for under-water speed, other qualities, notably surface speed and endurance, the amount of armament and other stores carried, must be sacrificed.

A corresponding loss of submerged endurance is involved, and, all things considered, it would appear the Germans' best policy to be content with a moderate full speed submerged.

Considerations limiting use of Full Speed.

The length of time a submarine can maintain her full speed under water depends very much on the locality in which she is working, the time of day, and the duration of darkness.

In open waters, where a submarine is not harassed by patrols, she will probably start an attack with her batteries fully charged.

An attack may be always followed by a hunt, and consequently she will be very unwilling to run her batteries down low early in the day.

Danger Angle (Submarine submerged).

In calculating the angle on the bow of a convoy within which a submarine is dangerous, it is considered a safe general assumption that the submarine can travel 7 miles in an hour. This allows for her easing down at intervals to look through the periscope -- a necessary precaution, since at 7 knots it would show a very conspicuous feather.

--- 5 ---

In clear weather a submarine when diving can see the masts and smoke of a convoy through her periscope at about 7 miles.

For a 7 1/2-knot convoy this gives a danger angle of about 7 points.

Effect of Low Visibility on Danger Angle.

If the visibility is less and not accompanied by calm weather, the danger angle becomes rather greater, since the submarine can proceed at greater average speed for a short time.

Effect of Zigzagging on Submarine's Speed.

When working through a screen or attacking a ship or convoy zig-zagging, a submarine must take frequent short looks through her periscope, and consequently can make less use of her speed.

II.-EFFECT OF BAD WEATHER.

Surface.

With full buoyancy on the surface, submarines are affected by weather to much the same extent as torpedo craft of the same displacement. They are rather more comfortable, but cannot steam so well into a head sea owing to the comparative lack of buoyancy forward and low freeboard.

Their guns being placed low down, can only be fought under great difficulties if steaming with even a moderate sea ahead or on the bow.

Submerged.

In bad weather there is a critical depth above which a submarine is not under control. This depth varies with the state of the surface, size of the submarine, and the speed at which she is moving. If the submarine gets above this depth she is liable to take charge suddenly and rush to the surface, often taking 5 or 10 minutes to force under again.

When the sea is such that the submarine cannot remain below the critical depth and use her periscope she becomes useless as a submarine, and must either definitely come to the surface or dive deep. The latter course is most generally followed, since a submarine, when on the surface and shut down, has a very poor all-round lookout in bad weather, and may be caught by gunfire from a vessel she has not seen.

When submerged for this reason she usually dives to about 60 to 80 feet and goes dead slow, *i.e.*, about 1 1/2 knots. At this depth there is very little motion, and the whole crew, except those actually on tricks, can rest.

Nothing definite is known as to what state of sea is required to make the German submarine unmanageable, but from the evidence available it is probably about 6 to 8. Should a submarine attempt an attack in weather approaching her limit she is very liable to break surface with her conning tower, and a good lookout should be kept for this, although from the state of the surface it may appear hopeless to try and spot a periscope.

--- 6 ---

III.-SURFACE SPEED.

Full Speed.

To economize fuel and save wear and tear of engines, German submarines very seldom appear to use their full speed. The occasions on which they do so are limited to--

- (a) passage of dangerous areas when visibility is good.
- (b) Chasing a single ship.

- (c) Steaming round a ship or convoy in order to get ahead of it.
- (d) Escaping with a damaged pressure hull or otherwise unable to dive.
- (e) Escaping from slow patrol craft.

In order to steam at full speed a submarine must have full buoyancy. In this condition she probably will not take more than 3 minutes to submerge, but she will be in her most visible condition, and she will be more conspicuous if there is any sea on account of the bow wave and spray thrown up.

Steaming with reduced Buoyancy.

With only her bow and a little of the upper deck above water a submarine can steam from 10 to 11 knots. In this condition she is much less visible, and can submerge to a depth safe from ram or gunfire within a minute.

At Night or in Thick Weather.

At night or in thick weather a German submarine usually proceeds with reduced buoyancy, using one motor as a dynamo to drive the other motor and propeller. In this condition she can make 8 to 9 knots, and is instantly ready to dive.

IV.--HEARING POWERS.

German submarines are well equipped with hydrophones. Though these are not so sensitive as our own, they are certainly capable of hearing a convoy at a considerable distance. To employ them effectively the submarine must be stopped or proceeding slow under her electric motors. If there is much sea on she cannot hear much unless diving, on account of water noises. Directional effect is obtained by having three pairs situated in different positions in the external ballast tanks or inside the superstructure. At night or when visibility is low it must be assumed that submarines can hear a convoy some time before they can see it, and consequently no precautions should be relaxed under such conditions.

When close to or in the middle of a convoy the sounds are so confusing that they are not of much assistance.

When almost ahead of any ship the sound of that ship's propellers is at its minimum, and may well be drowned by the sounds of other ships further off but on a different bearing.

This point becomes very important when maneuvering close to a number of ships, since if a submarine relies upon hearing, she may come up to periscope depth (top of hull 20 to 25 feet) in the silent area almost right ahead of a ship she is listening for, and in a position to be rammed by her.

--- 7 ---

V.-SUBMARINE OPERATING BY NIGHT.

Night Periscope.

In addition to the two periscopes usually carried in all submarines, some, if not all, of the larger U boats have a third. This is situated before the conning tower, and is referred to by prisoners as an emergency periscope. It is, however, thicker and shorter than the others, and it is possible that it may also be used for night work. No authentic reports have been received of diving attacks being made by night, but many night attacks are recorded in which nothing has been seen of the submarine.

Very Dark Nights.

On very dark nights a submarine is working under the same conditions as in thick fog, and stands a good chance of being run down. Unless ships are showing lights it is considered improbable that a submarine will attempt to attack a convoy under these conditions.

Starlight Nights.

If the night is starlight or not quite dark, a submarine can be fairly sure of seeing a ship before she is herself seen, and if she finds herself amongst a convoy may do a good deal of damage. She will have very little time to manoeuvre, however, and depends for her chance of success on a ship passing within range.

Moonlight Nights.

On moonlight nights submarine will probably operate on the surface with very little buoyancy. Under these conditions they are very hard to see, especially if their position is well chosen with regard to the moon. The Germans are known to possess very good night glasses, which give great assistance in enabling them to make out ships and patrol vessels without being themselves seen.

A submarine captain will not get between the lines at night if he can avoid doing so, as he will be exposed to close-range gunfire if sighted, but will probably try for a shot from outside the escorting craft on the flanks, or, closing in after they have passed, try and pick off any stragglers.

The submarine is most dangerous to the convoy when on a bearing away from the moon, and this position should always be guarded, if possible, by stationing one of the escort on that bearing, but outside the short-range escort.

VI.--TACTICS OF SUBMARINE ON SIGHTING A CONVOY.

In Open Waters.--Clear Weather.

In clear weather a submarine will sight the masts and smoke of a convoy over the horizon before she is in any danger of being seen herself. If she is not in its path and there is sufficient time before dark, she will steam round on the surface, keeping the masts in sight, until she gets nearly ahead of it. She is then in a position to select her method of attack, and will dive at slow speed until she can make out its composition and formation.

Low Visibility.

If the visibility is such that the bridge and upper works of the nearest ships are sighted at the same time as the masts and smoke, the submarine knows she is in danger of herself being sighted.

If inside the danger angle she will probably dive in and attack at once.

If outside the danger angle her only chance of getting in an attack is to dive out for a short time until she has lost sight of the convoy, and then make a blind cast round on the surface in order to get in its path. When she considers she has reached the desired position, she will trim down and wait for it.

In Narrow Waters.

If in waters where there is a good chance of being sighted by patrols or aircraft whilst steaming round on the surface, the submarine will probably attack at once if inside the danger angle. If outside it, she will probably not delay any longer than is necessary to get comfortably inside the danger angle.

VII.--TACTICS OF SUBMARINE WHEN ATTACKING.

Convoy.

(a) Submarine on the bow.

If the captain of a submarine finds himself at the commencement of an attack well on the bow of the convoy, he must be content with a flank attack. Whether he will try for a short-range shot at a selected ship, or a browning shot from outside the escort, depends upon the disposition and density of the escort and his own personal equation.

If originally near the limit of the danger angle, he must content himself with a browning shot from the beam or quarter.

(b) Most attractive position.

If in a position to choose his form of attack, i.e., if ahead or nearly ahead, the most attractive position to an experienced and skilful submarine captain, if there appears to be room, is to get between two of the inner columns (1,000 yards between the columns would be considered good enough at convoy speeds, and possibly 800 yards).

In this position he may be able to place all his torpedoes effectively. He will be some distance away from the escort craft, and also may expect to find the largest and most valuable ships.

If this position does not appeal to him, he will attempt a flank attack on one of the outer columns.

Whatever he does, once he has committed himself to one form of attack he cannot subsequently change his mind. To be successful, the final stages of an attack must be made at slow speed, otherwise there is a

very good chance of his periscope being given away by the feather, and even if not depth-charged or rammed, his attack will probably be frustrated.

--- 9 ---

(c) Deciding factors.

The deciding factors in choosing the method of attack are the personal element, the appearance of the convoy when the decision has to be taken, and the state of the surface.

If the formation of the convoy appears to be irregular, and the disposition of the columns cannot be made out, or if they are close together and well closed up, even the most experienced captain will probably decide for the flank attack.

If the convoy is in close formation, but there appears to be plenty of room between the flank escorts and the wing columns, it would be an inducement to attack the latter.

(d) Attack between columns.

If he decides to attack between the columns, he will approach the convoy at slow speed, or let it overtake him. When about a mile ahead of it he will turn at right angles to its course, and adjust his speed so as to pass close ahead of, or underneath, the leader of one of the inner columns. When, judging by the sound (*vide* "Hearing Powers," Section IV.) or by time, he considers he is in a safe position, he will come up to periscope depth again, and should then be in a good position to fire at a ship in the next column, and possibly bring off the double event by using his stern tubes.

(e) Alternative if position cannot be reached.

If on near approach to the head of the convoy he finds he has miscalculated, or the convoy has altered course, and, the attack not being so easy as it looked, his nerve fails him, he may take a browning shot across the front of the convoy at the further columns.

If he fires from 500 yards ahead, taking the convoy speed as 8 knots, he will have nearly a full minute to get to a safe depth, and as his hull is already 20 to 25 feet under water, he runs little risk of serious damage.

(f) Flank attack.

If he decides to attack from the flank, he will steer out of the path of the convoy until he reaches what he feels to be a comfortable position on the bow, viz., from 2 to 3 points, and then turn in at right angles to its course. His subsequent movements will depend on the position of the escort.

If there appears to be room between the wing columns and the escorting craft, he will adjust his speed to pass between or under them, and should then find it easy to get into a good position, i.e., 400 to 800 yards somewhere on the beam of one or other of the ships of the wing column.

If the flank is closely guarded, or the problem appears too difficult on account of the zigzags and numbers of the escorting craft, he will keep outside them, and fire a browning shot from the best position he can.

(g) Attack on the quarter.

It may happen that, after he has committed himself to a short-range attack on the flank, some alteration of course of the convoy or the zigzags of the escort may upset his calculations and place him in a dangerous position if he persists in it. If he does not care to take the risk he may keep down until the escort craft have passed,

--- 10 ---

and try for a shot from abaft the beam of the rear ship. Consequently, the most dangerous position for stragglers is in rear of the wing columns.

(h) Angled gyros.

Although it is known that Germans have angled gyros, which can be angled up to 90°, there is no record of their having been used from submarines.

The arguments against their use from submarines are—

(a) The increased difficulty of making accurate shooting.

(b) The tendency of a sharply angled torpedo to keep a bad depth line whilst turning, possibly breaking surface and so giving its position away.

The deflection for a shot with an angled torpedo varies with the range, and as the firing range in a submarine attack cannot be previously determined, and only roughly estimated when she puts her periscope up to fire, the chances of error are greatly increased.

VIII.-TACTICS OF SUBMARINE AFTER AN ATTACK.

Submarine escaping.

After discharging all the torpedoes he can without undue risk, the submarine captain's chief concern is escape. He will probably dive deep, if the depth of water permits, in order to get as far away as possible from depth charges and sweeps. Having now no reason to go slow he can use full helm and high speed for a short time, to get quickly away from the spot where he might be expected to be. When he considers after using his hydrophones that there are no vessels in his immediate vicinity, he will come up to periscope depth and look round. If he finds the coast clear he will wait till the convoy is hull-down and then come to the surface. If remaining hours of day-light and other considerations are favourable, he may try to steam round on the surface and get into position ahead again.

IX.-EFFECT OF CONVOY ZIGZAGGING.

To a submarine approaching a convoy, zigzagging has a very confusing effect.

If she decides for the flank attack, she has almost the same difficulties to contend with as when attacking a single ship zigzagging. If attacking the centre, it is much more difficult to decide how the columns are

disposed and the intervals between them. When close to the leading ships, she can only afford to show her periscope at fairly long intervals, and must always have the uncomfortable feeling that, owing to an alteration of course, she may find herself right ahead of a ship when she looks again (*vide* "Hearing Power," [Section IV](#)).

As long as there is sufficient light for the submarine to make out the position of the several ships nearest him, whether by night or in thick weather, zigzagging adds greatly to the difficulties of attack and consequently forms a valuable defence.

--- 11 ---

X.-TWO OR MORE SUBMARINES CO-OPERATING.

Up to the present there have been no authentic reports of three submarines working together, though the presence of two has been definitely established on several occasions.

Tactical Considerations.

If two submarines are working together it is very difficult for them to deliver an attack which will develop simultaneously, however carefully prearranged. As soon as one submarine fires a torpedo, or if her periscope is spotted, the convoy may alter course, and in any case will be much more on the alert. This will make the attack of the second submarine far more difficult.

Consequently, two submarines working in company and starting an attack close together cannot expect to do twice the damage that one can do alone.

If the two submarines, working separately, spread at right angles to the probable convoy routes, they will have twice the chance of intercepting a convoy.

Probable Methods.

This applies to a greater extent if three are employed. Consequently, although concentrations of submarines may be met with in narrow waters, or in the approaches to convoy harbours, it is considered that the enemy are more likely to operate a little distance apart, relying upon their wireless for passing information.

If this method is adopted, a submarine sighting a convoy may (*a*) either signal its course to all submarines in the vicinity before attacking, or (*b*) wait until she can get to the surface after delivering her attack and signal its apparent course whilst following up astern but out of sight.

The objections to (*a*) are the chances of her signaling being heard and the convoy being warned of her presence. If she does (*b*) she may be kept down by a patrol vessel attached to the convoy or one that has been called to the position by W/T.

In open waters, outside the escort zone, (*b*) appears to be her best course.

XI.--SINGLE SHIP ESCORTS.

The value of any vessel as an escort craft may be considered generally under two heads, passive or defensive, and offensive.

Defensive.

A patrol vessel simply by being in a certain position will interfere with a submarine's attack--

(*a*) By forcing her to keep her periscope down and actually to dive deeper at the critical moment in order to prevent damage by collision, which, though not likely to be fatal, would certainly spoil the attack. This is very much accentuated if the vessel has a sweep out.

(*b*) By making it very difficult for the submarine to show her periscope in close proximity to the patrol vessel without it being seen. If seen, the attack may be frustrated by timely warning being given to the ship and the submarine being forced to dive to save herself.

--- 12 ---

If the escort is zigzagging, the attack is made very much harder, since the submarine cannot forecast the escort's movements and judge her own so as not to be hampered at the moment she wants to fire. This uncertainty will in itself make the submarine show her periscope more often and so increase the chances of detection.

If, when the submarine shows her periscope in order to fire, the ship has passed the sights, it is a matter of difficulty to get them on again. If at close range the submarine will not be able to get round until the ship has gone some distance, and in any case a more or less following shot will be the result. The correct deflection for this shot is difficult to calculate quickly, and if the track of torpedo is seen there is a good chance of avoiding it.

Offensive.

The capacity of an escort vessel to damage the submarine if and when seen is the measure of her offensive value. The time that elapses between the depth-charge being dropped and the last sighting of the periscope is the all-important factor. In many cases, however, the periscope is not seen at all, as the submarine lowers it immediately on firing, and the only thing visible is the track of the torpedo. The best thing the escort vessel can do under these circumstances is to run back along the track and drop depth-charges where it apparently begins.

Submarine's Best Position.

In order to arrive at the best position for an escort vessel, the best position for the submarine to fire from must be considered.

When attacking a ship protected by an escort, the best position for the submarine to fire from is one in which her torpedo will travel at right angles to the course of the ship fired at. (With a 40-knot torpedo and an 8-knot ship this angle is 11° before the beam.)

If the submarine is spotted as she fires in this position the ship has least chance of avoiding the torpedo.

The best range for submarines to fire at is from 800 to 400 yards. Inside 400 the chances of the torpedo not having picked up its set depth are increased. On the other hand, as the range increases the chances of hitting decrease in direct proportion.

Best Position for a Single Escort.

Referring to "Tactics of Submarine," Section VII., it will be seen that if there is apparently sufficient room between the escort and the ship the submarine will try for a close shot. If the escort is close in the submarine will decide to fire from outside in the best position as regards bearing.

Consequently the best all-round distance must be decided on, and this is considered to be **800 to 900 yards.**

If the **defensive** value of the escort vessel were only considered, it is apparent that the best bearing would be a point before the beam (in the case quoted, but if the ship escorted is steaming fast, the position will be further forward).

If the **offensive** value only were considered, the best position would be somewhere on the quarter, more or less, according to speed through the water of escort vessel and her reserve of speed.

On account of the uncertainty of determining the actual position of a submarine from a track which may be fading away when spotted,

--- 13 ---

and the fact that our offensive weapons as yet are far from perfect, we **cannot afford to rely on the offensive position**, and consequently in deciding on the best all-round position a **compromise** must be made.

For a ship steaming 8 knots this is considered to be about the **beam** of the escorted ship.

If the speed is greater the submarine will fire, if possible, from further forward, and the escort should be advanced to a position before the beam.

Effect of Weather on Position of Escort.

In calm weather, in addition to the periscope of a submarine being most easily seen, the air bubbles caused by the discharge of a torpedo are almost sure to be seen if an escort vessel is anywhere near. The

bubbles will mark the position of the submarine at the moment of firing even if the periscope has been lowered before they reach the surface.

Under these circumstances the **offensive** value of the escorts is at its greatest, and they may be placed with advantage abaft the position selected as the best compromise.

In ideal submarine weather, i.e., a short sea with many white horses, a submarine's periscope is very hard to see, and she will also feel that she is in little danger of being given away by the bubbles on firing. The chief value of the escort is then the **defensive** one, and the escorts may be advanced a point with advantage.

Escort-Zigzagging.

The value of an escort is very much increased if it zigzags. The more pronounced and erratic the zigzag the greater will be the submarine's difficulty in making an attack.

The escorts should be under helm as constantly as practicable, as this makes it most difficult for the submarine to forecast what their position will be when he next wants to put his periscope up.

In the case of several vessels guarding a flank, they should adjust their zigzags so that when some are at the inner limit of their zig-zags others are near the outer limit.

XII.-CONVOY ESCORT.

Referring to "Submarine Tactics," Section VII. (*b*) and (*c*), it will be seen that if there is apparently plenty of room between the wing columns and the escort the submarine will be disposed to favour the flank attack.

Again, if the escorting vessel stationed ahead of the wing columns are too far ahead, the submarine can keep his periscope down whilst they are passing, and have plenty of time to take observations of the leaders of columns if he has decided to attack between the lines.

Browning Shots.

It is impossible, with any number of escorts likely to be available to protect a convoy completely against long-range browning shots. If intent on browning, a submarine can choose a position anywhere within wide limits, and if an escort craft gets in the way in one position the submarine can afford to wait without losing her target. For this reason an escort's *offensive* value is the one chiefly to be considered when stationing her as a protection against browning.

--- 14 ---

All things considered, it appears the best policy to protect a convoy against short-range attacks as far as possible. If, after adequate provision has been made for this, there are any escort craft available, they may be stationed (*a*) on the flanks, zigzagging from 1,500 to 2,000 yards from the wing columns, in order to

attack a submarine taking a browning shot, or (*b*) if convoy is in a very broad shallow formation (*i.e.*, Diagram VII. with 16 ships) in positions to attack a submarine browning from ahead or astern.

Diagrams.

Diagrams I. to VII. give a number of possible formations for a convoy, with the suggested mean positions of escorts in average weather. It is apparent that when several vessels are guarding the flank the **offensive** value of each backs up the **defensive** value of the one ahead of her, consequently it is considered that the leading wing escort should be advanced to about a point before the beam of the leading ship, and the stern-most one dropped about 2 points abaft the beam of the rear ship of the wing column. The leading escort, then also covers the best short-range browning position, which, for an 8-knot convoy, is a point before the beam.

If the number of wing escorts available falls below one to each ship of the wing column, it is advisable, if other considerations permit, to increase the number of columns.

Ships straggling.

These should be removed from the wing columns and stationed at the rear of the centre columns. If after this has been done the centre columns straggle badly it may be necessary to station the two stern-most escorts on the outer quarters of the stragglers, and readjust the wing escorts accordingly.

Sun and Moon.

Unless the sun and moon have a high altitude, a submarine will prefer, if possible, to attack from the direction of the sun's rays and, at night, from a direction opposite to the bearing of the moon.

This should be considered if the number of escort craft available do not permit of all the close escort positions being filled.

If the moon is on the bow or beam, it is advisable to take one of the leading escorts (positions 7 or 8 in the 8-escort diagram) and station her outside the close-range escort on a bearing opposite to that of the moon.

Thick Weather.

If the visibility is low, *i.e.*, less than about 1 to 2 miles, the leading escorts (positions 7 and 8) should cover the whole front of the convoy when zigzagging, and their mean position may be advanced with advantage.

Speed of Convoy reduced.

If, on account of bad weather or for any other reason, the speed of the convoy is reduced, it becomes easier for the submarine to drive past the escorts stationed ahead and take more observations of the convoy before finally coming up to fire his torpedo. In these circumstances the distance they are stationed ahead may with advantage be reduced to 600 yards, according to speed of convoy.

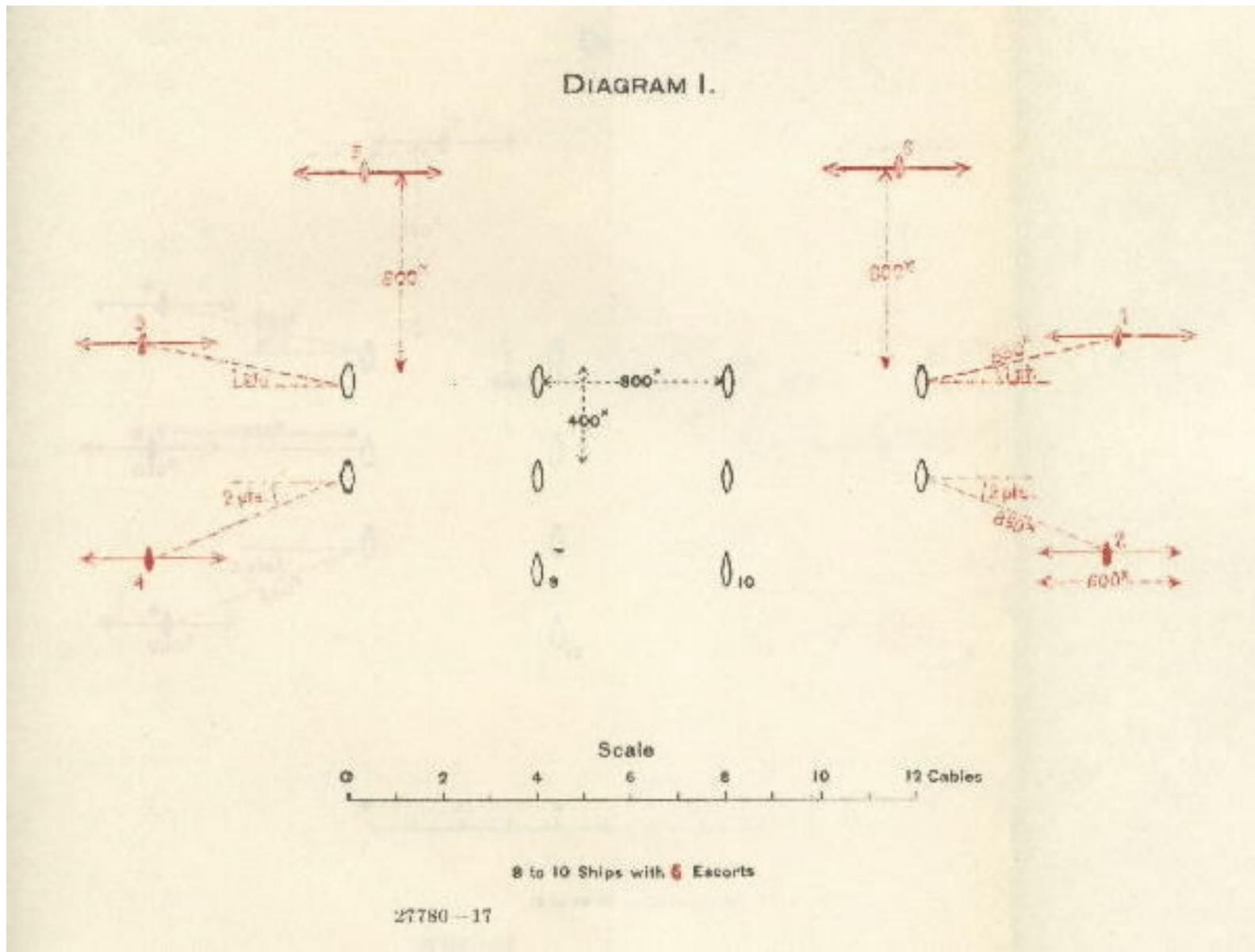
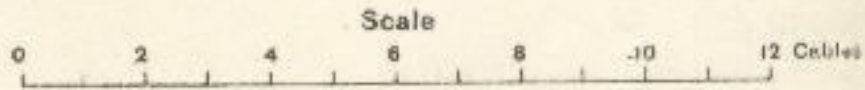
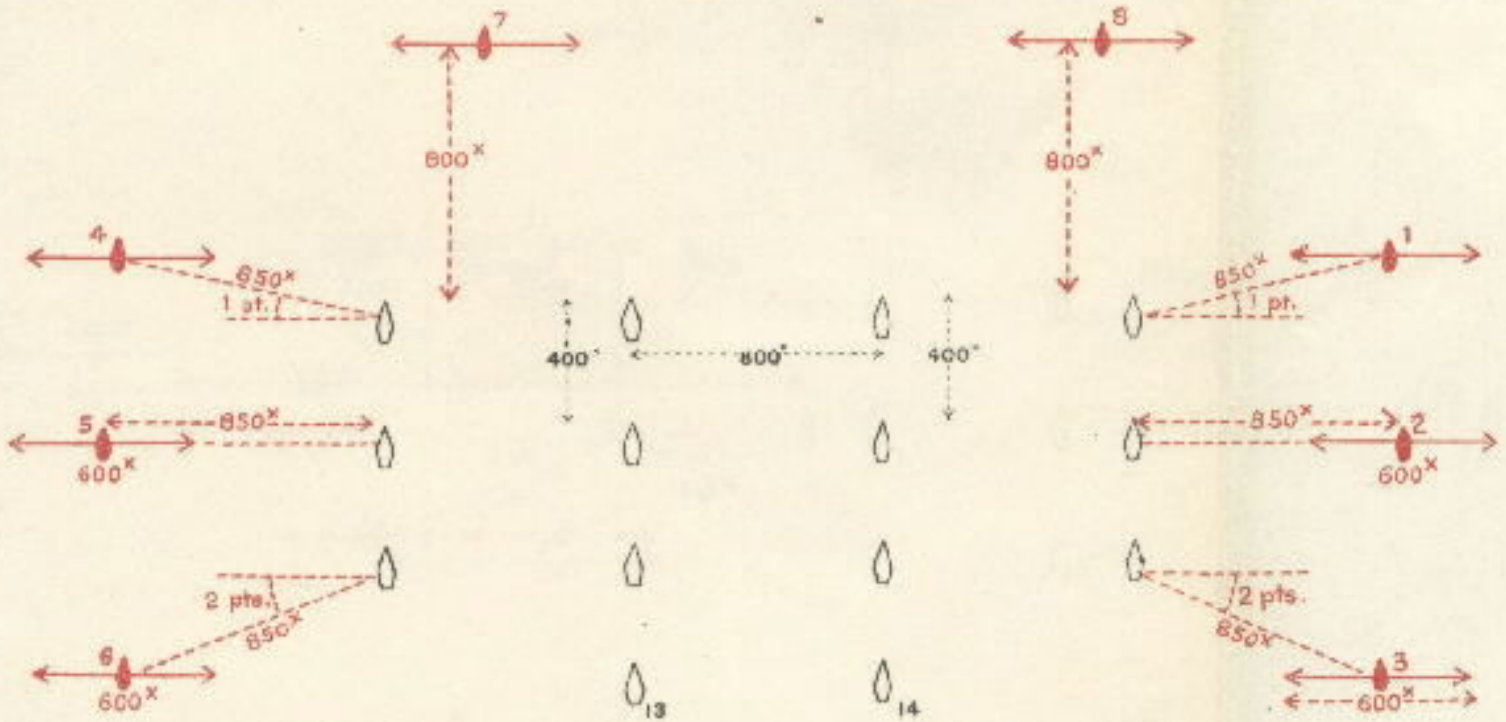


Image of Diagram 1. - Showing 8 to 10 ships with 6 escorts.

DIAGRAM II.



12 to 14 Ships with 8 Escorts.

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Image of Diagram 2. - Showing 12 to 14 ships with 8 escorts.

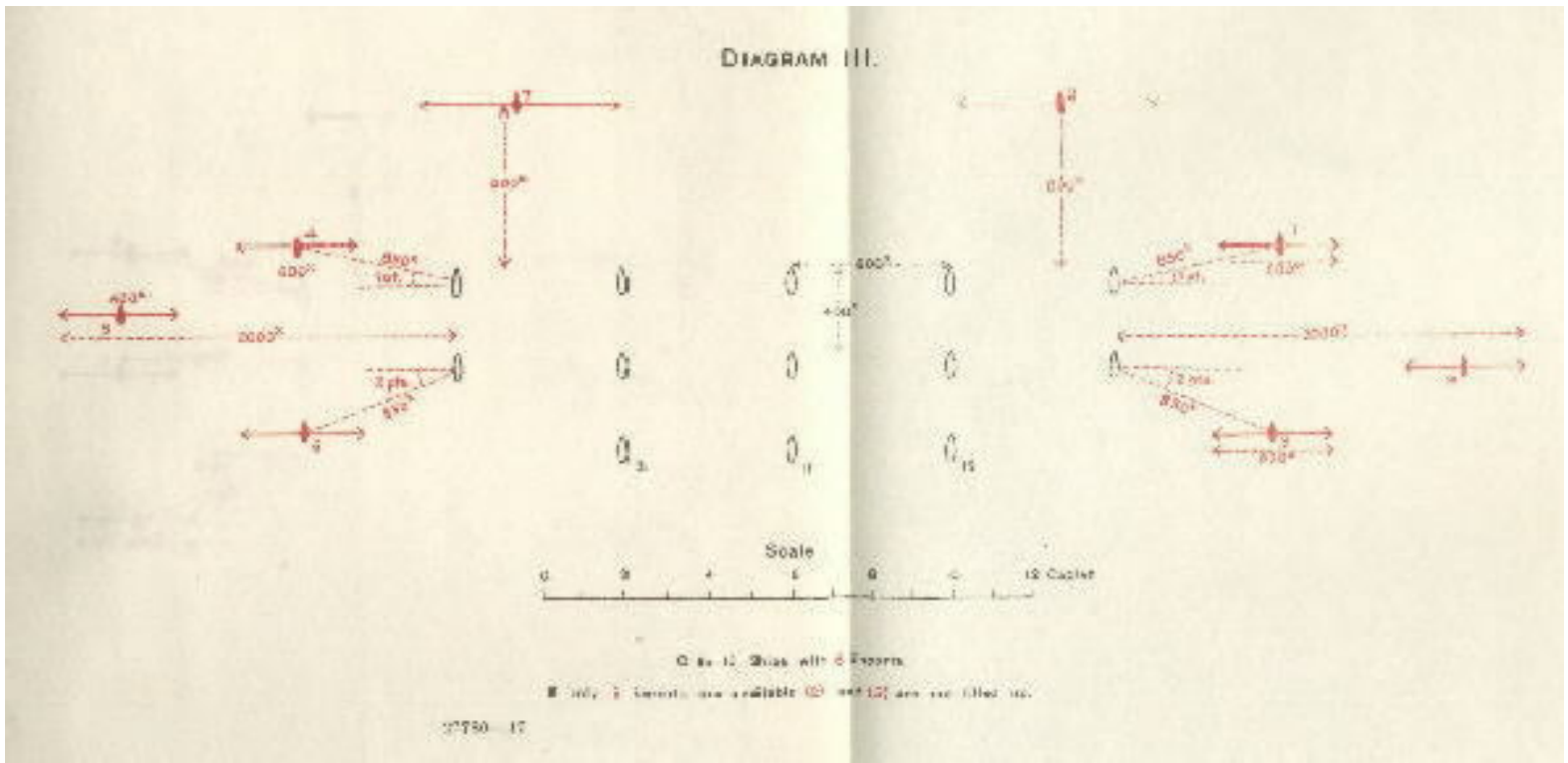


Image of Diagram 3. - Showing 10 to 13 ships with 8 escorts. If only 6 escorts are available (2) and (5) are not filled up.

DIAGRAM IV.

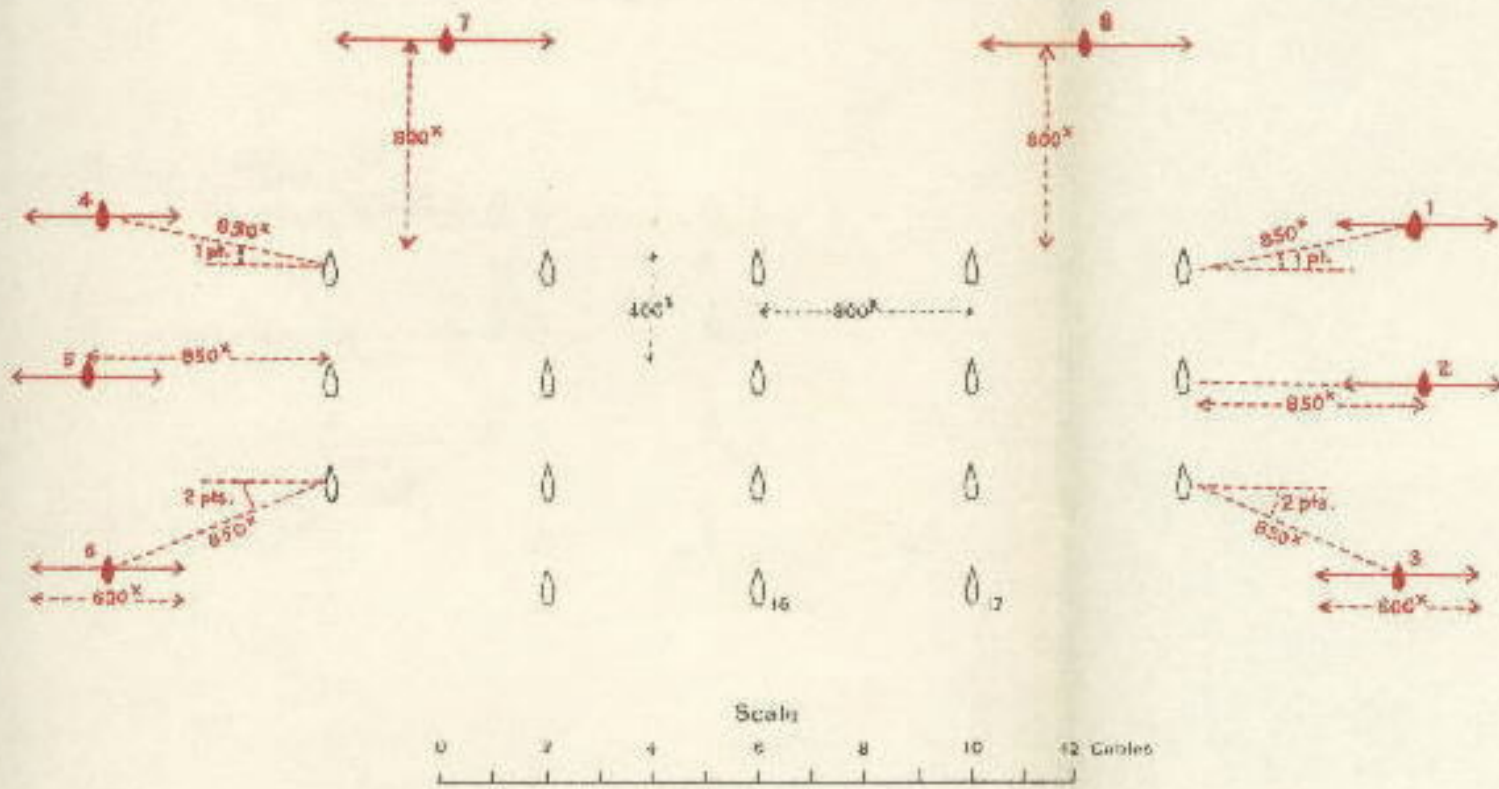


Image of Diagram 4. - Showing 15 to 18 ships with 8 escorts.

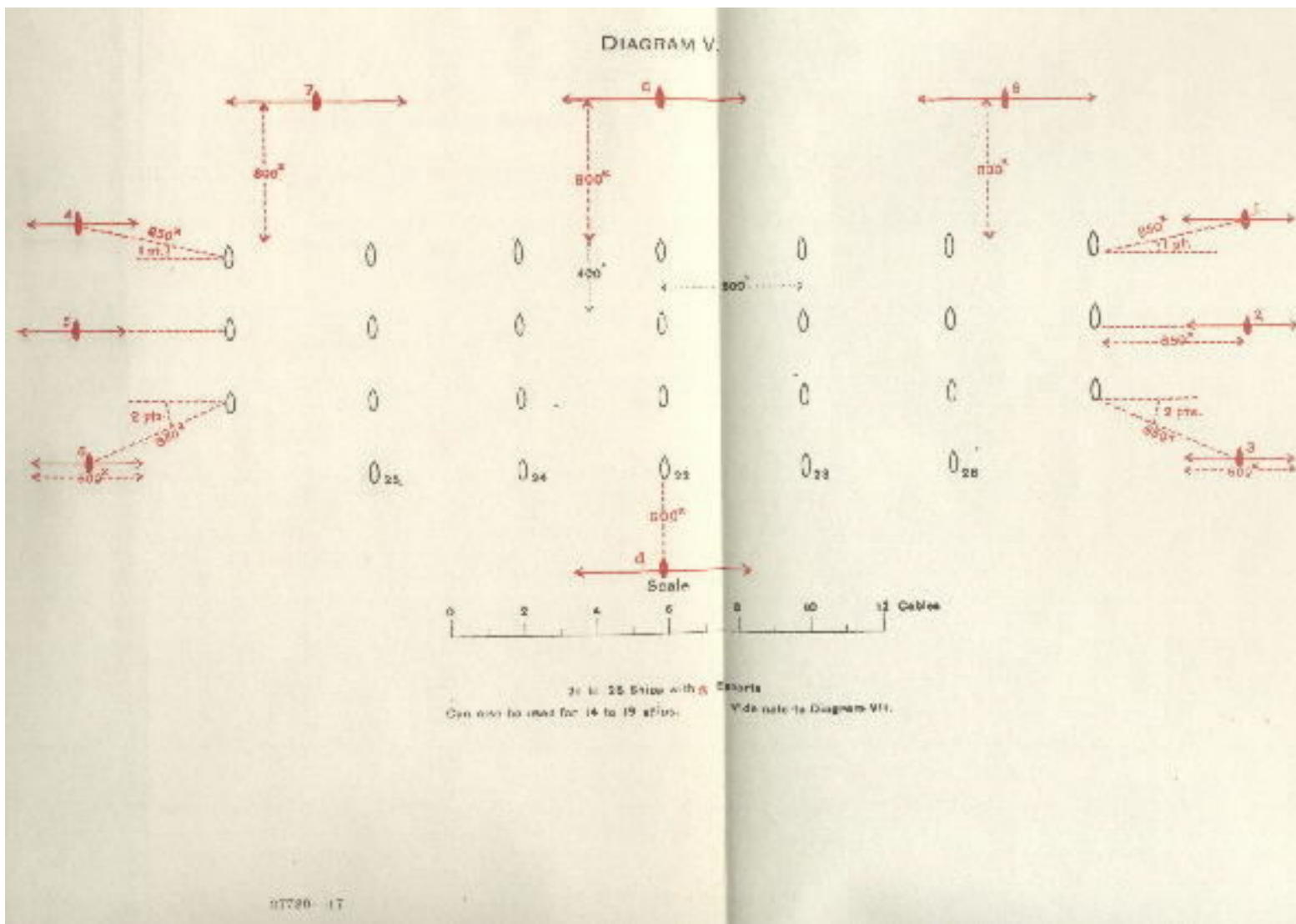


Image of Diagram 5. - Showing 21 to 26 ships with 8 escorts. Can also be used for 14 to 19 ships. Vide note to Diagram 7.

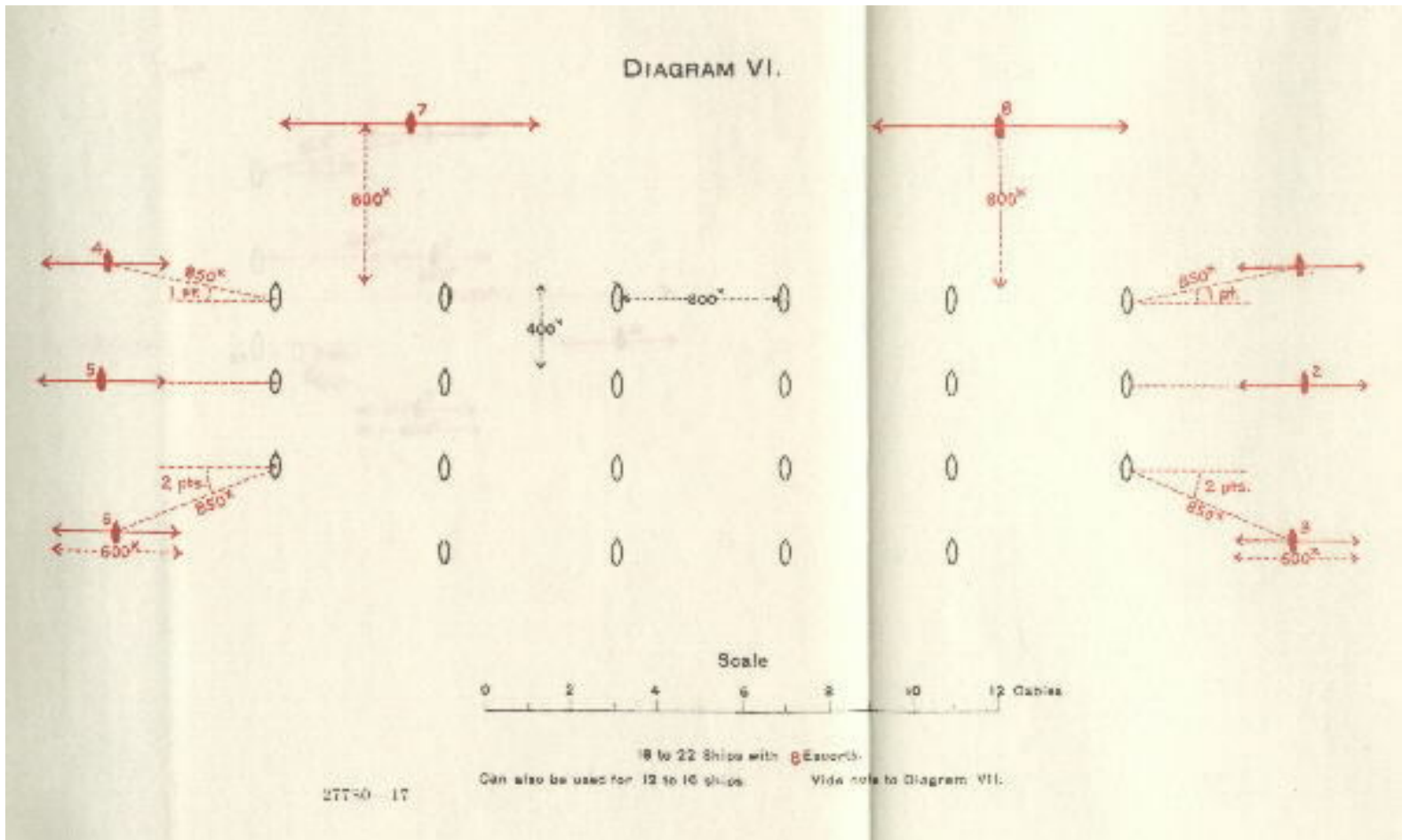


Image of Diagram 6. - Showing 18 to 22 ships with 8 escorts. Can also be used for 12 to 16 ships. Vide note to Diagram 7.

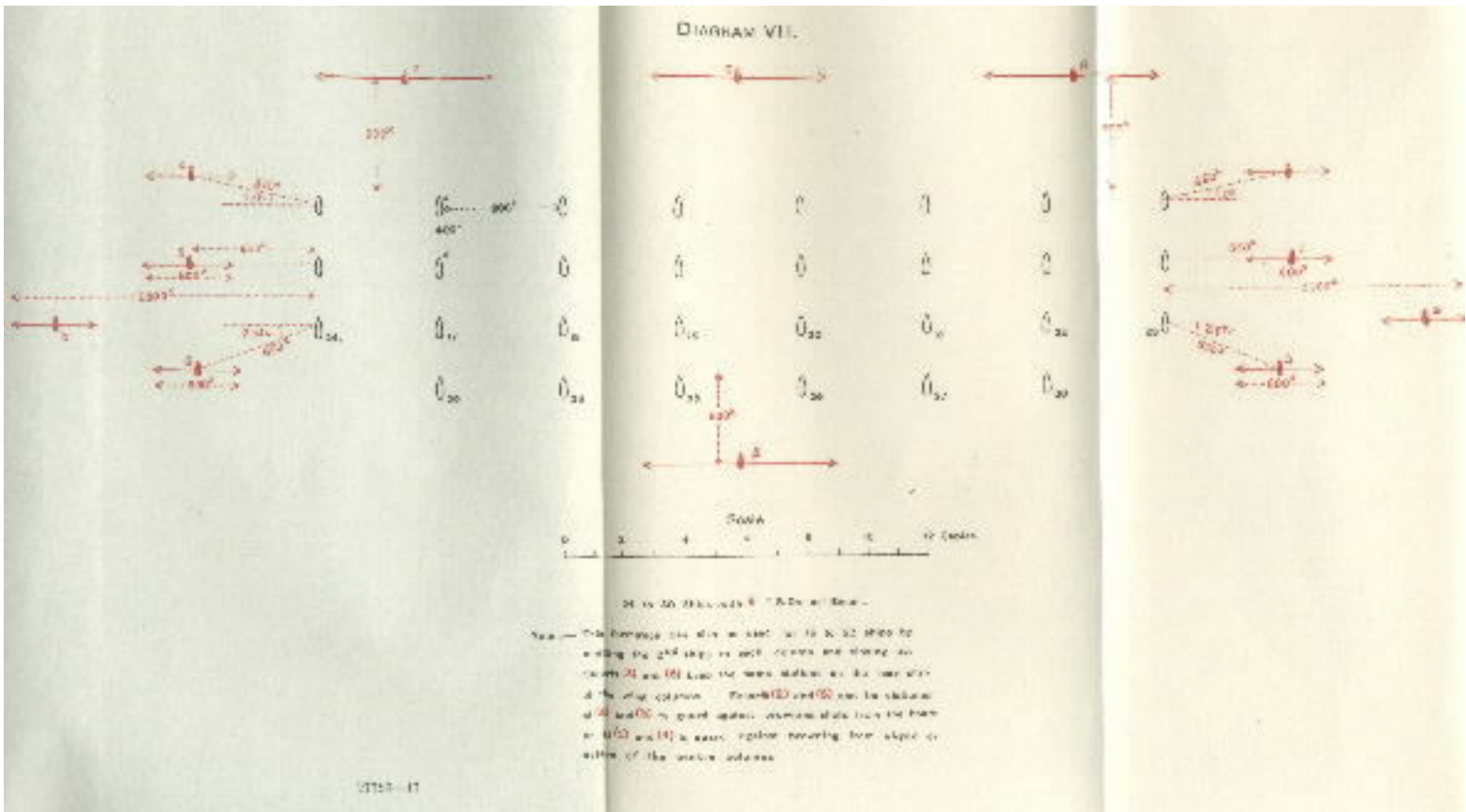


Image of Diagram 7. - Showing 24 to 30 ships with 8 T.B.D.s as Escort. Note: - This formation can also be used for 16 to 22 ships by omitting the 2nd ships in each column and closing up. Escorts (3) and (6) keep the same stations on the rear ship of the wing columns. Escorts (2) and (5) can be stationed at (a) and (b) to guard against prowling shots from the beam or at (c) and (d) to guard against prowling from ahead or astern of the centre columns.

Source: "ONI Publications, WWI" ZV file, Navy Department Library.

03 May 2006