

Most Confidential!

DEPTH-CHARGE PROBLEMS



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DEPTH-CHARGE PROBLEMS.

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In O. N. I. Publication No. 44, "German Submarine Attacks" it was seen that Germans use four standard torpedo shots:

1. Direct bow shot.
2. Direct stern shot.
3. 90° angled bow shot on parallel courses.
4. 90° angled stern shot on opposite courses.

As in other parts of the subject of naval tactics it is neither possible nor desirable to lay down hard and fast rules for the depth-charge attack. A study of a great number of actual situations will result in the deduction of several general principles regarding the attack. Once these principles are mastered a depth-charge doctrine can be laid down. This can be followed in a majority of the actual situations which may be expected. In some situations, however, it will not apply and then the commanding officer must fall back upon his general knowledge of the subject and decide on the spot as to the best measures to take.

It would be a tremendous undertaking to present all the actual situations which might be reasonably expected in actual practice. The submarine, as we have seen, may fire at least four standard shots; it may be a UB-boat with a small turning circle of 200 meters, a U-boat with one of 400 meters, or a converted mercantile submarine with one of probably 500 meters. The vessel making the depth-charge attack may have a turning circle of from 200 to 800 yards and a speed from 10 to 30 knots. The submarine may attack from on the bow, from on the beam, or from on the quarter. As this paper is primarily written for the officers of the American Patrol Detachment, composed of yachts, gunboats, and cruisers, the vessel making the depth-charge attack will be assumed to be a cruiser of 15 knots speed and a turning circle of 600 yards; her length is assumed to be 300 feet. The submarines which may be expected in the waters covered by the detachment are the large converted submarines of the U-Deutschland type; it is assumed that their maximum submerged speed is 9 knots and that their turning circle submerged is 500 yards; that their length is 210 feet.

Twelve typical situations will be considered; the submarine will be assumed to fire each of the four standard shots in turn from firing positions broad on the bow, on the beam, and on the quarter of the target vessel. Firing ranges of 400 and 500 yards will be used. In each case it will be assumed that a submarine exposes its periscope in a favorable firing position; that the commander is able to fire a torpedo at the target vessel on a correct course at the expiration of 15 seconds; that at this instant he lowers his periscope again and is able to commence making any change of course and speed which seems most desirable; nothing further is seen of the submarine for the duration of the problem—five minutes.

It is assumed that the lookouts on the target vessel see the periscope at the instant when it is first exposed; that the ship may commence any maneuver at the expiration of 15 seconds—that is, at the instant the torpedo is fired from the submarine. This instant is considered as zero minutes of the problem and the times of all events which occur later are referred to it.

In all the problems a number of courses are plotted for the submarine and the ship. The course considered best is marked: "First course for submarine" or "First course for ship." The second best course is marked "Second course for submarine." The positions of the ship are plotted at half-minute intervals. Depth charges are assumed to be invariably effective at a distance of 70 feet and circles drawn with this distance as a radius indicate the danger areas of all depth charges dropped. The figure inside the circle indicates the depth at which the explosion occurs, while the figures alongside the circle indicate the time in minutes and seconds after the beginning of the problem at which the charge explodes. The position of the submarine is plotted whenever it is within several hundred yards of depth-charge explosions.

The 12 special cases will now be considered.

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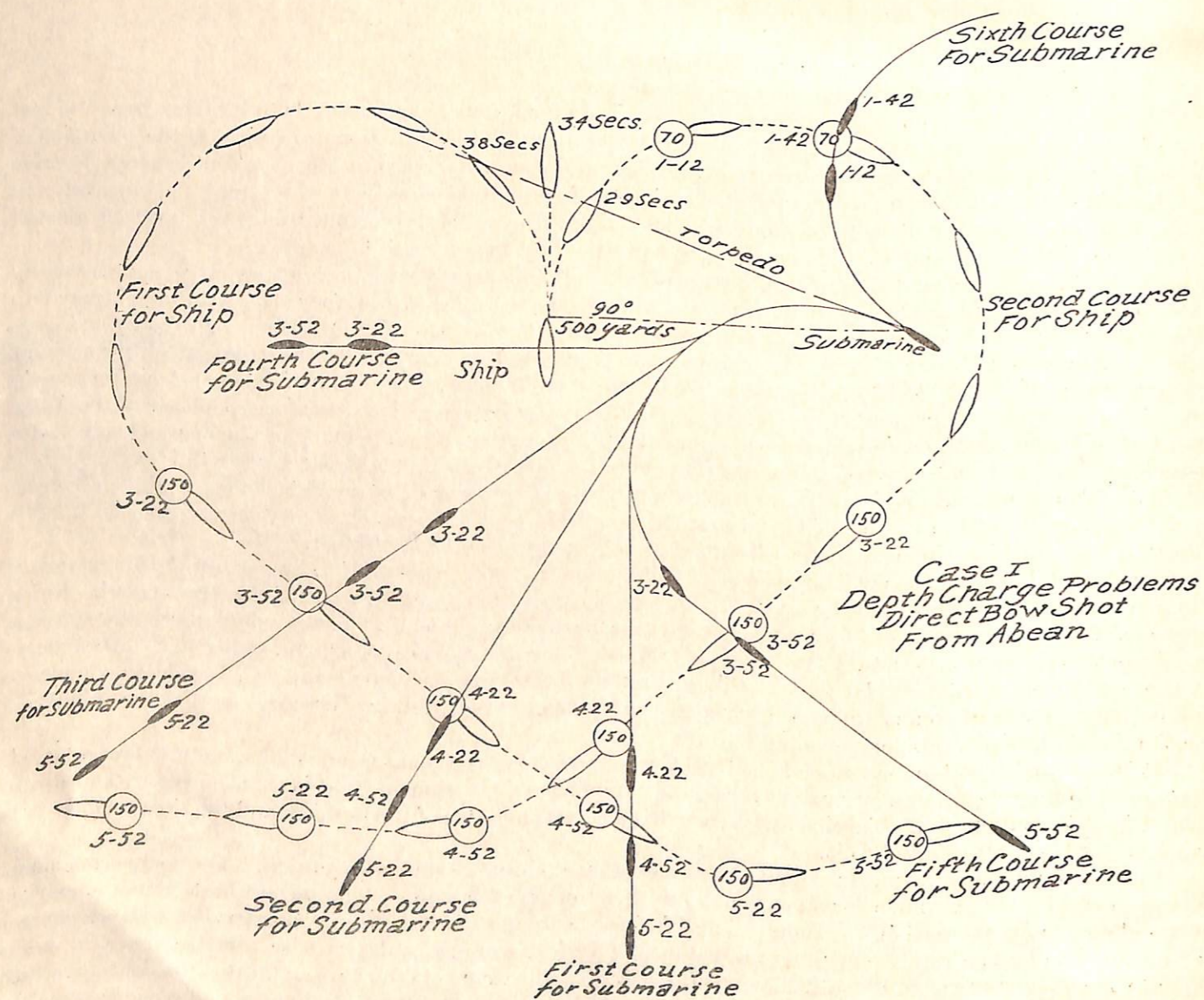
NAVY DEPARTMENT,
OFFICE OF NAVAL INTELLIGENCE,
Washington, October 1, 1918.

By direction of Office of Naval Operations this Study of "Depth Charge Problems," made in the American Patrol Detachment, based on O. N. I. Publication No. 44, is issued for the information of the United States Naval Service.

This pamphlet is most confidential and for the use of commissioned officers only.

ROGER WELLES,
Rear Admiral, *United States Navy,*
Director of Naval Intelligence.

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CASE I.

DIRECT BOW SHOT FROM 500 YARDS ON THE BEAM.

SUBMARINE.

A direct bow shot from about this position will probably be the most frequent of all torpedo shots. It is, however, only a moderately good shot. The "track angle"—the angle between the course of the torpedo and the course of the ship—is a good one; it is about 75° , which is specially recommended by the German instructions. The range—500 yards—is rather great, as it allows the target ship about 34 seconds in which it can maneuver to avoid the torpedo. The submarine is moderately secure against depth charge counterattack.

German submarine commanders have, according to their instructions, two courses of action open to them after firing a torpedo:

1. To submerge immediately to 148 feet and run for 15 minutes.
2. To watch the results of the shot, observe the counter moves of the target vessel and then submerge to 148 feet for 15 minutes.

If it can be assumed that the submarine commander can expose his periscope so skillfully that it can not be seen by the lookouts on the target ship—who will be specially alert after the torpedo has been sighted—then the second course of action has great advantages. If the target ship is missed and it turns to the right, a second torpedo can be fired, probably an angled stern shot. If the target vessel is seen to turn to the left, then all the submarine has to do is to turn to the right, thus completely avoiding a depth charge attack. However, it seems that it would be extremely improbable for a submarine to repeatedly expose its periscope at 500 yards range without being sighted by a well-organized lookout system, such as that used in the vessels of the detachment. While, therefore, some extremely skillful commanders may observe the shot—for example, one submarine commander claims to have avoided 200 depth charges in this way—it seems that the great majority would submerge immediately to 148 feet after firing at a man-of-war. While the speed of the submarine, while going to this depth, is not given in the German instructions, it would seem that their spirit implies that the submarine gain this depth as quickly as possible; therefore a high speed will probably be used.

After the depth of 148 feet is reached, the submarine has, in general, two courses of action open to it:

1. To run at very slow speed so as to keep within the turning circle of the target vessel.
2. To run at full speed so as to get outside the turning circle as soon as possible and to gain the greatest start possible on the target ship before it can turn around.

The first method may look excellent on paper; in actual practice it is, however, not so good. The attacking vessel will probably drop a circle of depth charges around the submarine. While a skillful commander may be able to keep near the center of the circle and thus avoid coming within the certain effective radius of a charge, it is certain that several charges at least will explode within 200 to 300 yards of him. Some of these are very liable to cause slight material damage and at least to hurt the morale of the crew. It requires great resolution to await without making a move the attack of the enemy. The morale of the crew will be much higher if the vessel is proceeding at high speed in an attempt to avoid the attack.

In all search problems the chances of success are greatest immediately after the instant when the object of the search was last definitely located. As the area in which the enemy may be is that of a circle with an increasing radius, and as this area increases with the square of the radius, it follows that the chances of success decrease greatly as the time interval, since the object of the search was last located, increases—perhaps as the square of this time interval. Thus at the end of a two-hour search the chances of success are perhaps only one-fourth what they were at the end of the first hour. If the submarine can then run at high speed on a course away from the attacking vessel so that it can not possibly be overtaken by it for about four minutes, an inestimable advantage will be gained. If the attacking vessel uses a form of the retiring search, it will be necessary for it to estimate the speed of the submarine. An error in the estimate of only 1 knot an hour will cause a miss of the depth charge of about 132 yards after an interval of four minutes. If a 2-knot error is made this miss will be 264 yards, thus giving the submarine practical immunity from attack. It will therefore appear that the submarine should run at a high speed for at least five minutes. After this period he may expect the attacking vessel to use listening devices and may therefore slow to 2 knots for the rest of the 15 minute run.

Now we must consider what the most desirable course is for the submarine commander. He will assume that it is probable or at least *very possible* that the ship will turn to the right, which is considered the usual procedure for a man-of-war finding a submarine on her beam. Even the mere possibility of such a move on the part of the target vessel will prevent a move of the submarine to the right, as it would lead to practically certain destruction should the vessel turn in this direction. Thus it is extremely improbable that the submarine will employ the sixth course of action, as shown in the sketch. All the five other courses are moderately good ones. The fifth is, however, probably a little more dangerous than the other four as it may bring the submarine in three and a half minutes into a danger area should the ship turn to the right. The fourth course looks very nice on paper; however, it will not be so good in actual practice as there is considerable danger in deliberately staying inside the turning circle; it is, therefore, not so probable as the first three courses. These are all nearly equally satisfactory, but the first is considered slightly the best, as it prevents the ship from overtaking the submarine until after four and a half minutes have elapsed, no matter which way the target vessel turns. It also accords with the German instructions, which are to turn on an opposite course to that of the target.

SHIP.

In deciding upon the best course of action for the ship we must make our examination from two points of view:

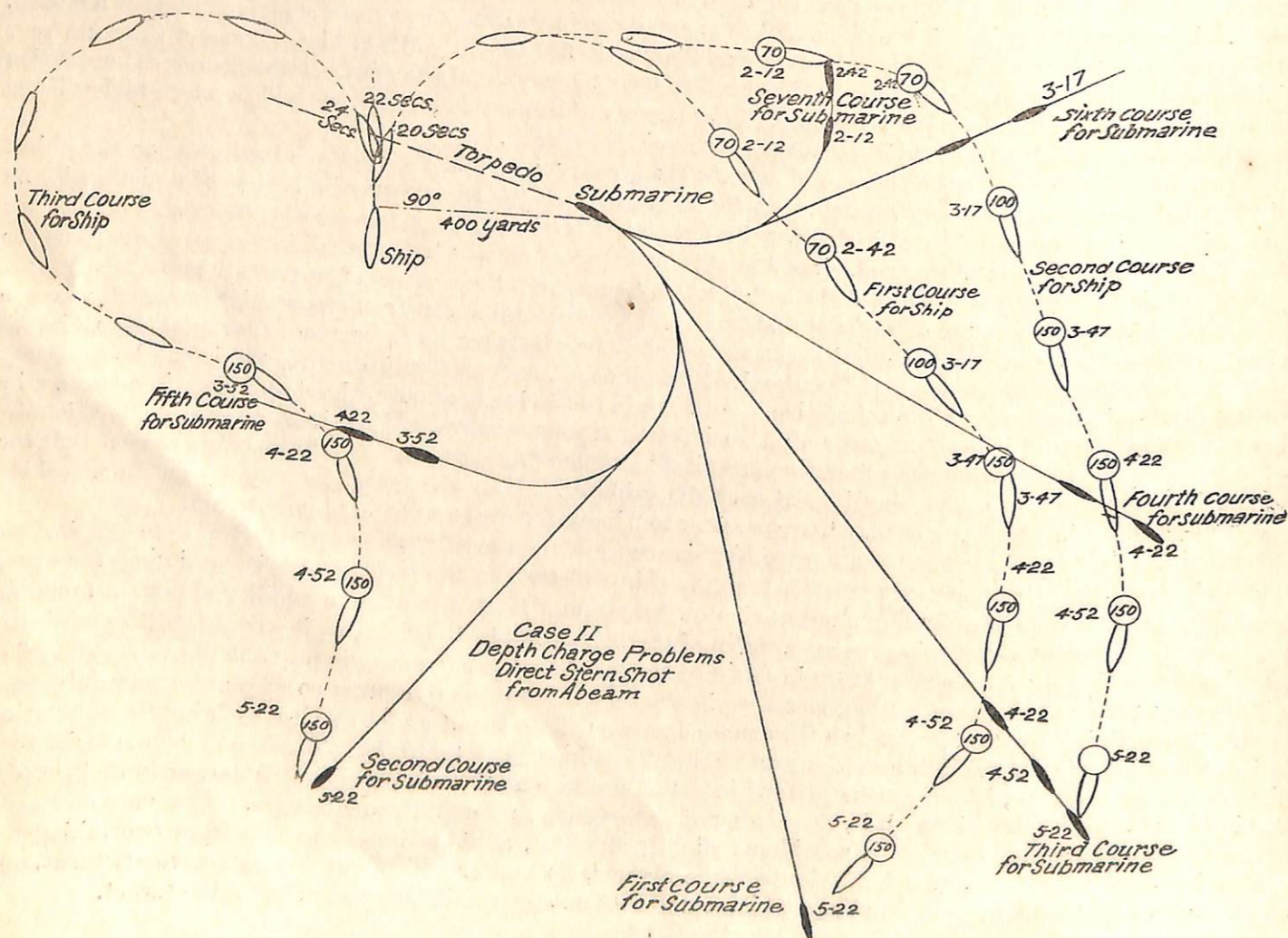
1. Defensive—what course will offer the best chances of avoiding the torpedo?
2. Offensive—what course will offer the best chances of injuring the submarine in the depth charge attack?

Of these two points of view the offensive must always predominate, especially as it can not be assumed that a submarine will always fire a torpedo when it exposes its periscope in a firing position, but nevertheless the defensive must always be considered and given due weight.

In this case the two courses of action are turns to the right and left, a course similar to that used in the retiring search being steered after the turn has been completed. A torpedo fired as in this problem has probably a 50 per cent chance of hitting if the ship continues on its course. If it turns to the right the ship, as shown in the position marked "29 Secs.," is in nearly the same position with reference to the course of the torpedo as though it proceeded straight ahead. The chances of hitting, should the ship turn to the right, will therefore still be about 50 per cent. Should the ship turn to the left, its position with reference to the torpedo's track will be considerably changed and the course of the ship will make an angle as small as 30° with the course of the torpedo. The chances of hitting will therefore be considerably reduced by a turn to the left, probably to about 15 per cent. A turn to the left has therefore a very decided advantage from the defensive point of view. Should the firing range be greater the chances of hitting will be reduced still more by a left-hand turn; should it be less the advantage of a turn in this direction will be considerably less. When the range is as short as 300 yards there will be practically no chance of avoiding torpedoes by maneuvering.

Looking at the situation from the offensive point of view, we see that a turn to the left will cover the three most probable courses for the submarine rather sooner and therefore better than a turn to the right. It will also be better, should the submarine take the fourth course, although even then this will not be properly covered. It will not be so good as a right-hand turn in the case of the fifth course and will not cover the sixth course at all, while the right turn will cover the course perfectly. The chances of the submarine taking this course are, however, very slight, unless the commander should watch the results of the shot. In this case a right-hand turn by the ship would expose it to a torpedo shot at the closest range. Everything considered, the left-hand turn is considered best from the offensive point of view.

Therefore, it is decided that the left-hand turn—first course for ship—is the best both defensively and offensively and should be made. All depth charges are set at 150 feet and dropped at half-minute intervals beginning at 3-00 after the beginning of the problem.



CASE II.

DIRECT STERN SHOT FROM 400 YARDS ON THE BEAM.

SUBMARINE.

This is probably the best of all shots for the submarine. It is a simple straight shot without angle fire. The range could be slightly shorter, but still there should be a 75 per cent chance of the torpedo hitting. The submarine is practically immune from depth charge counterattack.

The submarine commander can not estimate with certainty as to whether the ship will turn to the right or the left. However, as the range is so close that there is little chance of avoiding the torpedo by maneuvering, the probability is strong that the ship will turn to the right, as this course has all the advantages from an offensive point of view.

However, in this case it matters little to the submarine commander what course the ship takes. By turning on to a course opposite to that of the target—between the first and second courses for submarine as plotted—and continuing at full speed the submarine can not be overtaken until over more than five minutes have elapsed and escape is practically certain. It would seem almost certain that the submarine would take this course of action. The third and fourth courses are fairly good and the fifth course would be excellent if the submarine commander could watch the results of his shot and see the ship turn to the right. Otherwise, it would be very dangerous, as there would be a possibility of the ship turning to the left. The sixth and seventh courses are out of the question, unless the submarine commander sees the ship turn to the left. In all cases the submarine commander will undoubtedly run at high speed for at least five minutes.

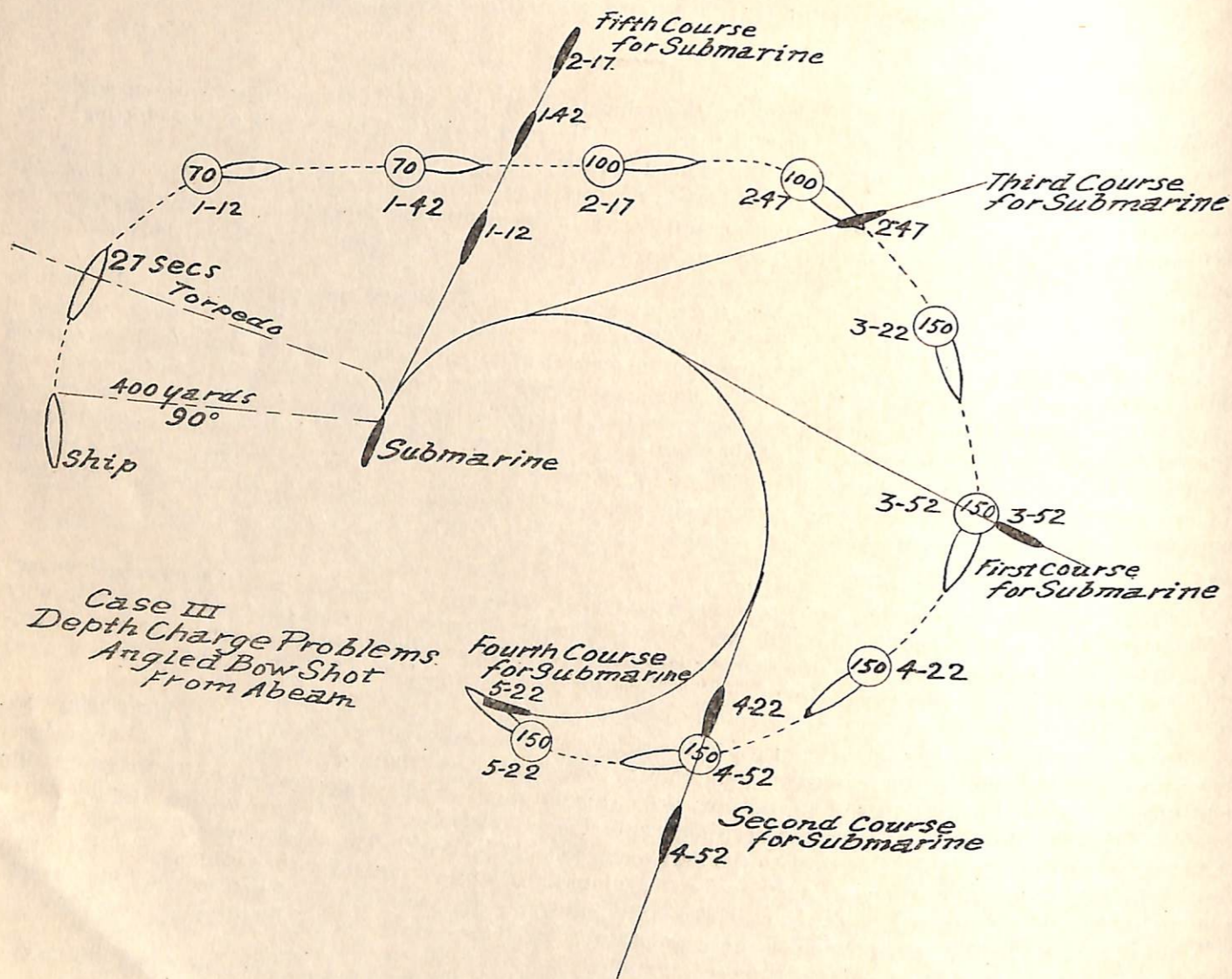
SHIP.

In this case there is an important difference from Case I. The submarine is at a range of 400 yards instead of 500 yards as in that case. In fact, the stern of the submarine, from which point the torpedo is fired, is only about 330 yards distant. At this range there is very little chance to avoid the torpedo by maneuvering. Therefore, from the defensive point of view, there is practically no advantage of turning to the left rather than to the right.

From the offensive point of view a turn to the right has all the advantages. A turn to the right brings the ship into an area in which the submarine may be expected after a two-minute's run, while a four-minute's run is required for a left turn. The right-hand turn also covers far more possible courses of action for the submarine than the left-hand turn. The only real decision required is as to whether a wide course like the second course or a course considerably inside of this, as the first course, should be used. The outer course covers excellently the third, fourth, sixth, and seventh courses for the submarine, but does not cover the first course. The inner course covers the seventh course fairly well, the sixth course poorly, the third and fourth courses moderately well, but it covers the first course, which is more important than all the courses covered by the outer turn together. Therefore the inner turn is considered the better.

In this case there is little to choose between the three courses from the defensive point of view. From the offensive point of view the inner right course—first course for ship—is recommended.

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CASE III.

ANGLED BOW SHOT FROM 400 YARDS ON THE BEAM.

SUBMARINE.

This shot may be expected quite frequently. It is used by the Germans when they get in too close in making the usual attack for the direct bow shot. It is only a moderately good shot. The parallax due to the turning circle of the torpedo increases the difficulties of the submarine commander and reduces somewhat the chances of hitting. While the range could be somewhat shorter the target ship has not a very great chance of avoiding the torpedo by maneuvering. The position of the submarine makes it extremely difficult to avoid a depth-charge attack.

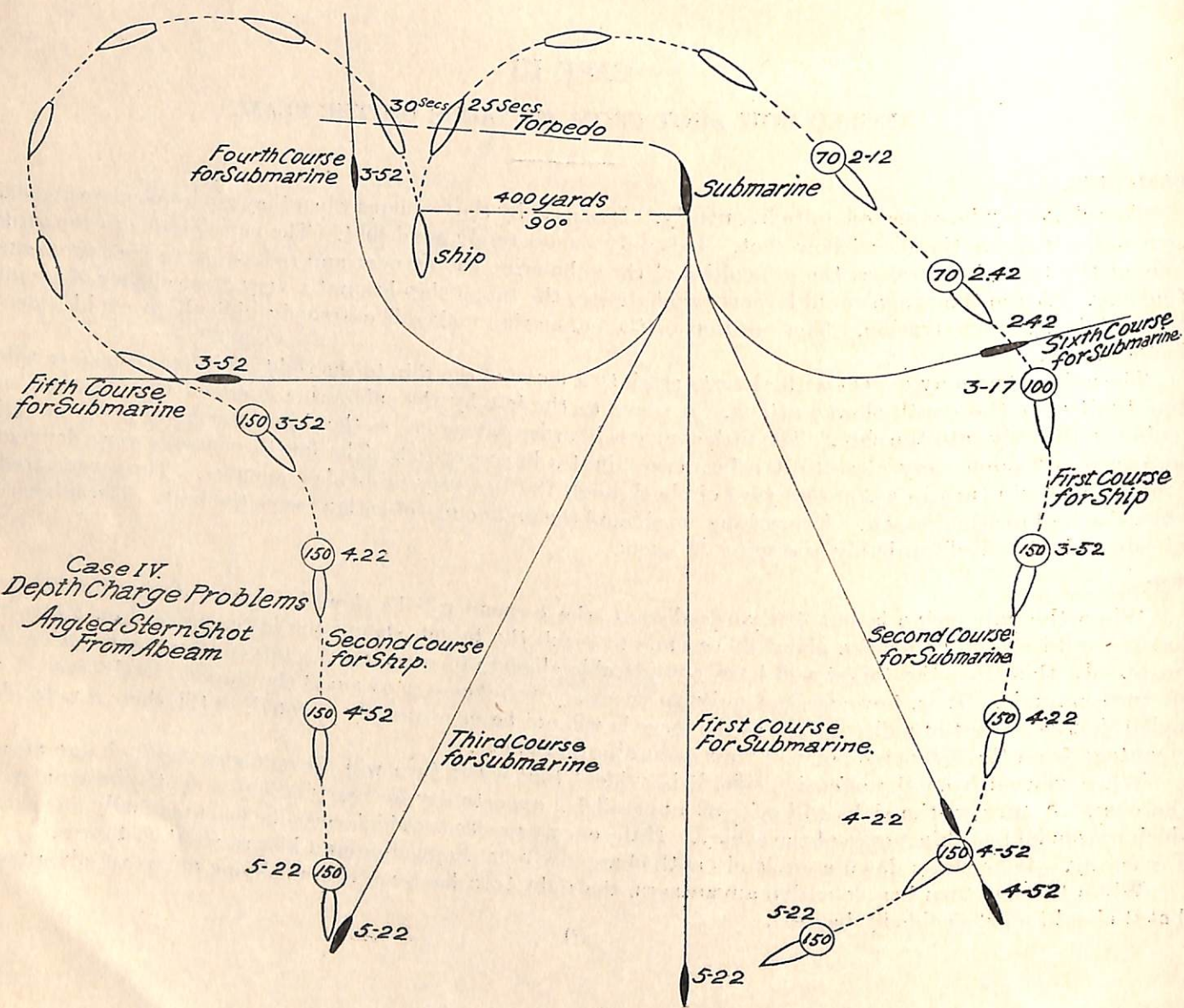
The submarine may expect with almost certainty a move of the ship to the right, as it has such an excellent opportunity for the depth-charge attack. A move to the left by the submarine is out of the question, as it would run directly into the ship. The fifth course is likewise dangerous, as the ship making any form of a right-hand turn will come very close to it before two minutes have expired. The fourth course is very dangerous if the ship should turn in a 600-800 yard circle through 180°—a very probable maneuver. The second course is likewise bad for this reason. Everything considered the first course of action seems the best. The submarine will run at high speed, probably averaging 7½ knots.

SHIP.

While the submarine is but 400 yards distant, the torpedo will be slowed down so during its 90° turn that it would probably require about 29 seconds to reach the target, should the latter proceed on a straight course. In this time the target will have considerable chances of escaping the torpedo by maneuvering if a left turn is made. It is, however, not quite so necessary to maneuver to avoid the torpedo in the case of an angled shot as in that of a direct shot, as the torpedo will not be so accurately directed. Still, there is a decided advantage from the defensive point of view in turning to the left.

When viewed from the offensive side, it is evident that a left turn will prevent any depth-charge attack whatever. A turn to the right will offer an unparalleled opportunity for carrying out a depth-charge attack, which covers all possible moves of the enemy. If the enemy proceeds at high speed he has practically no chance of escaping. If he slows down a circle of depth charges will be dropped around him at short distances.

While the left turn has defensive advantages, the right turn has such overwhelming offensive advantages that it should most decidedly be used.



CASE IV.

ANGLED STERN SHOT FROM 400 YARDS ON THE BEAM.

SUBMARINE.

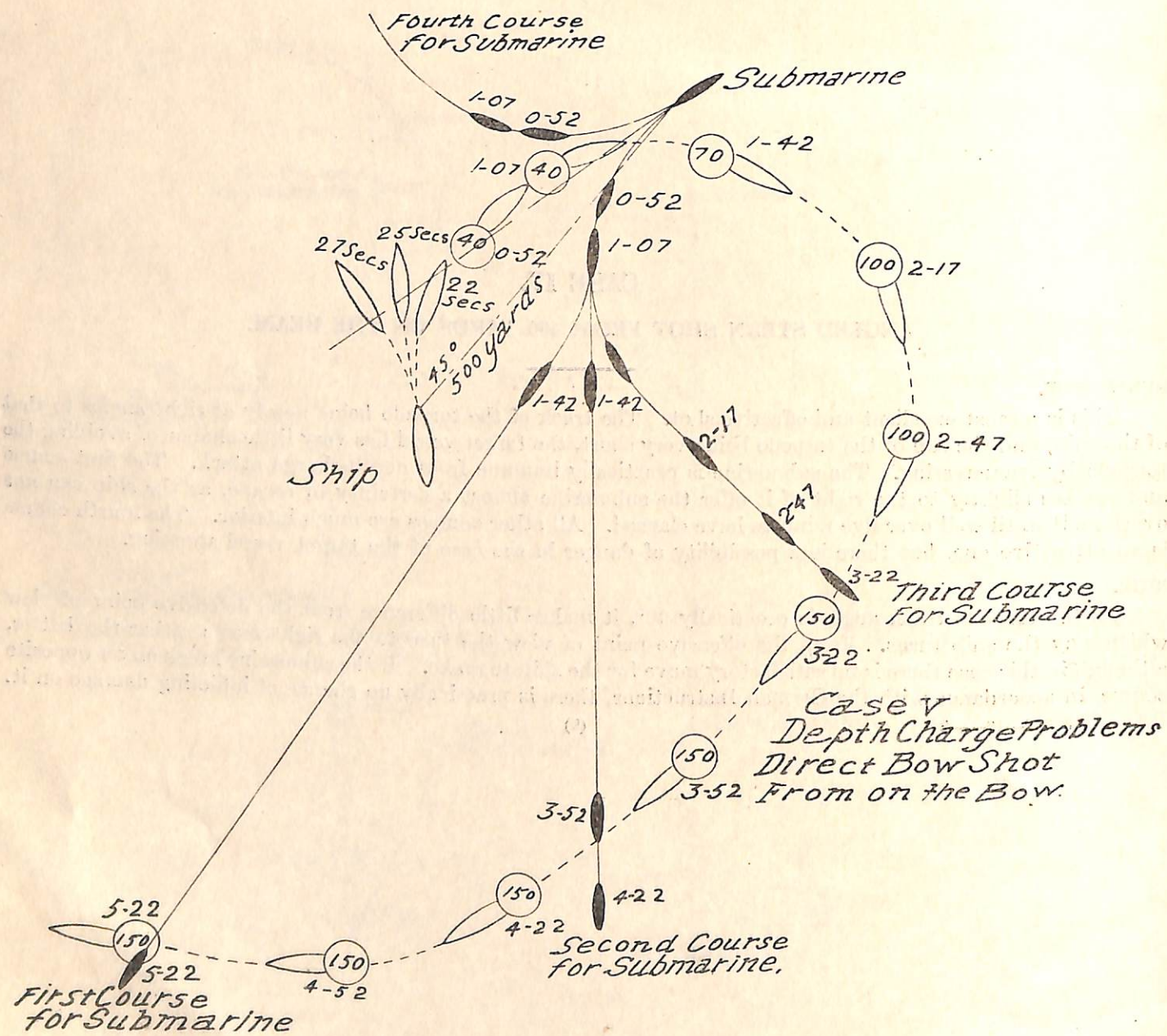
This is a most excellent and effective shot. The track of the torpedo being nearly at right angles to that of the ship, and the run of the torpedo being very short, the target vessel has very little chance of avoiding the torpedo by maneuvering. The submarine is practically immune from depth-charge attack. The first course and courses slightly to the right of it offer the submarine almost a certainty of escape, as the ship can not overtake it until well over five minutes have elapsed. All other courses are much inferior. The fourth course is an attractive one, but there is a possibility of danger in the case of the target vessel stopping.

SHIP.

As the torpedo track angle is practically 90°, it makes little difference from the defensive point of view which way the ship turns. From the offensive point of view the turn to the right seems rather the better, although in this case there is no satisfactory move for the ship to make. If the submarine keeps on an opposite course, in accordance with the German Instructions, there is practically no chance of inflicting damage on it.

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CASE V.

DIRECT BOW SHOT FROM 500 YARDS ON THE BOW.

SUBMARINE.

This is the most unsatisfactory shot of all the 12 cases to be considered. If the ship turns toward the submarine, there is little chance of hitting it with the torpedo. In addition, the submarine has practically no chance of escaping the depth-charge attack.

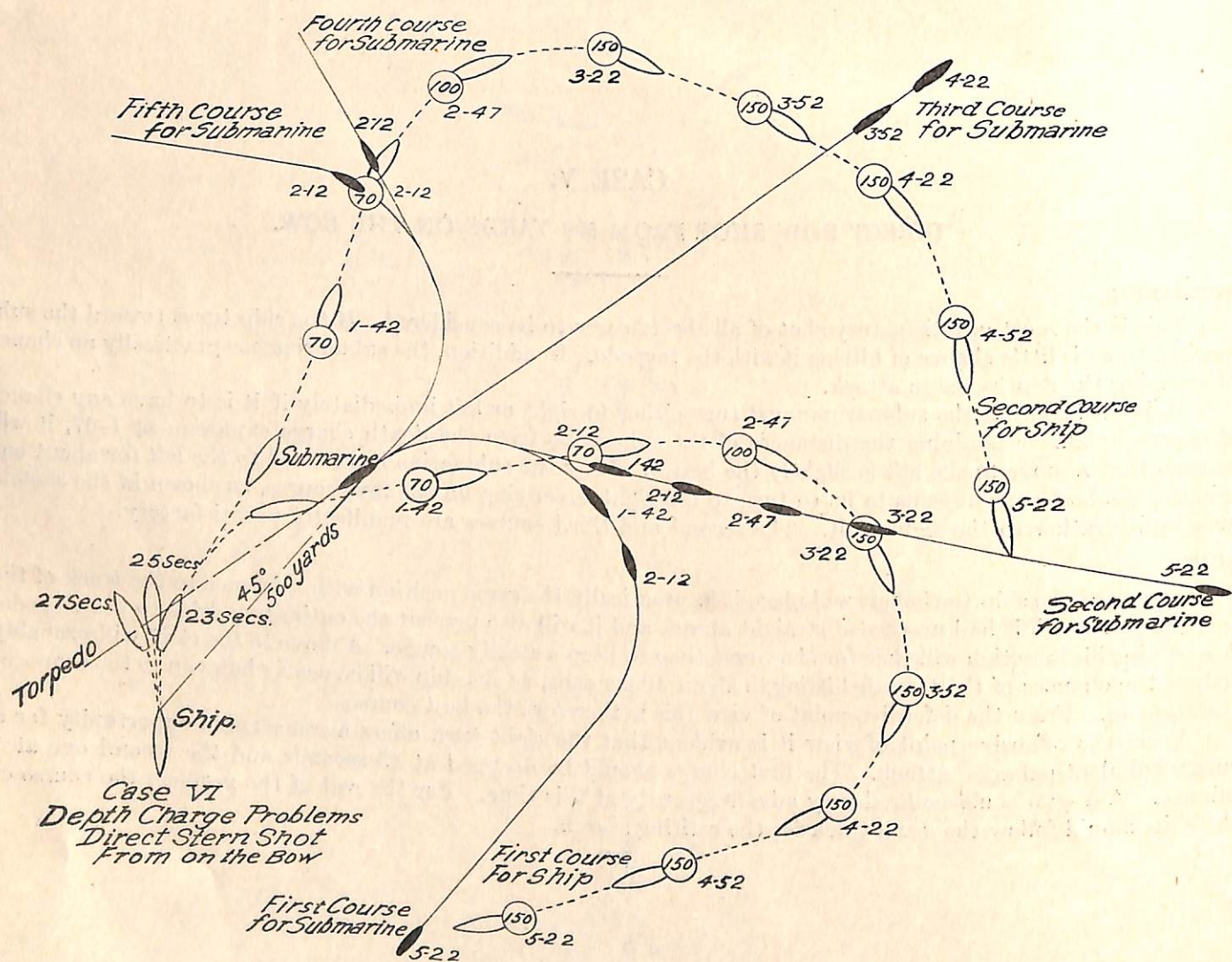
It is evident that the submarine must turn either to right or left immediately if it is to have any chance of escape at all. Examining the distances of the submarine from the depth charge explosion at 1-07, it will be seen that a move to the left is slightly the better. After the submarine has turned to the left for about one minute, the best course seems to be to turn to the right, steadying on the first course, as shown in the sketch, or steering rather to the right of it. The second and third courses are manifestly unsatisfactory.

SHIP.

A turn of the ship to the left will place it in practically the same position with reference to the track of the torpedo as though it had proceeded straight ahead, and it will also present the entire broadside to the torpedo. A move in this direction will therefore be worse than to keep a steady course. A move to the right will probably reduce the chances of the torpedo hitting to about 10 per cent, as the ship will be nearly bows on to the course of the torpedo. From the defensive point of view this is therefore the best course.

From the offensive point of view it is evident that the right turn offers a remarkable opportunity for a successful depth-charge attack. The first charge should be dropped at 45 seconds and the second one at 1 minute. A Y-gun could be fired very advantageously at this time. For the rest of the problem the course of the ship should follow the usual track for the retiring search.

(11)



CASE VI.

DIRECT STERN SHOT FROM 500 YARDS ON THE BOW.

SUBMARINE.

The submarine's position is so far forward of the target's beam that this shot is a very unfavorable one. This situation will occur very rarely in actual practice. The target vessel has an excellent opportunity to avoid the torpedo by maneuvering. The submarine, however, has an excellent chance to escape the depth-charge attack, and therefore this shot is far better than a direct bow shot fired from the same position.

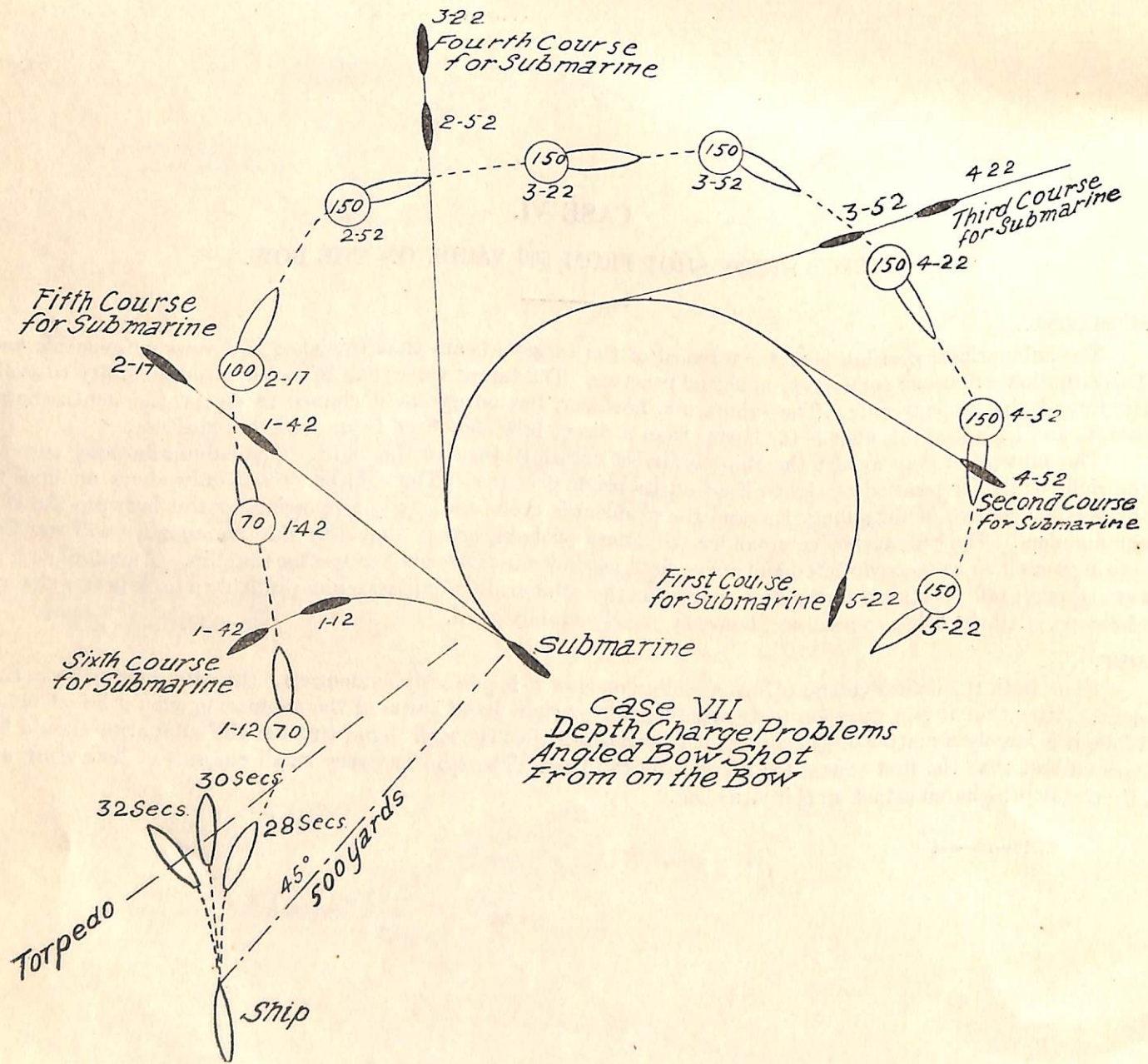
The submarine may expect the ship to almost certainly turn to the right. The submarine may turn to the right or left or proceed straight ahead on its original course. The ship can cover only about one-half of the possible courses of the submarine, and the problem is therefore largely a guessing contest between the two commanders. The submarine commander will most probably guess that the ship commander will run the retiring search so as to cover left-hand turns first, as shown in the second course for the ship. Therefore a right turn through 180°, as shown in the first course for the submarine, would give him probably a little better chance of escape. All the other courses are, however, nearly equally good.

SHIP.

From both the defensive and offensive points of view it is perfectly evident that the ship must turn to the right. After that it is a question as to whether left or right hand turns of the submarine should be covered. While it is largely a matter of guesswork, it is suggested that the right-hand turns of the submarine should be covered and that the first course for the ship is the best. The ship has very small chances of delivering an effective depth-charge attack in this situation.

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CASE VII.

ANGLED BOW SHOT FROM 500 YARDS ON THE BOW.

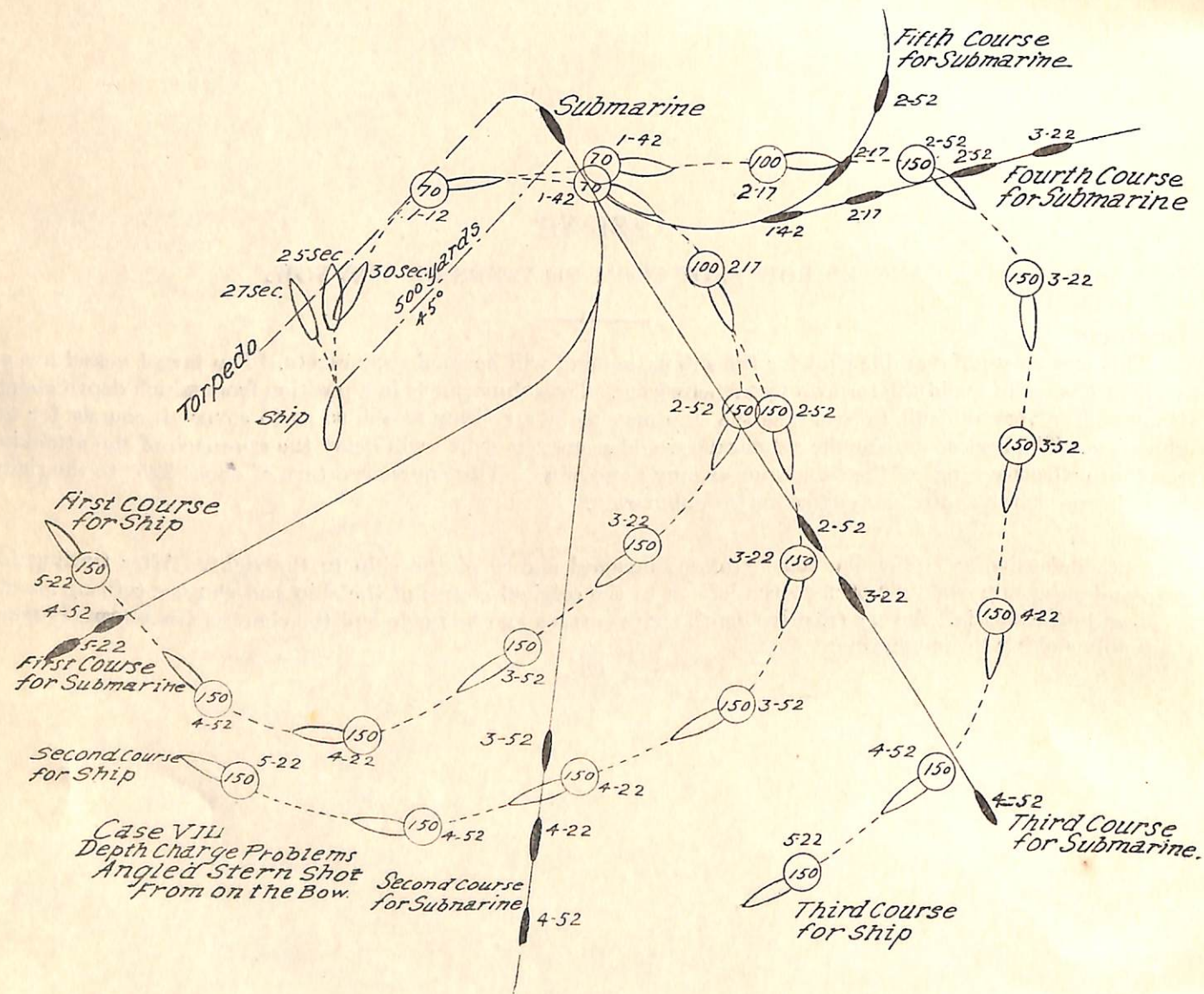
SUBMARINE.

This is a very unfavorable shot for the submarine and will be used very rarely. The target vessel has an excellent chance to avoid the torpedo by maneuvering. The submarine is in a position from which depth charge attack will be very difficult to avoid, as the ship may make a retiring search so as to cover all courses for the submarine. The best course for the submarine would seem that which will delay the approach of the attacking vessel into effective range of the submarine as long as possible. This course is a turn of about 225° to the right, shown in the sketch as the first course for the submarine.

SHIP.

Both defensive and offensive considerations demand a turn of the ship to the right. After turning for 30 seconds, the ship can then turn to the left on to the original course of the ship and run the retiring search as shown in the sketch. A very effective depth charge attack can be made and the chances are extremely good of actually sinking the submarine.

(15)



CASE VIII.

ANGLED STERN SHOT FROM 500 YARDS ON THE BOW.

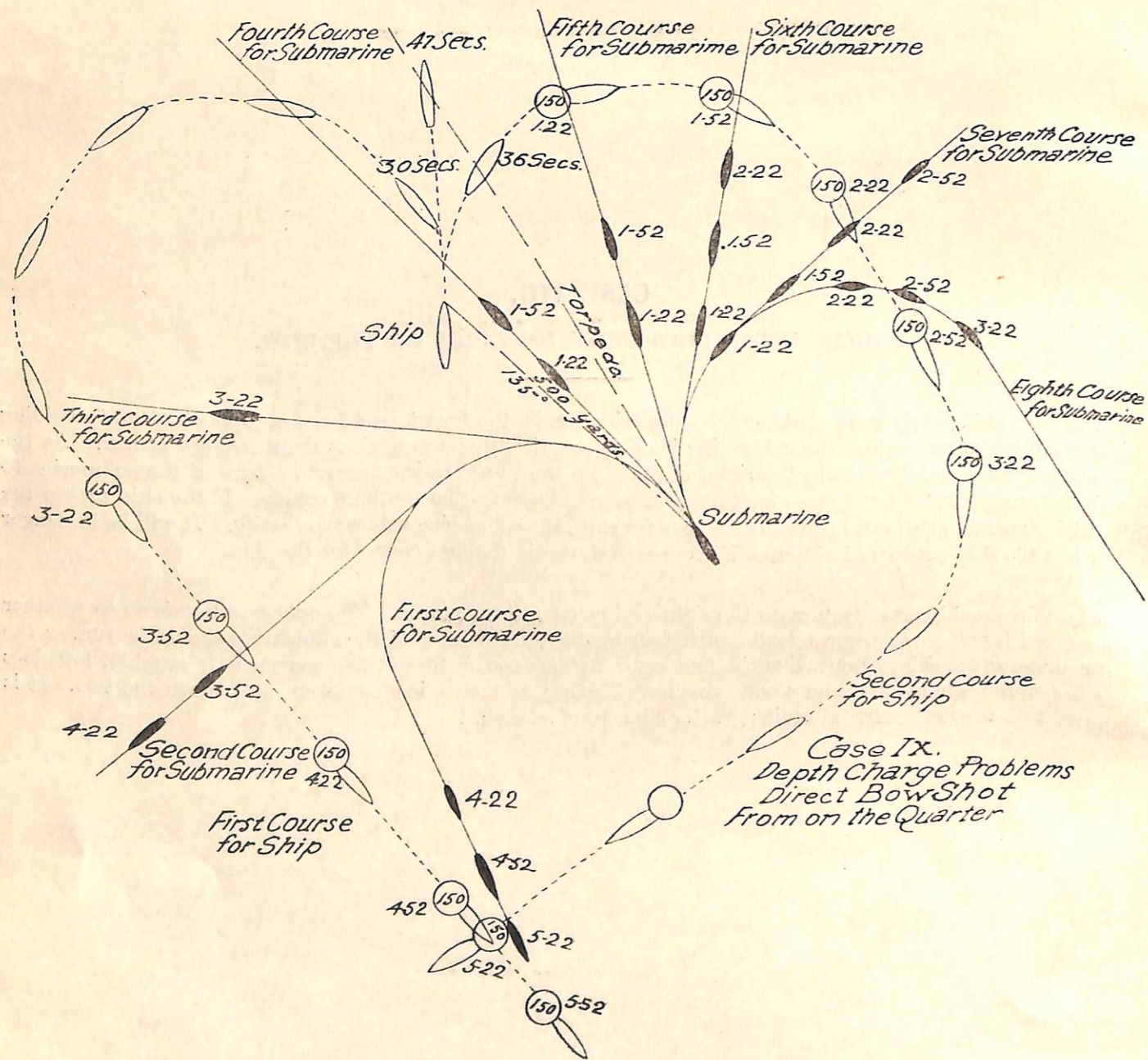
SUBMARINE.

This is a moderately good shot for the submarine; while the target vessel has an opportunity of avoiding the torpedo by maneuvering, the submarine itself is practically secure against depth charge attack. As the ship will almost certainly turn to the right and take up the usual retiring search, a turn of the submarine to the right through 90°—first course for submarine—would seem to be the best course. If the ship makes the full retiring search, as shown in the third course for ship, the submarine will escape easily. It will be in danger only when the ship cuts well inside the full course as shown in the first course for the ship.

SHIP.

The ship should certainly turn to the right and run a retiring search. The only question is as to whether a course which will cover accurately the fifth, fourth, and third courses of the submarine should be run, as the third course for the ship, or one, like the first course, which covers these three courses only roughly, but does cover the more probable first and second courses. The second course is a compromise between the two. It is suggested that the first course contains greater chances of success.

(17)



CASE IX.

DIRECT BOW SHOT FROM 500 YARDS ON THE QUARTER.

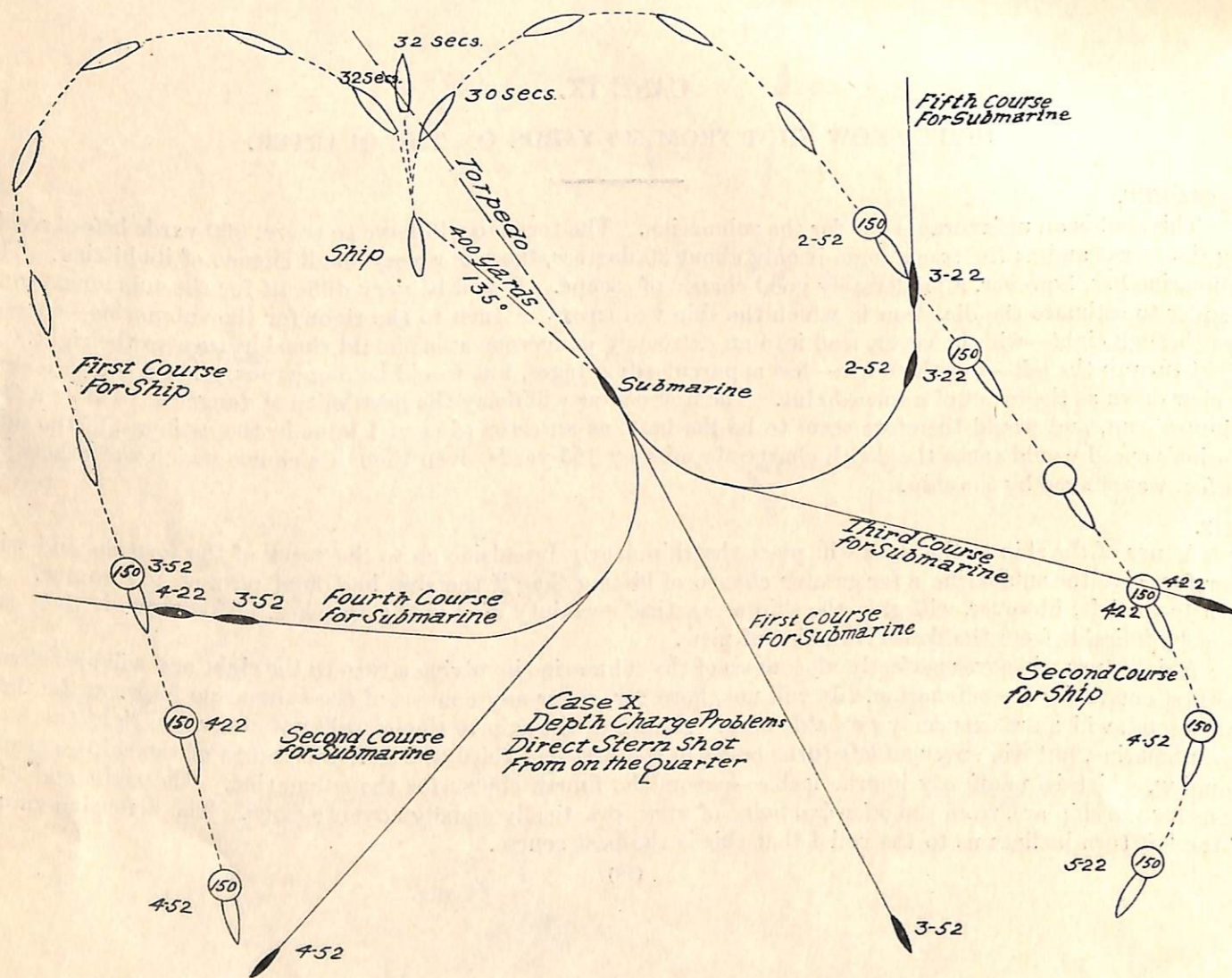
SUBMARINE.

This shot is an unfavorable one for the submarine. The torpedo will have to travel 800 yards before reaching the target and as the track angle is only about 30 degrees, there is a very small chance of its hitting. The submarine has, however, a moderately good chance of escape. It will be very difficult for the submarine commander to estimate the direction in which the ship will turn. A turn to the right for the submarine—courses five through eight—will, however, lead into an extremely dangerous area should the ship turn to the right. A slight turn to the left—fourth course—has apparent advantages, but would be dangerous, should the ship stop or slow down as the result of a torpedo hit. The first course will delay the possibility of danger until after a five minutes' run, and would therefore seem to be the best, as an error of even 1 knot in the estimate of the submarine's speed would cause the depth charges to miss by 165 yards, even though a course which was otherwise perfect was steered by the ship.

SHIP.

A turn of the ship to the right will place the ship nearly broadside on to the track of the torpedo and will therefore give the submarine a far greater chance of hitting than if the ship had kept on a steady course. A turn to the left, however, will give the ship a practical certainty of avoiding the shot. This move is then extremely desirable from the defensive point of view.

A right turn will cover perfectly all courses of the submarine involving a turn to the right and will also cover the first course for the submarine. It will not, however, cover any courses of the submarine between the first and second, which are extremely probable ones. A turn of the ship to the left will not cover any right turns of the submarine, but will cover all left turns between the first and third courses. No course of the ship—except stopping, which is manifestly impracticable—covers the fourth course for the submarine. The right and left turns for the ship are, from the offensive point of view, practically equally advantageous. The defensive value of the left turn inclines us to the belief that this is the best course.



CASE X.

DIRECT STERN SHOT FROM 400 YARDS ON THE QUARTER.

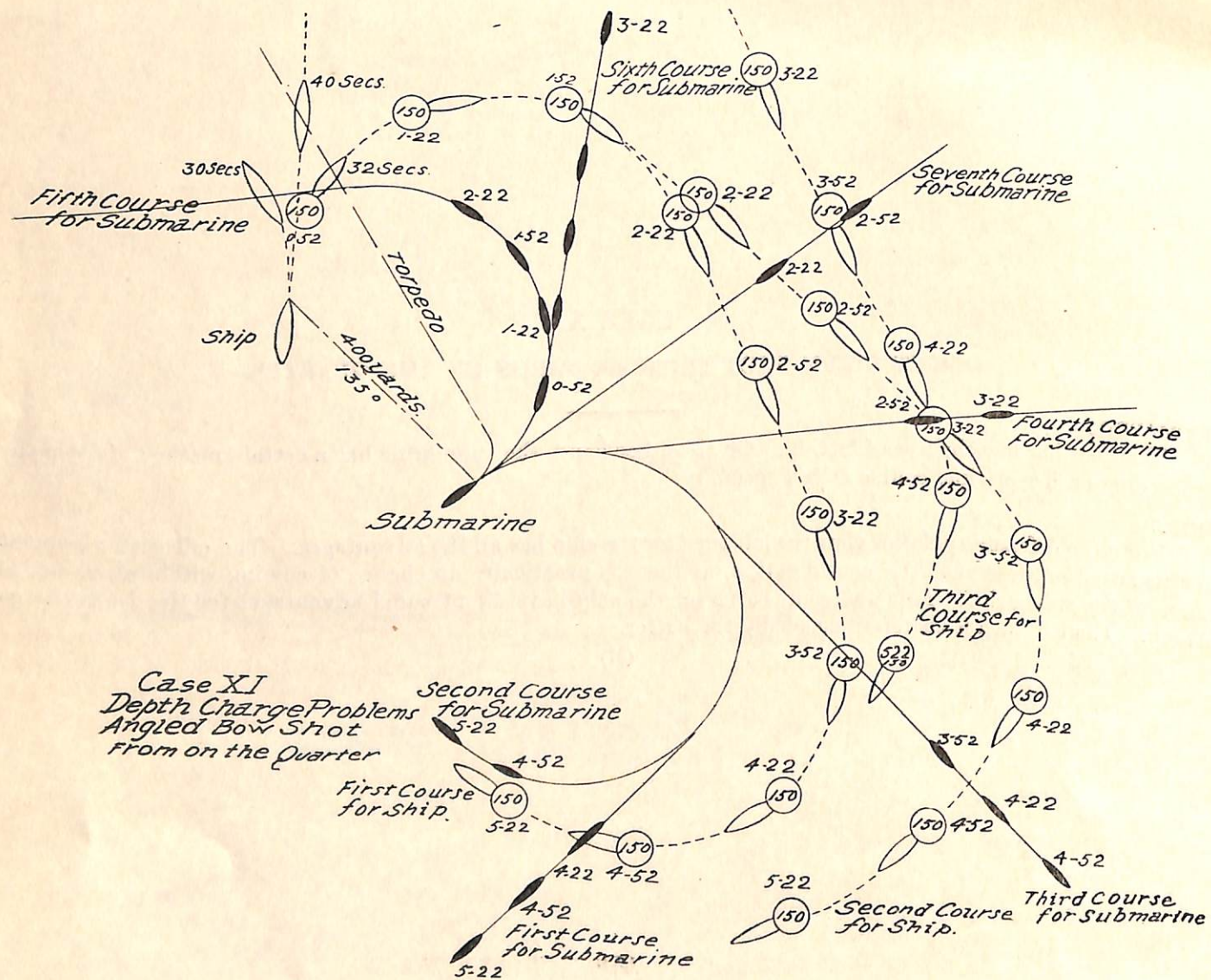
SUBMARINE.

This shot has few chances of hitting. On the other hand, the submarine has a certain method of escape by proceeding on her original course at full speed.

SHIP.

From the defensive point of view the left turn for the ship has all the advantages. The offensive viewpoint in this situation deserves little consideration, as there is practically no chance of coming within a reasonable range of the submarine. Left and right turns for the ship have about equal advantages for the depth charge attack. The left turn is therefore decidedly the better.

(21)



CASE XI.

ANGLED BOW SHOT FROM 400 YARDS ON THE QUARTER.

SUBMARINE.

This shot has only small chances of hitting should the ship steer a straight course. However, should the ship turn to the right for the depth-charge attack, these chances are considerably increased. The submarine has only moderately good chances of escape, because the ship is in an excellent position to take up the retiring search by means of a right turn. A left turn for the submarine, or a right turn through only 90°, will be very dangerous for the submarine, and a turn to the right through 180° would appear decidedly the best course, as this will prevent the submarine being overtaken until after five minutes' run.

SHIP.

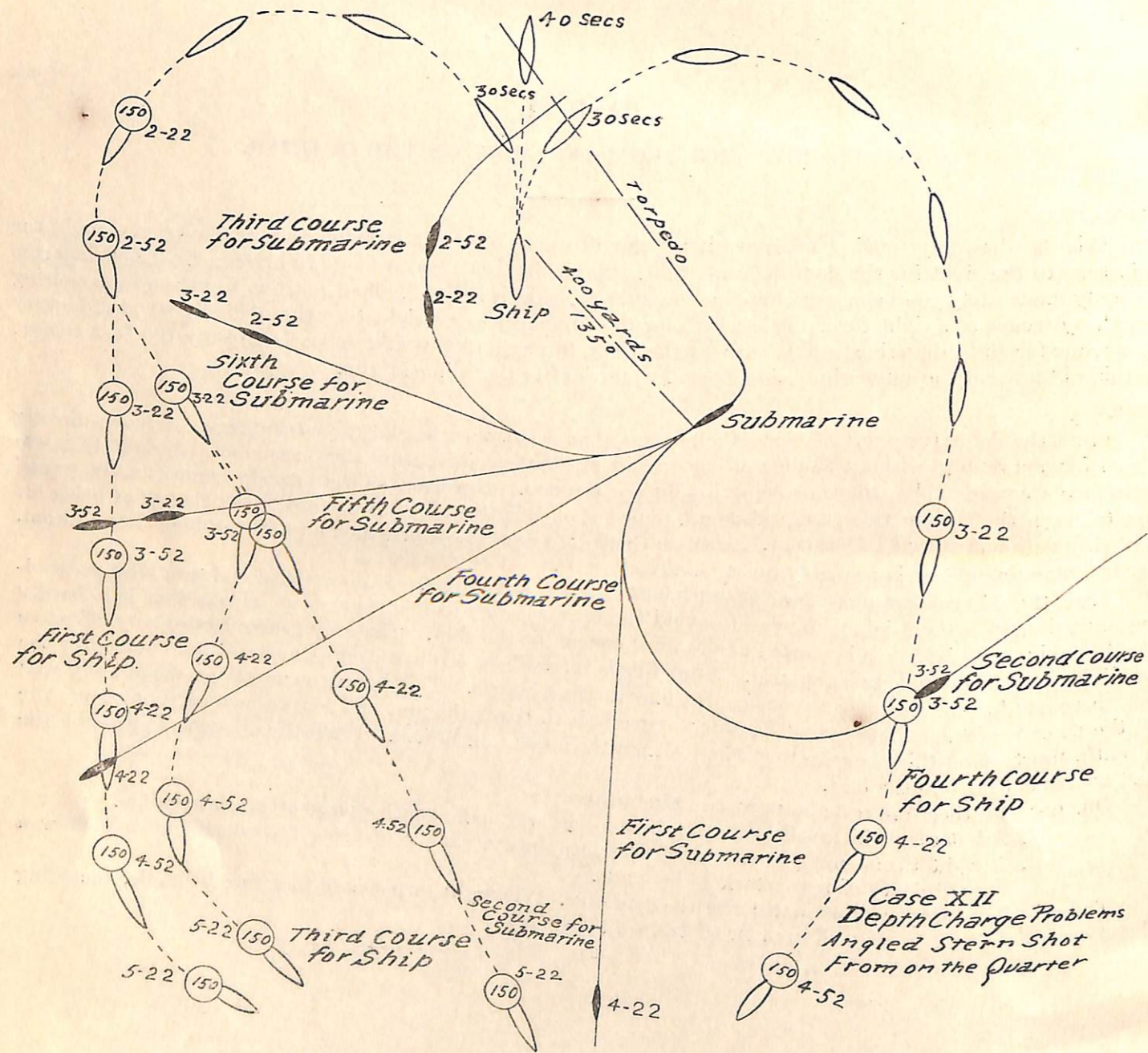
From the defensive point of view it is evident that a left turn has all the advantages. A move directly ahead for one minute without change of course will also be excellent from this viewpoint. A right turn will introduce a considerable danger of being hit by the torpedo. However, as the torpedo requires a 600 yards' run to reach the ship in this case and as an angled shot is rather difficult to direct, the chance of being hit probably does not exceed 15 per cent. Also, as the submarine has gained such an unfavorable firing position, her commanding officer is probably not specially efficient.

From the offensive point of view a left turn for the ship is impossible. Even a right-hand turn after proceeding one minute on the original course—to avoid the torpedo—has so few chances of success that it is hardly worth making. This course is plotted as the third course for the ship. The only course having any offensive possibilities is an immediate right turn. After this is made there are two courses open—a full course like the second course for the ship or an inner course like the first course. This inner course covers moderately well all the courses of the submarine. The outer course fails to cover the first and second courses, but covers the seventh, fourth, and third courses much better than the inner course does. From the offensive viewpoint the first course is therefore the best.

Our decision therefore rests between two alternatives:

1. A left turn which will avoid the torpedo but will make depth-charge attack impossible.
2. A right turn—first course—which will introduce a chance of being torpedoed but will allow a good depth-charge attack to be made.

The offensive always predominates over the defensive. The right turn should therefore be made, accepting the chance of damage to yourself in order to damage the enemy.



CASE XII.

ANGLED STERN SHOT FROM 400 YARDS ON THE QUARTER.

SUBMARINE.

While the submarine has a very small chance of making a torpedo hit, it has an almost certain escape. If it steadies on a course opposite to that of the target vessel, it can not be overtaken until after five minutes have elapsed, after which interval a depth-charge attack has very few chances of success. The submarine commander will be able to estimate that the ship will almost certainly turn to the left. A turn of the submarine through 180° either right or left—second and third courses—will therefore be attractive. They are, however, not so safe as the first course, which the submarine commander will almost certainly make.

SHIP.

It is apparent from both defensive and offensive viewpoints that a left turn has all the advantages. It should therefore be most certainly made. The only question is as to whether a full retiring search track should be followed—first course—or whether an inner course—second or third course—should be used. As in any case it will be impossible to cover the first course for the submarine, it would seem better in this case to cover some courses effectively than to attempt to cover all and really cover none. The first course is therefore suggested as being the best in this situation.

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CONCLUSIONS.

SUBMARINE.

(a) OFFENSIVE.

1. The best firing position is one slightly forward of the target's beam, such that the track angle will be nearly 90° . When the track angle is less than 60° or more than 120° the chances of hitting with a torpedo are very greatly reduced.

2. The range should be as short as possible, but should not be decreased below 200 yards. At 300 yards, the target can not maneuver to avoid the shot; at 400 yards, it has a slight chance to avoid the torpedo; at 500, a fair chance; and at 600 or over an excellent chance.

(b) DEFENSIVE.

1. To avoid depth charge attack after firing the torpedo, the submarine should be as far aft as possible with reference to the target.

2. A stern shot is far safer than a bow shot.

3. After firing, the submarine will submerge to 150 feet and run at high speed for at least 5 minutes.

4. The submarine commander will assume that the target vessel will make either a right hand or left hand turn and run a retiring search, dropping depth charges at frequent intervals.

5. If the submarine has a safe course, irrespective of any possible course of action of the target, the submarine commander will steer this course. (Cases II, IV, X, XII.)

6. If the target vessel has one course so much better than all the rest that it will almost certainly be taken, the submarine will steer such a course as will avoid the target vessel altogether, if this is possible, or as will at least delay as long as possible close contact with it. (Cases V, VII, VIII, XI.)

7. If several courses of the target vessel are practically equally good, the submarine will steer a course which will delay close contact with the target vessel as long as possible, assuming there were several of these vessels which could follow simultaneously each of the nearly satisfactory courses. (Cases I, VI, IX.)

8. In general, the course will be within 45° of being opposite the original course of the target.

(c) OFFENSIVE AND DEFENSIVE.

1. The offensive rôle predominates until the torpedo is fired; after that the defensive.

2. The submarine will attempt to fire from a position between 200 and 300 yards from the target and about 2 points forward of the beam.

3. If practicable, a stern shot will be fired.

4. After firing, the submarine will submerge to 150 feet and run at high speed on a course which is generally opposite to the original course of the target.

SHIP.

(a) DEFENSIVE.

1. The ship's best maneuver for avoiding the torpedo is a change of course in the direction which will most quickly bring the ship on a course which is parallel or opposite to that of the torpedo. In general, this means a turn toward the submarine when it is less than 70° on the bow and a turn away when more.

2. When the submarine is between 60° and 80° on the bow and the range is less than 300 yards there is no use in attempting to avoid the torpedo by maneuvering. The chances increase as the bearing differs from 70° and as the range increases. Whenever either the range is over 500 yards or the bearing differs by 30° from the standard of 70° on the bow the chances of avoiding the torpedo are most excellent.

3. Whenever there are chances of escape by maneuvering by a turn in the right direction, a turn in the opposite direction will considerably increase the risk of being hit over that which would be run should the vessel proceed on a steady course.

(b) OFFENSIVE.

1. The most effective course is one which will cover quickly and thoroughly as many as possible of the most probable courses of the submarine by the retiring search method.

(c) OFFENSIVE AND DEFENSIVE.

1. It is very important for the ship commander to fix as accurately as possible the bearing, distances, and course of the submarine, and determine, if possible, whether or not a torpedo has been fired.

2. He must then by a quick estimate—based upon an intensive study of depth-charge problems in the past—decide upon which way to turn. In this estimate he must consider the following:

- I. Whether or not a torpedo has been fired.
- II. Its chances of hitting if the vessel proceeds on a steady course.
- III. How much these chances will be decreased or increased by right and left turns.
- IV. What the chances are of making an effective depth charge attack by right and left turns.
- V. That the offensive should always predominate over the defensive, unless there is practically no chance of making an effective depth charge attack or unless the chances are practically equal with right and left hand turns.

3. While turning he must make an estimate as to the most probable courses of the submarine and run such a retiring search that the greatest number of these courses will be covered as quickly and as thoroughly as possible. Depth charges should be dropped at about one-half-minute intervals for about 5 minutes, whenever there is a possibility of the submarine being within effective range, set for the calculated depth of the submarine.

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