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Most Confidential

TORPEDO FIRING *from* SUBMARINES

Compiled in German Submarine School

OFFICE OF NAVAL INTELLIGENCE

JUNE, 1918

WASHINGTON
GOVERNMENT PRINTING OFFICE
1918

MOST CONFIDENTIAL.

NAVY DEPARTMENT,
OFFICE OF NAVAL INTELLIGENCE,
Washington, June 6, 1918.

This pamphlet is a reprint of a secret British publication. It is very important that this information be kept most confidential. No person not a commissioned officer of the United States Navy is to be allowed to examine it.

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

NAVY DEPARTMENT,
OFFICE OF NAVAL INTELLIGENCE,
Washington, June 21, 1918.

To Officers receiving a copy of this Publication:

The following is quoted from a letter of the Force Commander U. S. Naval Forces Operating in European Waters regarding the Admiralty secret document C. B. 0693, "Torpedo Firing from Submarines":

"It is urged that great care be taken in handling this publication, allowing it to be in the hands of commissioned officers only, inasmuch as it is one of the most secret publications which has been issued by the Admiralty."

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

Most Confidential

C. B. 0693
O. X. O.

TORPEDO FIRING
from
SUBMARINES

Translation of a German Document

JANUARY, 1918

NAVAL STAFF, INTELLIGENCE DIVISION

WASHINGTON
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1918

PRELIMINARY REMARKS BY TRANSLATOR

From internal evidence it is clear that this book has been put together in a hurry. A number of repetitions and some almost equally obvious gaps occur in it.

The most trivial of platitudes will be found sandwiched between theories and conclusions of extreme interest (this characteristic is frequently displayed in German Staff work). Rules which appear to speak for themselves are elaborated in much detail, whilst, in other cases, conclusions which can only be verified by mathematical investigation are baldly summarized in a few words.

A few misprints and purely verbal errors have been corrected in the translation.

Although numerous references are made to the experience gained on active service, it may safely be assumed that the views put forward are primarily those of the German Submarine School. The writer's own individuality appears very strongly, both in peculiar turns of speech and in the constant recurrence of certain views. Judging by the latter, one would conclude that he is a former Destroyer officer and a keen torpedoman. From other evidence it seems likely that the writer is Lieutenant-Commander Freiherr von Forstner, who is in fact a former Torpedo Lieutenant with some experience in Destroyers. This officer is known to be one of the lecturers in the Submarine School and has the reputation of being an able writer on technical subjects.

Naval Staff,
Intelligence Division.
January 1918.

CONTENTS

CONTENTS

APPENDIX A

APPENDIX B

APPENDIX C

[Instructions from British Admiralty to officers receiving copies of this book:]

SECRET

This book is the property of H. M. Government. It is intended for the use of the recipients only and for communication to officers under them (not below the rank of commissioned officer) who may require to be acquainted with its contents in the course of their duties. The officers exercising this power will be held responsible that such information is imparted with due caution and reserve.

TORPEDO FIRING FROM SUBMARINES

(Compiled in the Submarine School on the Basis of Practical Experience.)

PREFACE TO FIRST EDITION

The following pages contain the teachings of practical experience both in the Submarine School and on active service, arranged in as convenient and concise a form as possible.

A compilation of this nature appeared desirable, as no regular manual of instruction existed, and there was danger that the numerous ingenious methods which the Captains of instructional boats in the Submarine School had discovered in the course of their 400 practice attacks might be lost; it also appeared that the valuable experience gained on active service could not otherwise be utilized by all concerned.

For convenience of reference the following form has been chosen: on the left-hand side is placed the actual experience, or observation, or phenomenon; on the right-hand side the reasons for or explanation of it.

This compilation is not intended to be merely a mass of dry theory; **theoretical considerations** are contained for the most part in the reasons given on the right-hand side of the page.

The Submarine School shares the opinion of the Submarine Service afloat, that for submarine attacks practical work is **all important;** but it is considered that theoretical understanding must precede the use of the rule-of-thumb method.

It is also held desirable to draw special attention to the many small appliances which are supplied to Captains of submarines in the most handy form, but, as experience shows, frequently are not utilized; it is believed that the utmost thoroughness and exactitude may often achieve a hit which would not be obtained by so-called feeling (not identical with seamanlike vision).

This **feeling,** which is so important in the case of **destroyer** attacks and which is embodied in the grip of the hand on the movable 'enemy arm' of the director and the unimpeded view of both eyes in all directions, must, in the case of submarine attack, where these conditions do not obtain, be replaced by **intelligence,** which goes hand in hand with seamanlike vision.

This applies particularly to the correct estimation of the track angle,* the influence of which on hitting or missing has not hitherto been sufficiently appreciated.

Naturally a compilation of this nature, which is intended to be of use to every reader, contains some well-worn commonplaces; many submarine

* For definition of **track angle,** *see* p. 27.—Tr.

PREFACE TO FIRST EDITION

Captains will find these statements too obvious altogether, but to render the book as complete as possible and also for instructional purposes it was necessary to include them.

It must be taken for granted that errors will have crept in and that omissions of all kinds will be found in this collection of experiences; a special request is therefore made to all Captains on active service to pick the book to pieces and criticize it, in order that it may be made as practical and useful a production as possible, both for sea service and for the Submarine School.

SUBMARINE SCHOOL.

ECKERNFÖRDE,
August 1916.

PREFACE TO SECOND EDITION

The compilation of experiences regarding torpedo firing from submarines has been **thoroughly** revised in view of the memorable 1st February 1917, on the basis of comprehensive criticism from the Service afloat and from the Torpedo Inspection, combined with detailed private letters and conversations with former pupils of the Submarine School.

Additional matter was provided by the experiences contained in the war diaries of boats on active service and the experiences obtained in the Submarine School itself; the latter, in consequence of the great number of pupils under instruction during the past year and the almost overwhelming number of boats being prepared for active service, can now, on 1st February, look back on over 9,000 attacks carried out during the two years of war.

This revision is intended at the same time to give a reply to the many widely different suggestions and opinions put forward in criticism, thus obviating the necessity for separate answers.

It appears desirable to refer specially to one point:—

In many of the criticisms the following appears:

'It is not desirable to lay down such and such a principle in **so decided a manner,** for instance, the inadvisibility of firing torpedoes in a heavy sea or from a great distance; in practice, Captains **would** in any case fire in order not to let a target escape them.'

It is just because this last statement is so true and, in consequence, a large number of valuable torpedoes have already been fired away to no purpose, that an instructional book (if, for want of anything better, this small compilation may aspire to that title) must lay down **definite** rules.

Things of this sort are in the same category with a daringly conceived exhibition of seamanship which **leaves no margin** for safety; when it is successful it is pronounced good, but in the reverse case it is rightly condemned.

The only possible rule is: Proceed in a seamanlike manner!

The former sequence and arrangement of the matter has been adhered

to, as it has been well received by submarine Commanders; alternate pages are left blank with a view to inducing Captains to make notes and corrections to the text and to facilitate the insertion of any manuscript corrections issued at a later date.

A few new sections have been introduced, for instance, the method of attack which gives the quickest opportunity for firing, and the procedure in case of a breakdown of the gyro-compass installation.

A further addition is provided by the experience obtained in the sinking of steamers, to which is appended the procedure for the **use of gunfire** which has been adopted in the Submarine School with good results for the training of boats for active service.

Additional emphasis is laid on the attention required by the torpedo matériel on active service, as in the Submarine School it has been found by bitter experience that there is a lack of care in this respect.

For instance, on one single day 3 boats under training for active service fired no less than **4 torpedoes which sank.** These torpedoes were at once salved, and in each case gross errors of adjustment were clearly established and duly punished.

We have every reason to hold a **high opinion** of the quality of our torpedoes; they do their best always, but we must not demand the **impossible** from them.

Finally, on the basis of an exhaustive series of experiments, in which the late lamented President of the Torpedo Experiments Committee, Commander Holtzapfel, enthusiastically placed at the disposal of the Submarine Service his profound knowledge and wide experience, the question of salvo fire has received new treatment from the standpoint that firing at a range of **over** 3,000 metres [3,280 yds.] is useless and therefore better not attempted.

A torpedo is not a shell and will never become one, as it is confined to the water.

Though nevertheless the technical requirements for a long-range shot were further developed, this was done solely with a view to the firing of large formations making a torpedo **mass** attack, which may have a decisive effect; but this does not come into consideration in the case of a single submarine.

The rule for submarines remains as before:

PROCEED UNOBSERVED TO A POSITION FROM WHICH A HIGH-SPEED SHOT CAN BE FIRED AND A HIT CERTAINLY OBTAINED!

It is hoped that this small compilation may serve as a book of reference for Captains of submarines on active service, and a book of instruction for Captains qualifying in the Submarine School; and further, that the Watch-keeping Officer, who after successful service afloat is likely to receive a command without first visiting the Submarine School, may find in it the necessary material with which to instruct and educate himself **without** any methodical course of instruction and with only a limited number of practice runs (15–20 runs as compared with 30–45 in the Submarine School).

PREFACE TO SECOND EDITION

If all this is attained, the object of the compilation will be achieved.

The former request is repeated, that the Service afloat will co-operate in improving the book and supplying its omissions. Any criticism is welcome and will help the cause; the more outspoken it is, the better, whether communicated in writing or by word of mouth to the compiler.

SUBMARINE SCHOOL.

KIEL,
1st February, 1917.

First day of Unrestricted Submarine Warfare.

A. GENERAL REMARKS ON THE DAY ATTACK.

I. Most Favourable Side for the Attack.

1. Side, with reference to sun and wind.

(*a*) When choice is possible, the sunny side should be chosen, particularly when the sun is not too high, and provided the shot can be fired more or less from the direction of the glare of the sun.

When firing, you must have the sun **behind you** in order that you may not be dazzled but may be able clearly to distinguish the sharply outlined target.

As regards under-estimation of range, under conditions of clear atmosphere and high visibility (*see* A. V. 5, *f*).

When firing **towards** the sun, estimation of distance is particularly difficult, the enemy appears as a black silhouette, and it is hard to estimate speed, as the bow wave and wash completely vanish in the glittering water.

Conversely, the periscope, if shown with caution (i. e. frequently, but only for a short time and only a few inches of it), **cannot** be seen by any possible means from the target in water in which the glare of the sun is reflected; even the track of bubbles will probably not be seen until it is too late to avoid the torpedo.

Under these conditions, the periscope, even with the most advantageous painting (*see* A. III. 8), appears snow-white.

Conditions of light play a very important rôle:

If possible, do not attack with black thunder clouds behind you, which may be about to burst as a hail storm.

If forced to fire **towards** the sun, use a shade with the periscope.

The shades are in the periscope accessory box.

(*b*) Side, with regard to wind.

With wind and sea behind you the periscope is not easily seen (assuming it is properly used).

Whenever the periscope is to **leeward** of the enemy it is betrayed by the spray, which the periscope produces even at the slowest speed and even with a high wind.

It is difficult for the observer on

As regards the side with respect to the wind, the stern shot in the case of moderate wind, force 2–3, forms an exception.

In this case the **lee side** is to be preferred for a stern shot.

Principle: The periscope must, as far as possible, move **with** the sea.

In a **strong** breeze, however, the weather side is preferable.

2. When attacking a formation, the side on which there are no vessels disposed towards you.

3. To sum up: If you have the choice of side (for instance, when you are well ahead), **before** altering course take a look round with the periscope, imagine yourself on board the enemy ship and ascertain from which direction the attack will be least easily perceived by the bridge personnel of your enemy, and also which will be the most unpleasant for them, whilst at the same time offering you the best chances of success and rendering your estimations and measurements most reliable.

At the same time, ascertain exactly your course of approach and the bearing of the enemy, in order to form an idea as to the conditions to be expected **when firing.**

II. Strength of Wind and Sea.

1. **Do not** fire in a calm with a perfectly flat sea.

Exception: From the direction of the glare of the sun (*see* A. I. 1).

A submarine is not likely to be able to approach unseen, and is generally discovered whilst making her attack.

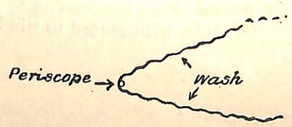
board the enemy ship to keep a look out in the teeth of the wind (eyes watering); with a stiff breeze and rain he is more inclined to look out to leeward (at all events in the case of the average look-out).

Spray is less perceptible, as the boat in proceeding away from the target keeps more or less ahead of the seas, whilst when moving to windward conspicuous spray is produced even at the slowest speed.

The enemy will keep a **better** look-out to leeward and will more readily detect the periscope there than to windward.

More favourable chances of a hit (*see* D. IV. 4).

The boat is more secure from being rammed (*see* A. V. 2).



Typical view (from above).

If a shot is fired, it **cannot fail** to be seen and can be avoided at distances of 400 m. [437 yds.] and upwards.

U. B. 2, U. B. 10, U. 34, U. 35, U. 19.

Exception: A slow cargo steamer.

An incredibly bad look-out is kept on board such ships.

Submarine Flotilla, Pola.

2. Force of wind 3–4 and sea 2–3 present the most favourable conditions for attack.

The sea just washes over the periscope if the latter is shown sparingly, and, without masking the submarine Captain's view, makes it difficult for the enemy to recognize the periscope.

At any considerable distance, the periscope feather cannot be distinguished from small breaking seas.

The boat is easily kept at the proper depth for attack.

3. If the sea is 5–6, when it may be just possible to fire, fire **at right angles** to the direction of the sea.

This is the most favourable direction with regard to the sea for both the boat and the torpedo; in other directions the torpedo may easily break surface (propellers racing).

U. 24.

A shot at a destroyer, with 1.5 m. [4.9 ft.] depth setting, is out of the question. In a case of this sort, do **not** attempt an attack.

(*See* A. X. 1.)

A shot at a destroyer, with 2.5 m. [8.2 ft.] depth setting, **using** lever-pistol (*Hebelpistole*),* is possible.

4. **Do not** attack in a heavy sea and a long Atlantic swell.

It is impossible to keep the boat at a proper depth for attack; she may therefore be discovered and become a target for gunfire.

The depth-keeping of the torpedoes is most unreliable, especially when they are set to run shallow; even type 'G' torpedoes fail.

U. 27, U. 38, and Torpedo Inspection.

This **cannot** be sufficiently emphasized.

A typical example is furnished by the case of U. 57, two of whose tor-

* For particulars of the use of **the 'lever-pistol,'** *see* p. 36.—Tr.

III. Use of Periscope.

1. *General Principle:*

Do not deprive yourself of your view too soon or for too long! And do not on any account dive directly you sight the tops of masts or columns of smoke!

Masts and funnels suffice only to enable you to estimate your first approximate course of approach.

It is not until you get close in for your attack (from about 4,000 m. [4,374 yds.] onwards) that you need proceed **unseen** in accordance with par. 2 below, when **everything** depends upon showing very little periscope, proceeding at low speed and choosing the favourable side for attack.

With a calm sea and **high** visibility, it is advisable to establish a look-out (with good binoculars) in a boatswain's chair rigged on the foremost W/T mast.

2. An unseen attack (periscope used sparingly) implies keeping the periscope low and showing it frequently but for **quite short** periods (a few inches of periscope only so that the object glass is almost awash).

After you have been able to estimate the speed and course of the enemy, it must suffice for you to see the tops of his funnels and masts.

You cannot form a clear idea of the enemy's position and of the considerations which will apply when firing, until you have seen his **hull.**

Using the stereoscopic rangefinder, the most highly skilled rangetakers have never yet succeeded in making out a periscope showing 1.5 to 2 m. [4.9 ft. to 6.6 ft.] above the surface at a distance of 4,000 m. [4,374 yds.], provided a suitable speed was maintained and the favourable side for attack chosen.

With binoculars, it has not been possible to distinguish the periscope even at 2,000 m. [2,187 yds.].

Frequent experiments in the Submarine School.

Argument in brief:

You cannot make an attack with your eyes shut.

This considerably increases the range of vision and thus renders it possible to proceed on the surface to a position ahead of the enemy.

U. 64. (Using this method, sighted and sank a large transport in the Mediterranean.)

With a slightly ruffled surface, the periscope, when moving to leeward at a **low** speed, is difficult to make out or even to keep in view.

If a periscope is properly handled, then, even if it is sighted and reported once, it is not likely to be picked up again soon enough for the Captain of the ship to make up his mind to the necessary alteration of course, and the ship should not escape unless

pedoes jumped right out of the water. Waste of munitions.

Torpedo Inspection, Torpedo Experiments Committee, Submarine Inspection.

Even in a calm sea the periscope must remain hidden by the ripples on the surface.

It is absolutely wrong to run for a certain distance, or to alter course 'by the watch' with periscope lowered when within attacking distance of the enemy.

You must not for any length of time omit to take a look round.

Remark:

This principle applies to attacks under action conditions in the Submarine School.

For Captains who are thoroughly sure of themselves, the following procedure may be suggested:

Shortly before firing and before the periscope is shown in order to fire, assuming you are well within range, alter course 2 points away from the enemy.

Then put your helm over the opposite way, and, as soon as the boat starts to turn, show your periscope, and fire as the boat's head passes the target.

Remember, however, that this procedure is largely a matter of theory and sacrifices considerations of safety and peace of mind.

3. When, shortly before firing, the periscope has been set for deflection, let your Navigating Warrant Officer keep an eye on the periscope to prevent it being accidentally turned.

4. When the periscope is lowered its top should be at least 1 m. [3.3 ft.] below the surface, but not much more.

Captains will soon acquire the habit of judging how much to lower the periscope.

every look-out is authorized himself to give the necessary orders.

The attack would be no more 'unseen' than when carried out as laid down above, and might lead to the destruction of the submarine by ramming, or to the loss of the opportunity for a shot owing to the enemy altering course.

Such has been the experience even with sea-going boats, which have carried out firing in the Submarine School and have collided with the target ship.

The numbers of the boats need not be mentioned.

This will obviate the necessity for waiting with periscope raised, and will shorten the time during which the attack is visible to the enemy.

Submarine Flotilla, Pola.

The periscope easily gets turned when being raised or lowered, thus causing errors in the deflection and consequently a miss.

In this way variations of depth and the wash of the sea will be allowed for, and the necessarily **frequent** lowering and raising of the periscope can be effected with less expenditure of time.

(Skilful juggling with the periscope.)

5. When raising and lowering the periscope, do not rely too much upon the limiting switch.

6. Take particular care that the periscope tube is always completely desiccated.

7. Lower the periscope **completely** and go to a depth of 18 m. [59 ft.] when high speed (full speed or utmost speed) is necessary to attain the position for firing.

Before you go up to attacking depth, ease to slow speed and have all noise in the boat stopped.

8. Painting of periscope:—**a dull dirty grey colour,** similar to that used for the hull, is recommended; in any case, some sort of grey, **not** green or stripes or squares. The top of the periscope should also be dull grey, not black like all other horizontal surfaces of submarines.

Silver bronze, which merges with the water, is suitable for the Mediterranean but not for northern latitudes.

9 (*a*). Never show two periscopes at the same time!

The control-room periscope also must be lowered right below the conning-tower rivet heads.*

This has been known to fail at critical moments.

Otherwise, at the critical moment the glasses may cloud over.

III Submarine Flotilla.

The wash of the propellers and periscope causes the boat, even with a moderate sea, to be **much more** easily detected than one would oneself believe, if she is at any less depth than this.

The periscope, in any case, vibrates so much that it would be impossible to see through it.

U. 19, U. 66, in a flat calm.

In order to prevent the periscope from being detected when it is raised, and to enable the sound of propellers to be heard in the boat.

Under **all** conditions of light, this colour is the least easily detected.

A shiny coat of paint sparkles in the sun, green is **very** conspicuous on a dull day, and the same applies to stripes and squares.

A periscope, painted black on top, stands out very sharply from the water when just above the surface.

This paint takes the colour of the breaking seas.

U. C. boats in the Mediterranean.

Two periscopes enable the submarine's attack and her course to be easily detected, and facilitate alteration of course to avoid the attack.

The one periscope is the only spare fitting for the other (a chance hit with gunfire).

There is **no possible** object in showing both periscopes.

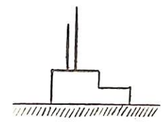
* i. e. presumably as far as possible.—Tr.

(*b*) This also applies when proceeding on the surface on your hunting ground.

Consequently the periscope must not be raised whilst you are diving, but only when the boat has reached her proper depth.

If, in order to increase the height of eye, **one** periscope is raised for a time, it must be lowered again immediately after use.

You must avoid presenting the



typical submarine silhouette, which is recognizable at a **great** distance.

The conning-tower, without the conspicuous periscopes, is not so striking and may readily be mistaken for a sail.

(*c*) Come to the surface with periscope lowered!

The following is the procedure recommended for coming to the surface: First whilst submerged (according to weather conditions, up to a depth of **7** m. [**23** ft.]), with a considerable length of periscope out of the water, have a **careful look round** both with and without magnification, then lower periscope completely, come quickly to the surface and open the conning-tower hatch as soon as possible to enable the Captain himself to have a **clear** look round from the bridge.

Do not start the main engines until the horizon has been thoroughly searched.

Experience shows that this is frequently forgotten.

There is often, particularly in the twilight or in hazy weather and with a swell, something or other in sight which is not visible in the periscope.

II Submarine Flotilla.

As the eye takes some time to accustom itself to a clear view, you may, after blowing your tanks, easily fail to notice vessels whose attention would be drawn to the submarine on your changing over from your electric motors to your main engines.

U. 28.

(*d*) When on your hunting ground do not feed the gulls, but hunt them away.

Flights of gulls may easily betray the submarine.

U. 28.

Remark: (*b*), (*c*), (*d*) do not bear directly on the attack, but are so important for it that it appeared advisable to include them in this Section.

10. Handling of periscope immediately after firing.

(*a*) Lower the periscope and dive to the greatest possible depth (45 m. [148 ft.]); this applies particularly to small boats with **only one** periscope.

Advantages: The submarine in this manner renders herself more secure from counter measures.

If the English method of tactical employment of submarines (attacking the enemy from both sides) is adopted, this procedure gives additional security against **a chance hit** on one of our own boats.

Disadvantages: (*α*) No authentic knowledge can be obtained as to the result of the attack.

(*β*) It is impossible to complete a partial success, as the Captain will not be inclined to come nearer the surface when he hears the sounds of propellers, &c., in the neighbourhood.

(*γ*) It is impossible to observe the depth-keeping and run of the torpedo, which is important in forming an opinion of the shot for your own instruction and in forming an opinion of the torpedo matériel and the manner in which it has been handled.

(*b*) A BETTER METHOD:

Observe the shot and the hit! Also whether a second shot is necessary and possible.

For this purpose, **after** firing, show the periscope as sparingly as possible in every way: that is, show very little of it and, as the boat invariably rises somewhat, always first lower the periscope a little; then raise it again according to your depth.

After observing the hit and the counter measures adopted, then (and not till then) proceed for about **15** minutes at the **greatest** possible depth. Lower the periscope completely and preserve silence in the boat!

In this manner you will often at least be able to observe the position of the hit. Always endeavour to ascertain the result with certainty and, when possible, to complete your success by a further attack.

(*α*) *Guiding Rule*:

Better **a few** vessels destroyed than **many** vessels damaged.

(*β*) The Higher Command must know with certainty, when a ship is reported merely as hit, whether she has to be reckoned with for the future or not.

Hits, which have been heard but **not** seen, consequently possess little value. It is easily possible to mistake

If after this nothing further is heard (no propellers or depth-charges, or projectiles striking the water) have another cautious look round.

the explosion of a depth-charge, or a projectile striking the water near the submarine, for the sound of a hit.

(*γ*) It is important to observe depth-keeping and run of the torpedo (*see* (*a*)).

U. 9, U. 21, U. B. 22, U. 52, U. 66.
II Submarine Flotilla.

11. (*a*) A shot, when proceeding submerged in an **ice-field**, offers no certainty of success, owing to the effect of the ice on the periscope.

When the periscope is raised, it receives such heavy blows from the floating ice, even at the lowest speed, that the glasses are badly shaken, and even endangered. In addition, the object glass soon clouds over, and does not clear again until the periscope has been lowered for some considerable time.

U. 9, U. 10, U. 19.

(*b*) If, though it is freezing, a keen wind prevents ice forming and thus renders possible the use of the periscope, the following procedure has proved successful:

(*α*) In order to melt the coating of ice over the object glass so as to obtain a clear view, dive to a depth of **20** m. [**66** ft.]!

(*β*) To have a look round, let the periscope break surface as rapidly as possible and proceed yourself so near to the surface (**9** m. [**29½** ft.] or less) that no spray falls on the object glass.

In addition, in order to avoid causing spray, proceed **with** the wind and keep ahead of the seas; when looking round the horizon, train the periscope as rapidly as possible past the direction of the wind.

(*γ*) If, nevertheless, the object-glass freezes over, use the **2** periscopes alternately.

In a very short time the view again becomes clear.

This renders the risk of the object-glass freezing over as small as possible.

It is mainly spray (mixed with air) which causes freezing; the water left on breaking surface runs straight off.

U. B. 25 in the Submarine School.

The periscope which is lowered is always ready for use.

With practice you can have a continuous view.

U. 4 in the Submarine School.

63887—18——2

12. If, when proceeding at high speed, the periscope vibrates, it must be lowered a little and the attacking depth correspondingly reduced.

The position of the periscope not in use (whether lowered right down or only half way) has an influence upon the vibration of the periscope in use (this probably is the case with school boats only).

The limits vary in different boats and must be found by experiment.

13. Do not rely on the supposition that at a great distance **you cannot** under any circumstances be detected (*see* A. II. 2).

This applies with more force to men-of-war than to merchant vessels, though the latter in time will keep a better look-out.

14. The periscope raising wire must be absolutely in order (spare raising wire).

15. (*a*) Periscopes should be cleaned and slightly greased daily; it is best to wipe them down directly after diving, but **do not** clean them with emery paper.

As far as possible, this should **not** be done by daylight.

It is otherwise impossible to take bearings of the enemy, and the vibration injures the optical properties of the periscope.

At present a better watch and look-out are kept in men-of-war, and the training is superior.

An attack may easily fail owing to the periscope raising wire being defective.

This is in order to ensure the periscope working easily **without** the tightness of the gland being impaired.

In order not to betray the submarine by showing the full length of periscope.

U. 28.

Reflection of the sun's rays!

Submarine Flotilla, Pola.

(*b*) When on the surface, train the periscope away fron the sun.

In order to prevent any dirt from the exhaust falling upon the object glass.

U. 28.

(*c*) If there is no sun, train the periscope (i. e. the object glass) **forward** when proceeding on the surface.

In order to ensure a clear view.

(*d*) Clean the object glass frequently with wash leather. Take care not to scratch the glass with any particles of grit.

There is often an opportunity of doing this just **before** diving.

The periscope is then lowered and the object glass easily accessible.

U. 28, II Submarine Flotilla.

16. The periscopes must be of such a length that when they are right down on the lower deck, the glands are still tight.

Remember this when shipping a fresh periscope.

Otherwise water will pour in, if the periscope raising wire should carry away.

IV. Speed When Attacking.

The speed of the submarine is a vital factor in an 'unseen' attack:

1. To close the enemy, first proceed at high speed until the bearing does not change.

When actually attacking, endeavour to limit yourself to the **lowest** speed at which the boat keeps her depth well.

In order to ensure that the boat gets within easy range.

In this way the periscope will not readily be detected by the enemy, whilst at high speed there is always a distinct feather and wake.

The Captain must judge for himself whether to endeavour to remain unseen, accepting the fact that this will increase the possibility of the enemy altering course.

Any battery power expended unnecessarily reduces your submerged radius of action to no purpose.

In any case in which speed has no effect on your approach, e. g. when steering an opposite course or a parallel course to the enemy and not closing him laterally, **always** proceed at the lowest possible speed! *See* C. II. 4 *b* β.

2. **Before** using your periscope, **always** reduce speed.

When submerged, the boat does not carry her way for any distance.

In order that the boat may readily answer her helm at any moment.

U. 19.

3. If the enemy is zigzagging, it is advisable not to proceed at too low a speed.

The best means of meeting this is constantly to take bearings and accurately to ascertain the mean course and **alterations of course of the enemy,** using your watch, and then to make your attack accordingly.

See C. IV. 9.

under various circumstances, in order to approach to a range of 300 m. [328 yds.] when firing (*see* C. II. 4 *b* β).

Entering the table with the bearing of the submarine from the enemy, in points from right ahead, and the speed of the enemy in knots, you obtain the speed at which the submarine must proceed in order to arrive at a range of 300 m. (328 yds.) when firing.

SPEED OF ENEMY.	*Angle of Approach =90°	Bearing from Enemy: Points on the Bow.				*Angle of Approach =80°	Bearing from Enemy: Points on the Bow.			*Angle of Approach =70°	Bearing from Enemy: Points on the Bow.			*Angle of Approach =60°	Bearing from Enemy: Points on the Bow.		
		1	2	3	4		2	3	4		2	3	4		2	3	4
	5	½	1¾	3	4¾	5	1¾	2¾	3¾	5	1½	2½	3½	5	1½	2½	3½
	6	¾	2	3½	5¼	6	2	3	4½	6	1¾	3	4¼	6	1¾	3	4
	8	1	2¾	4¼	7	8	2¾	4	6	8	2¼	4	5½	8	2¼	4	5
	10	1¼	3¼	6	9	10	3¼	5¼	8	10	3	5	6¾	10	3	5	6¼
	12	1½	4	7		12	3¾	6½		12	3½	6	8¾	12	3½	6	8
	15	1¾	5	9		15	5	8½		15	4½	8		15	4½	7¾	
	18	2	6			18	6			18	5½			18	5½		
	20	2¼	7			20	7			20	6½			20	6½		
	24	2¾	9			24	8¾			24	7½			24	7½		
	30	3½	9½			30				30				30	9		

* i. e. the angle between the submarine's course of approach and the enemy's course.

V. Firing Range.

1. The most favourable firing range is 200 to 300 m. [219 to 328 yds.].

(α) With a target of sufficient length it is **impossible** to miss.

Range = 285 m. [311 yds.] Speed of Torpedo = 38 knots. Length of target = 120 m. [394 ft.]. | With an error of 8 knots in the estimated speed, a hit will in theory still be obtained.

If the submarine approaches unseen, the enemy in the 15 seconds available cannot avoid the torpedo, either by alteration of speed or by putting his helm over.

Compare the Disadvantages of the Distant Shot, A. V. 4.

(β) Except in the case of an angled shot with large parallax, which should in any case be avoided (*see* C. III. 1, U. 38), the submarine will be **inside** the enemy's turning circle and consequently cannot be rammed on the splash of the torpedo being seen; the splash is **always** very noticeable in spite of the arrangements for reducing it.

(γ) At a range of 200 m. [219 yds.] the submarine is **absolutely** clear of the danger zone produced by the detonation of the torpedo against the target.

(δ) With a moderate speed of enemy (up to 18 knots), the submarine is **not** affected by suction; the influence of the latter only makes itself felt with higher speeds.

U. B. 28 in Submarine School.

It is advisable, in addition, **after** firing to turn away in the direction of the enemy's stern.

In order, particularly in the case of firing at very close range, to avoid all danger of ramming or being rammed.

Submarine Depôt.

Note on 1: On active service the most favourable firing range, in the

(α) When attacking an unfamiliar target, a submarine attempt-

case of ships with which you are not absolutely acquainted, is 300 m. [328 yds.].

In the Submarine School, a firing range of 200 m. [219 yds.] should still be aimed at.

2. When attacking ships in a formation **do not** fire at less than 500 m. [547 yds.] range, particularly if the vessels are disposed towards you.

On the side on which there are no vessels disposed towards you, **if this can be recognized,** proceed as in 1. above.

3. (*a*) Do not fire at **less than** 170 m. [186 yds.] in the case of a direct bow or stern shot*.

(*b*) Whitehead torpedoes must **not** be fired at a range of less than 250 m. [273 yds.].

4. At longer ranges, the chances of a hit **soon** decrease to vanishing point.

ing to close to 200 m. [219 yds.] may easily get **too** close in.

(*β*) A range of 300 m. will allow for the influence of suction in the case of a high speed of enemy.

U. B. 28 in Submarine School.

In order to give officers practice in the most difficult form of attack (i.e. approaching unseen close enough and yet not **too** close). On active service there are additional difficulties which cannot be reproduced in the Submarine School.

In order not to run the risk of being rammed by a ship astern; you must allow 40 seconds for diving to a depth of 20 m. [66 ft.].

U. 29, U. 63 on 1.6.1916.

(*See* A. I. 2.).

(*α*) A torpedo will not have time to take up its depth properly and will pass **under** the ship; in the case of an angled shot, however, a torpedo largely takes up its depth whilst turning.

(*β*) Do not approach nearer in view of a possible magazine explosion in the enemy ship.

The radius of danger from your own torpedo **alone does not** exceed 50 m. [55 yds.] with a depth setting of 3 m. [9.8 ft.].

As they require a run of this distance to get down to their depth.

Leader of Submarines.

(*α*) If the distance which the torpedo has to run is too great, any small errors of estimation produce an unduly large error in the point of impact.

(*β*) The effects of the spread of the gyroscope and of variations in speed of torpedo each amount to 1 per cent. of the distance, and consequently increase proportionately with the range.

(*γ*) The track of bubbles, which may be sighted, can be avoided by an alteration of course.

(*δ*) In addition, in vessels fitted with a good hydrophone set, the firing and the track of the torpedo can easily be observed by this apparatus, even supposing that the submarine has not already been detected by the sound of her propellers.

Experiments in the Submarine School with target ships fitted with hydrophones.

* i. e. evidently a direct shot with bow or stern tube.—Tr.

(*a*) A long-range shot **over** 2,000 m. [2,187 yds.]; speed of torpedo 27 knots.

One isolated long shot is an absurdity.

(*b*) A high-speed shot at medium range **over** 1,000 m. [1,094 yds.]; speed of torpedo 38 knots.

An **isolated shot** has only a limited chance of hitting.

(*c*) We thus have the *rule:* Approach as close as you possibly can (*see* A. V. 1) and fire a **high-speed**

The chances of a hit are absolutely nil!!

Example: For a run of 2,700 m. [2,953 yds.] a 27-knot torpedo requires 200 seconds.

Supposing the speed is estimated only **one knot** in error, **all** the other data being mathematically correct (a practical impossibility, *see* 4 *β* in regard to natural spread of torpedo), the torpedo will miss ahead or astern by 100 m. [109 yds.].

U. 43, 52. Leader of Submarines.

Example: For a run of 1,200 m. [1,312 yds.] a 38-knot torpedo requires 63 seconds.

Supposing the speed is estimated 2 knots in error, the other data being correct as in (*a*) above, the torpedo will miss ahead or astern by 63 m. [69 yds.].

U. B. 21. Leader of Submarines.

shot (if possible a double shot (*see* D. I.)). Fire a **long-range shot** only when there is no possibility of the boat getting closer to the target.

For a long-range shot, **only** a quadruple salvo promises success, and then only **under** 3,000 m. [3,281 yds.] (*see* D. III. 2).

5. Measurement of Distance.

(*a*) Measurement of distance (range-finding) is not absolutely necessary for a short-range attack, but it is desirable to form an estimate.

The distance for a short-range shot, i. e. 200–300 m. [219–328 yds.], is obtained in the first place by the change of bearing of the enemy; it is consequently influenced by the method of attack (turning towards or away from the enemy).

Range-finding for a short-range shot bears no resemblance to that for a long-range shot.

(*b*) At long ranges, for instance 4,000 m. [4,374 yds.], the bearing of the enemy must be kept **absolutely** unchanged if the submarine wishes to close for a short-range shot.

Only at moderate ranges (2,000 m. [2,187 yds.]) may the bearing of the target be allowed to move forward a degree at a time according to the speed of the enemy.

The distance for a short-range shot is accordingly obtained by seamanlike vision and understanding.

(*c*) In order accurately to obtain the change of bearing of the enemy, particularly in the case of a bow attack, the course steered at the moment is **always** to be applied to the periscope bearing.

Since at medium ranges the bearing alters very little, i. e. by single degrees only, any yawing of the boat, the amount of which is shown **only** by the compass course at the moment, is of great importance.

Bearings should be taken of the **stern** and not of the **bow** of the enemy.

If this is not done, the eye will be deceived by the greater apparent increase in size of the forward part of the vessel, due to the change of perspective.

If bearings are taken when under helm, as is frequently necessary, the greatest care must be observed.

Mistakes in reading off may easily be made.

(*d*) General rule for obtaining correct change of bearing of the enemy:

The reason for this may easily be memorized as follows:

Bearing alters to the **right** when you are attacking the enemy's **starboard side** (bearing increases).

Bearing alters to the **left** when you are attacking the enemy's **port side** (bearing decreases).

The enemy proceeds to the **right** round the compass, whilst you stand in the centre of the card.

The enemy proceeds to the **left** round the compass, whilst you remain in the centre of the card.

(*e*) When firing at medium and long ranges (firing at formations), measurement of distance is **absolutely** necessary.

An estimation is not possible. The distance must be obtained within 200–300 m. [219–328 yds.] in order that the torpedoes, whether adjusted for high speed or long range, may be certain to reach the target.

Measurement of distance in combination with bearings at successive intervals, when plotted on squared paper, gives the course and speed of the formation. (*See* A. VI. 5.)

(*f*) Procedure for estimating or measuring distance.

(α) Goertz Range Estimator with periscope magnification 6 ×.

Supplied to every submarine, but unjustly regarded by Commanding Officers with disfavour. The instrument is very simple to use and does not interfere with the view in any way.

On the principle of the sextant range-finder with stand. It is necessary to know the approximate height of the target.

It can also be used independently of the periscope when on the surface. The distance in kilometres, read off from the curves, must be divided by 6 **when it is used in this way.**

This represents a simplification of the formula for range of visibility (in the List of Lights).

(β) Distance (in nautical miles) of the target, when the tops of the masts just touch the horizon, with high visibility, equals twice the sum of the square roots of the two heights of eye in metres.

$$d = 2(\sqrt{h} + \sqrt{H})$$

Example:

Boat submerged = 4 m.

Cruiser's masthead height = 36 m.

$d = 2\ (2+6) = 16$ nautical miles.

(γ) At short distances, i. e. **under** 1,000 m. [1,094 yds.], you must learn to estimate the range by eye, **constantly** practising yourself in this.

By practice you will learn to estimate a range of 300 m. [328 yds.] within 50 m. [55 yds.] just as you would with normal vision [i. e. without periscope.—Tr.]

63887—18——3

For this purpose it is necessary to use periscope magnification 1½ ×.

Never change the magnification during a short-range attack.

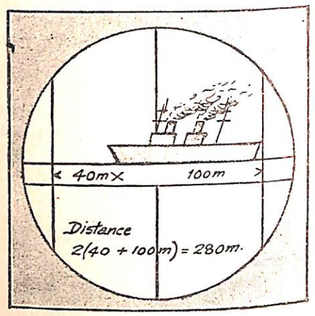
(δ) A good check on the estimated distance can be obtained by observing what proportion of the space between the two side wires of the 30° periscope field (with magnification 1½ ×) the target occupies when broadside on.

Rule of thumb: A target 100 m. [328 ft.] in length (when broadside on) will be enclosed between the two side wires when at a distance of 200 m. [219 yds.].

Range = twice the width of field thus enclosed.

If the target is not seen broadside on but at an angle, the target will occupy a smaller portion of the periscope field at the same range.

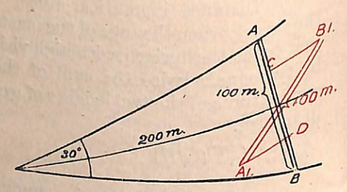
With magnification 6 × all sense of distance is lost.



This is a good method of obtaining range at the moment of firing.

Example: A target 100 m. in length, seen at an angle of 30° (i. e. with the submarine about 3 points on the bow), *see* A. VIII. 2, would fit in twice over between the side wires at a mean range of 200 m.

Sin 30° = ½.



$AB = A_1B_1 = 2 \cdot CD$.

(ε) If the ship attacked is seen at an acute angle, a better method is as follows:

Picture to yourself the mast or the funnel laid horizontallt and you will thus obtain quite a useful estimate of

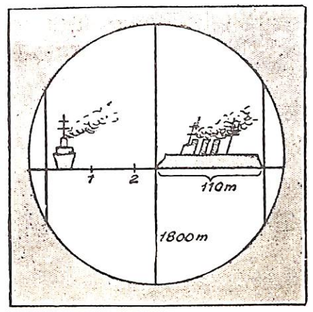
This estimate is independent of perspective (merely a measurement of height).

the length of the portion of the target between the side wires.

You will obtain a more reliable scale by using half the periscope field (i. e. between centre wire and one of the 2 side wires = 15°).

The distance is then not twice, but 4 times the length of the field between the wires.

For masthead heights, &c., Weyer* may be consulted or they may be judged by eye.



For this procedure, which is also applicable at long distances, use magnification 6 ×.

Distance = 8 times the length of field between the side wires.
= 16 times the length of field between the centre and side wires.

The two magnifications (1½ and 6) are in the proportion of 1 to 4.

Distance = 2.4 = 8

Distance = 2.2.4 = 16

(ζ) General rule for estimation of distance:

In clear weather and a bright light (sun behind you) the distance will be **underestimated;** in dull weather with low visibility it will be **overestimated.**

Exactly as in rifle firing and estimation of distances in the field.

VI. Speed of Enemy.

1. The more nearly the target comes abreast you, the more correct will be your estimation of speed; this is the opposite to estimation of the course, which can be made more easily from a position ahead.

2. Shortly before firing you will have to make an allowance ahead or

The change of bearing is then at its maximum, and the bow wave and wake can then most easily be made out.

In order not to disturb the plan of attack, no alteration is made in the

*i. e. the German Naval Pocketbook edited by Lieut.-Commander Weyer.—Tr.

astern for error in your estimation of speed.

(Use a decided amount, i. e. 30–40 m. [33–44 yds.]).

3. Do not base your estimate of speed solely upon the bow waves of enemy ships or destroyers.

4. The speed can more easily be estimated by the wake than by the bow wave.

5. At long distances a good method of ascertaining the enemy's speed, particularly when attacking a formation, is to obtain a series of ranges with the Goertz Rangefinder, at the same time taking bearings (as when plotting an action).

This serves also to determine the course.

Plot on squared paper (scale in nautical miles).

Speed Table for minutes!

In place of a pad of squared paper, obscured glass divided into squares is also recommended.

deflection, which is based upon the original estimate of speed.

Bow waves may be painted on, and this may be either temporary or confined to particular vessels.

U. 12.

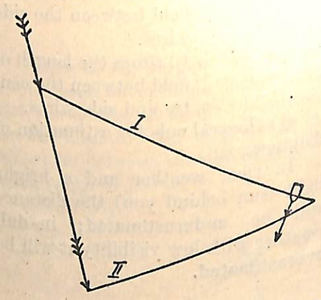
It is difficult to simulate a wake by painting or methods of that sort, and owing to its length it is more conspicuous than the bow wave, which with a sharp bow is often surprisingly small.

The periscope, when taking bearings, is trained **mostly** towards the stern of the enemy.

See A. V. 5*c*.

Example:

I.	300°	4,000 m.
II.	255°	2,900 m.



With the submarine steering 195° at 2 knots, we obtain the course and speed of the enemy formation = 170° 20 knots.

Checks can be obtained by means of repeated bearings and ranges.

The results should be meaned as in navigational problems.

U. 48.

Handy, and can be used indefinitely.

With this method of obtaining the speed and course of the enemy, it is **not** necessary to know the height of the target.

6. Captains of submarines are **strongly** advised to take with them large binoculars (magnification about 20 ×) on a stand, combined with a bearing plate.

It is only a question of the difference between the vertical angles at different times.

In order to be able to make out the nature of the target with certainty (e. g. whether a steamer is armed, &c.), and also the enemy's course and speed.

U. 35.

VII. Advantageous Position for Submarines When Hunting or Lying in Wait.

1. If the submarine is aware of the direction from which an enemy is to be expected, she should lie with her stern in this direction. The stern position is **always** a good one.

This rule gives the boat as free a hand as possible, as by increasing her speed she can reduce the rate of closing to a minimum. Owing to the low submerged speed and poor turning powers of the submarine, she may otherwise fail to get a shot in.

Daily firing in the Submarine School.

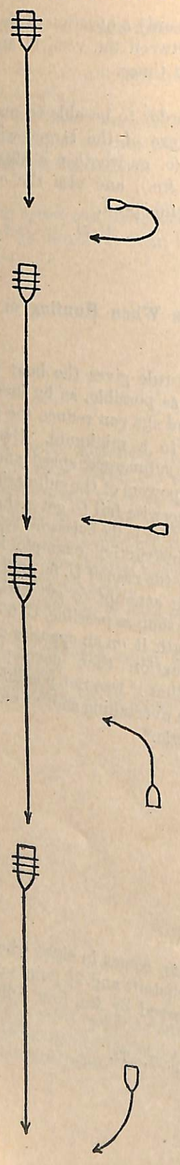
An instructive **example** is provided by the case of U. 66 on 31.5.16:

In an attempt to get inside the escort as soon as possible, U. 66 dived underneath it on an **opposite course.** The situation then developed so rapidly that it was not possible even to fire an overtaking shot at an acute track angle.*

The rule also applies when proceeding on the surface (**keep under way on account of enemy submarines**), and when attacking vessels which are zigzagging, and generally in all cases in which time is of importance (hazy weather, late sighting of the enemy, &c.).

2. *Example:* Enemy, proceeding at 15 knots, comes in sight when the submarine is 3,000–4,000 m. [3,281–4,374 yds.] distant and 2½ points on her port bow. The correctness of the rule was proved by the four following instances in the Submarine School.

* For definition of **track angle,** *see* p. 27.— Tr.



Case 1: Submarine is steering at right angles to enemy's course, and heading away (this is 50 per cent. bad luck). The boat must turn about 16 points to starboard and will not have time to get a shot in.

Speed of closing = 15 knots, i. e. enemy will be abreast submarine in about 5 minutes.

Case 2: Submarine is steering at right angles to enemy's course, but heading towards it (this is 50 per cent. good fortune). The boat has not got to turn and she will get her shot in.

Speed of closing as in Case 1.

Case 3: Submarine is steering approximately an opposite course. She must turn 90° and will not have time to get her shot in owing to the **rapid rate of closing.**

Speed of closing = 15+3 (submarine's submerged speed = 18 knots.

See **example** of U. 66 on 31.5.16 p. 25.

The boat really has to turn over 90°, namely 90°+the deflection.

Case 4: Submarine is steering approximately a parallel course. By increasing speed she can **reduce** the **rate of closing,** thus gaining a great deal of time and **always** being able to get her shot in.

Speed of closing = 15 − 6 (submarine's submerged speed) = 9 **knots.** The boat needs only to turn 90° − the deflection.

3. For other reasons also it is **quite** correct to turn your stern towards the enemy when diving.

Whilst the boat is diving, the seas break heavily against the conning-tower.

This attracts attention even at long distances, when seen from ahead, especially as the dive is always made at high speed.

II Submarine Flotilla.

VIII. Track Angle.

The track angle is the angle between the course of the target and the course which the torpedo is intended to take up.*

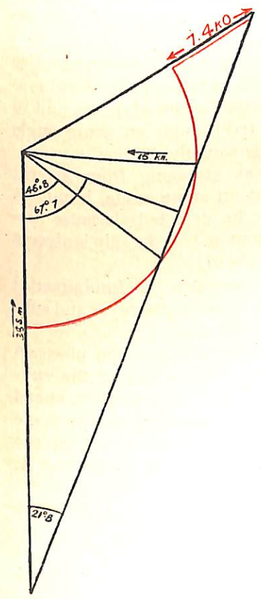
The correct estimation or determination of this angle is more important than the estimation of the enemy's speed.

The determination of the track angle, or (what amounts to the same thing) of the enemy's course, is the foundation of the whole art of firing submerged.

1. *Principal Rule*:

In endeavouring to make the track angle a right angle, an obtuse angle should be **avoided**; an acute angle, on the other hand, need not.

It is better to make it 75° than 95°!



Speed of torpedo	= 38 knots.
Speed of enemy	= 15 knots.
Deflection	= 21.8°
Track angle	= 120°, 90°, 67.7°, 46.8°.

Track angle 120°.

At 300 m. torpedo passes 57 m. ahead.
At 500 m. torpedo passes 95 m. ahead.
At 1,000 m. torpedo passes 190 m. ahead.

Track angle 90° or 46.8°—a hit.

Track angle 67.7°.

At 300 m. torpedo passes 9 m. astern.
At 500 m. torpedo passes 15 m. astern.
At 1,000 m. torpedo passes 30 m. astern.

The error increases proportionately with the range.

* The original reads: 'The track angle (*Schneidungswinkel*) is the angle between the course of the target and the submarine's course of attack'; but the above is a more correct definition of the sense in which the term is used throughout the book.—Tr.

Consequently: If the track angle is more acute than has been estimated, aim **a little further ahead.**

If the track angle is more obtuse than has been estimated, aim a **great deal further astern.**

The following is an old rule of thumb in the Destroyer Service: If the torpedo runs towards the target the track angle is obtuse, so 'fire later (a lot)'. If the torpedo runs after the target, 'fire sooner (a little)'.

You must force yourself not to lapse into obtuse track angles.

With enemy speed 15 knots.

Speed of torpedo 38 knots.

the figure on p. 27 shows that with obtuse track angles (even when the angle on the bow of enemy is only slightly overestimated), you get a miss **ahead,** and there is a rapid **progressive** increase in the amount.

With too acute track angles, on the other hand, the miss is astern and follows a **flat** curve, reaching its highest point at a track angle of 67.7°, and then declining as far as 46.8°, when it is again zero. If further errors of estimation are made in the direction of too acute an angle, they are only of importance when the enemy's speed is very low, and the miss is then **ahead** and increases progressively as in the case of errors of estimation in the direction of too obtuse an angle.

It is frequently shown in practice that one is inclined to overestimate the angle on the bow of enemy and to call the track angle on acute angle when it is actually 90°.

A boat attacking from astern, that is at an **acute** angle, is not so likely to be detected, because the best lookout on board a ship is always directed ahead.

Here we have a fundamental difference between destroyer and submarine attacks.

2. The determination of the track angle depends in the first place on estimation of the enemy's course (**which is the quintessence of the submerged attack**). This estimation can best be made from a position **ahead** (in contrast to the estimation of speed, *see* A. VI. 1), and thus can be made equally well at long distances. Magnification 6 × should be used for the purpose, or, on the surface, binoculars with magnification 20 × (*see* A. VI. 6).

The reference above to overestimation of the angle on the bow of enemy requires the qualification, that, **at long distances,** you will always be inclined in practice to think the angle **smaller** than it really is, i. e. to imagine yourself to be nearly right **ahead** of the enemy when, in point of fact, he will pass you at a considerable distance.

Supposing that at a distance of 10 km. this angle is 5°, the submarine is 1,000 m. away from the enemy's track. *See* C. II. 4 *b* 5.

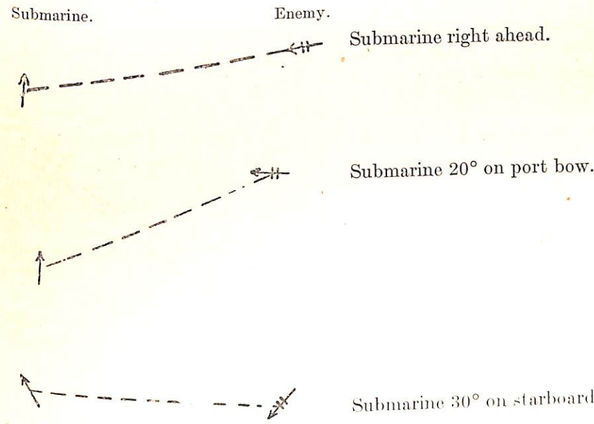
The principle of applying the estimated angle on the bow of enemy to his bearing when sighted is derived from the Rate of Change of Range Instrument used in gun control.

By systematic practice in recognizing the angle at which the enemy is heading with reference to his initial bearing, you will reach the stage of being able to determine his course within ½ point even at long distances, using magnification 6 ×. For this purpose study the pictures in Weyer* and exercise yourself constantly in estimating the courses of ships under way.

The determination of the lie of the enemy with reference to his initial bearing simply means correct estimation of the angle at which you see the target. This angle is here referred to as the angle on the bow (*Lagenwinkel*).

For a submarine only angles between right ahead and 3 points on the bow come into question, and in many cases it will be impossible to reach the enemy with an angle on the bow of even 3 points.

The following method of describing different angles on the bow should therefore be adopted:



The determination of the enemy's course can be made with sufficient exactitude at from 8,000–10,000 m. [8,749–10,936 yds.], according to the visibility; for this a stereoscopic view is, of course, not necessary, nor is a large height of eye required.

The following are a few hints for recognizing the lie of the enemy:

(*a*) As rough guides at very long distance or with low visibility, to

*See footnote on page 25. To

determine whether enemy is heading 'towards' or 'away from' submarine:

(α) Repeated bearings of the enemy:

If the starboard side is towards you, the bearing will increase.

If the port side is towards you, the bearing will decrease.

according to the general rule given under A. V. 5 *d*.

(β) A comparison between direction of wind and direction of enemy smoke (this often enables speed of enemy to be estimated at the same time).

(γ) A comparison between the position of the sun and the distribution of light and shade on board the enemy vessel.

(b) More exact guides for more accurate determination of the course:

(α) View right acrosss enemy vessel when abreast her.

(β) Thwart-ship surfaces, such as the forward and after sides of the bridge and superstructure; also the degree of illumination of these surfaces.

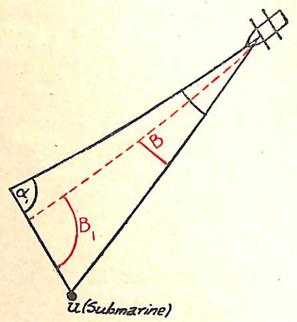
(γ) The lie of the yards or of tripod masts.

(δ) The relative positions of the turrets, bridge, masts, funnels, and derricks. Ships with only **one** mast, e. g. *Arethusa* class, make estimation of angle on the bow very difficult.

A comparison should be made with the familiar pictures in Weyer's Pocketbook and those in the book issued by the Admiralty Staff, 'Views of Merchant Vessels'.

General Rule:

In practice the angle on the bow is always somewhat **over**-estimated, consequently the track angle is made larger than it should be.



Estimated angle on the bow=a.
Actual angle on the bow=β.

In order, according to the rule, to allow a margin of 10° on the safe side so as to avoid an obtuse track angle, it is customary to let the Navigating Warrant Officer give you the **deflection for 80°**, in addition to laying off the course for an 80° track angle.

This is not strictly accurate, but is not sufficiently wrong to be of importance.

The best safeguard against too large angles on the bow and track angles is **consciously** to adopt a somewhat smaller track angle than that which would be given by the relative positions as they appear to you.

But if you apply the same correction to the deflection, you may easily make this angle smaller than it should be.

3. Given the course of the enemy, the following methods can be used to determine the attacking course which gives the most favourable track angle.

(a) The Method Principally Used on Active Service.

Principle: First steer at right angles to the initial bearing, then turn in by the amount of the angle on the bow.

For this purpose, bring the enemy on to periscope bearing 90° or 270° and read off your course; shortly before firing, alter course by the same amount as the enemy was open when you commenced your attack.

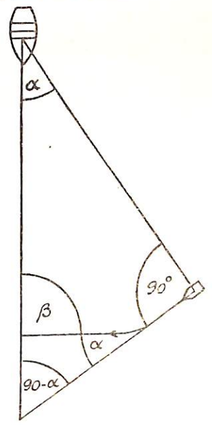
In most cases this angle will be between 15° and 20°; 30° is the highest amount at which you will be able to get your shot in at all.

Advantages: (α) This method soon makes it clear whether the submarine will get in her attack at all. It is the quickest method and therefore necessary in hazy weather. It tends to make the track angle acute, i. e. as favourable as possible.

(β) The submarine requires much less turning room and time to reach the advantageous parallel course (*see* A. VII, C. II 4 *d*) for firing an angled shot with small parallax (enemy zigzagging).

(γ) It is possible to carry out an attack with your compass installation **broken down.** *See* C. V.

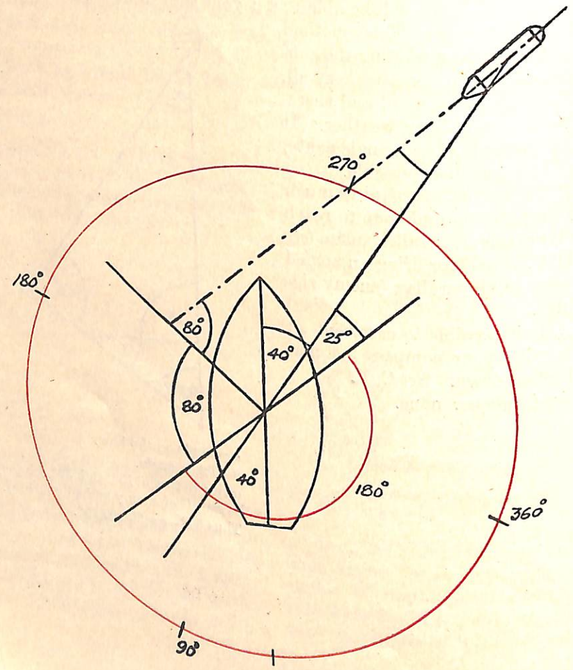
Disadvantages: none.



α=Angle on the bow.
β=Track angle.
α lies between 15° and 30° depending on the speeds of enemy and submarine.
Thus 90° − α = 60° to 75°.

(*b*) Method of Calculation.

Example: Course steered	240°	
Periscope bearing	40°	
Angle on the bow	25°	(on port bow, therefore add)
Sum, i. e. opposite course or fundamental bearing	305°	
(*Note:* The fundamental bearing is the direction from which the enemy comes)	180°	
Enemy's course	485°	
Track angle	80°	(10° margin to avoid obtuse track angle)
	565°	
Subtract	360°	
Course to be steered by submarine	205°	



Rule: If the port side of the enemy is open, the angle on the bow and track angle must be added; if the starboard side is open they must be subtracted.

The calculation is best made in writing by the Navigating Warrant Officer.

This complicated rule simply corresponds to the graduation of the compass card or periscope training arc, clock-wise from 0° to 360°.

Mental arithmetic may easily produce errors, even in the case of an expert.

Advantages: You use no apparatus and you get a clear idea of your compass course. A condition of the latter is that you can form a mental picture of the angles in question; this can be attained by practice.

Disadvantages: It is an involved method, which easily leads to mistakes in calcultion and to misses, or to not getting in an attack at all.

(*c*) Use of the Bearing Plate for Submarines.

This is the so-called Bierfilz apparatus, which is constructed afresh during every instructional course and has recently been produced in the form of a watch.

Principle: There are 3 disks, made to rotate one inside the other and graduated in degrees. These disks correspond respectively to the periscope, the compass, and the initial bearing.

It is fitted with pointers, which represent the direction of the periscope or the enemy vessel and the course at right angles to this.

After setting the instrument for the angle on the bow, the course of the submarine for a good track angle can be read off at a single glance.

Example: (Applicable even when the boat has already commenced her attack.) The Captain, standing at the periscope, orders: 'Stand by for estimation of course—Stop.' '20° on starboard bow; periscope bearing 325°.' The helmsman reports the compass course steered at th moment when the 'Stop' was given, as with the order 'Stand by for bearing—Stop.'

The Navigating Warrant Officer puts these data on the instrument and immediately reports the enemy's course and the course of attack.

There is no risk of errors of calculation. The Captain, Navigating Warrant Officer and Helmsman must have practice in working together.

Advantages: The simplicity of the instrument, which excludes the possibility of mistakes. A good view of the conditions of attack.

Disadvantage: This instrument, like any other 'ready reckoner,' may lead to the habit of not thinking at all.

(*d*) Use of Georg's Bearing Calculator (supplied officially).

Principle: Three disks, graduated in degrees and rotating one inside the other (as under (*c*)). The 'initial-bearing' disk carries a bearing bar and, on this, a revolving 'enemy arm.' The latter, in its turn, carries a sliding 'approach bar.' There is a 'course bar' for enemy's course and course of approach rigidly attached to the 'enemy arm' and 'attack bar.

63887—18——4

In addition, there are special bearing pointers.

Advantages and *disadvantages* as under (*c*).

In addition, however, there is the advantage of being able to ascertain the value of cross bearings at a glance, without first plotting them on the chart; also the advantage of being able to read off the required speed of attack corresponding to the measured distance.

It is an excellent instructional instrument to illustrate problems and their solution, and it is also of use on active service as a check on calculation and a help in weighing possibilities.

Use, as in example under (*c*).

(*e*) USE OF THE PERISCOPE TRAINING ARC AS A READY RECKONER.

To determine the enemy's course, make use of the graduations 0°, 90°, 180°, and 270°.

This saves calculation and is absolutely reliable, though it certainly requires a good deal of practice.

For instance, whilst the boat is turning, set the periscope at 180°, and, on the target passing the zero wire, obtain the compass course at the monent by giving a 'stand by' and 'stop.'

Enemy's course = compass course ± angle on the bow.

(*f*) RULE OF THUMB (suitable only as a check, and not for the initial determination of the track angle):

When taking bearings of the enemy, stretch your arm out towards the bow (it is advisable to paint a bright red line on the roof of the conning-tower in the right-ahead direction of the boat, in order easily to pick up your bearings).

Point your other arm in the direction of the estimated course of enemy. The angle between your arms is then the track angle.

General Principle: Each Captain must choose his own method of determining the best track angle.

Study and practice of all the methods will make him more certain of himself and enable him to check the work of his Navigating Warrant Officer. He will soon become accustomed to use the method which is most congenial to him.

In any case do not arrange your attack simply according to 'feeling' and rough estimation or, still worse, though it has been done on active service, on the assumption that the enemy's course coincides with the supposed steamer track. On the contrary, employ every appliance in order **carefully** to ascertain the enemy's course, and, consequently, to determine the track angle, always allowing a margin on the acute side.

In this there is a fundamental difference between submarine and destroyer attacks.

In the case of the latter your hand rests up to the moment of **firing** on the revolving enemy arm, which is set according to 'feeling.' The submarine, on the other hand, works with a periscope set to a predetermined angle (deflection), which cannot be altered just before firing without risk of disturbing the whole plan of attack.

IX. Firing When Under Helm.

1. *Advantage.*

The boat is able to fire sooner, thus reducing the chance of being sighted.

Disadvantage.

Estimation by eye becomes precarious: peace of mind is lost. When should you begin to turn? This will vary according to the range.

2. When firing under helm always have the compass course reported every 10°.

It is **essential** that you should constantly have the track angle clearly in your mind, in case you have not time to turn completely on to the course of attack before your sights come on.

Otherwise you will infallibly miss.

Drastic alteration of the point of aim is required should you be forced to adopt an obtuse track angle which will **not** correspond with the deflection that you have allowed.

3. As far as possible, if firing when under helm, so arrange your attack that the boat turns in the direction of an acute track angle (turning towards a parallel course). This will often be involuntary, but it is not disadvantageous.

In order to avoid an obtuse track angle.

4. When under helm do not alter your deflection.

In order not to miss your opportunity when swinging past the enemy or, if turning towards a parallel course, not to make a mistake as to the amount of the turn.

5. The angular speed and the lateral deflection of the torpedo on entering the water practically cancel each other.

The effects produced are in opposite directions, and are both comparatively small.

6. In the North Sea, with a heavy sea and swell, firing when under helm should be avoided.

The boat cannot be kept down and comes to the surface.

III Submarine Flotilla

7. Make it a rule not to turn with more than 10° of helm.

Avoid putting your helm hard over just before firing.

If the Depth Officer adopts energetic measures to prevent breaking surface when the helm is put hard over, you may easily make an involuntary dive.

X. Depth Setting of Torpedo.

1.

(*a*) When attacking destroyers, submarines on surface, sailing ships } = 1.5 m. [4.9 ft.]

The so-called destroyer shot (1.5 m.) should be fired **only** when, with the state of the sea **less than 4**, there is a good prospect of success.

Technically a destroyer shot is reliable **only** with a comparatively calm sea, **less than 4.** By firing under less favourable conditions the boat may betray her presence when otherwise it would not be detected.

U. 19, U. 29, U. 24 on 1.6.16.

Fire a destroyer shot using **lever pistol** (*Hebelpistole*), where supplied, and depth setting 2 m. [6.6 ft.] A demand must be sent in for these pistols.

The lever contact arm projects vertically 60 cm. [23½ ins.] above the striker. The pistol will detonate if this lever strikes under the counter or along the ship's bottom, provided that the surface struck does not form an angle of less than 25° with the horizontal.

The loss of speed with the lever pistol, in the case of C/03 heater torpedoes, amounts to 1.5 knots with reducer (*Regler*) down, and 1 knot with reducer up. It is 1 knot and ½ knot respectively in the case of G 7 torpedoes.

See E. 7 *a* and *b*.

Friedrichsort Torpedo Works.

See E. 7 *a* and *b*.

Look out for your deflection.

(*b*) When attacking—

Steamers	2 m. [6.6 ft.]
Light Cruisers	3 m. [9.8 ft.]
Large Tank Steamers, Older Battleships, Older Armoured Cruisers, Modern Capital Ships	4 m. [13.1 ft.]
	5 m. [16.4 ft.]
Submerged Submarines	8 m. [26.2 ft.]

See E. 7 *c*.

Depth setting 4 m. [13.1 ft] is the adjustment on the torpedo range.

Depth setting 6 m. [19.7 ft.] is not advisable owing to the run of the ship aft.

We have no experience so far as to whether, **when using** the lever pistol, the depth setting 6 m. [19.7 ft.] is advisable against modern capital ships.

There are obvious advantages in making the point of explosion as **low** as possible when attacking modern capital ships with good under-water protection:

The explosive effect is **far** greater, absolutely as well as relatively. For constructional reasons the vulnerability of under-water protection increases with the increase of depth.

Seen broadside on, light cruisers and battleships may be mistaken for one another, but from **ahead** you can distinguish them by the length of the bridge and the heavier appearance of the battleships.

(*c*) To decide on the most suitable depth setting (adjustable from outside the tube) it is important to make out the class of the enemy ship, preferably from a position **ahead.**

(*d*) In your endeavour to hit as near the surface or as deep as possible, avoid the extremes of a surface run (propellers racing) and a miss **underneath** (under the counter).

Appendix C. I. 5 should be noted.

(*e*) The speed of the torpedo does **not** vary with the depth setting.

2. The depth setting of a torpedo is influenced by the air pressure in the boat. **As far as possible** keep the pressure equal to that of the outside atmosphere.

Accordingly, when possible, establish equilibrium of pressure after testing for tightness and soon after firing torpedoes.

The most recent trials controvert those previously carried out by the Torpedo Experiments Committee on this point.

Friedrichsort Torpedo Works.

Otherwise too high a pressure forms in the balance chamber. The hydrostatic valve remains pressed **outward** for too long and the torpedo consequently runs at a greater depth than it was set for.

If this is not attended to there may be an error of as much as 1 m. [3 ft.].

See Appendix C.

III Submarine Flotilla.

3. A number of boats report having missed underneath and having seen the track of bubbles actually touching the stern of the target.

This cannot be in accordance with the facts.

With height of eye of .1 m. [4 ins.] immediately in line with the track of bubbles you cannot form any correct idea of lateral distance.

Even in the case of observers on board the target ship there may be differences of opinion amounting to 10–15 m. [11–16 yds.].

The shots in question must have been **misses for direction,** unless the torpedoes passed underneath the target owing to being fired at too close

4. Notes Regarding Depth Setting when attacking Submerged Submarines.

See 1.

A shot fired at a submarine proceeding submerged is a **very** uncertain quantity.

On sighting a periscope, when possible proceed out of sight.

As the other submarine will do the same the boats will quickly separate.

Do not under any circumstances come to the surface!

range (under 170 m. [186 yds.]), or owing to incorrect depth setting. At a suitable range and with correct depth setting, the depth keeping of our torpedoes **can be relied upon.**

Because it is **not** possible to ascertain her course. In one case of a torpedo being fired at U. 46, the torpedo passed **ahead** of her at a track angle of 120°.

It is possible to mistake one of our own boats for an enemy, and there is always the risk of the other boat making a chance hit.

Otherwise you are at a disadvantage as compared with the submarine proceeding submerged, which can get **her** shot in with 1.5 m. [5 ft.] depth setting.

XI. Special Notes.

1. When attacking, **at once** note, or get some one else to note, everything essential: type of ship, estimated distance, speed and course of enemy, own speed, course and deflection, &c.

On firing, start your stop-watch.

In order to have data for your plan of attack and for your subsequent report.

U. 17, U. 52.

In order to check the estimated firing range.

Every shot fired on active service should teach you something and add to your stock of experience.

U. 17, U. 52.

The books of reference for the conning-tower include the latest Weyer,* the book of 'Views of Merchant Vessels' and the latest list of enemy ships which are used for transport purposes, &c. (the two latter issued by the Admiralty Staff).

Keep a note-book for your own memoranda, aids to memory, firing

By making notes of this kind you learn something and avoid

* *See* footnote on p. 23.—Tr.

data, enemy masthead heights and ships' lengths, &c.

It is frequently of advantage to let the Officer of the Watch or the Navigating Warrant Officer take a glance through the periscope.

2. In practice, clearly arranged deflection and parallax tables are preferable to the director; Captains, as far as possible, should draw up these tables **themselves** in whatever form they find the most handy.

Prepare at least 2 tables for the different descriptions of torpedoes carried, and paste one of these up in the conning-tower.

3. If you do not feel entirely sure of getting a hit, break off your attack!

4. In hazy weather use magnification in order to be able to see at least something.

In very hazy weather it is preferable to use magnification $1\frac{1}{2}\times$.

burdening your memory; and they may be very useful to you when attacking.

In order to have witnesses.

U. 28.

The director only constitutes a ready reckoner with which to prepare tables that can be read at a glance.

By drawing up tables **personally,** Captains will avoid errors which others have made and will obtain a fresh and a comprehensive picture of the possibilities of firing under the conditions represented by the various data.

Otherwise the table will not be at hand at the decisive moment.

U. 28.

In order not to betray the boat's presence unnecessarily and thus prevent her carrying out other work, and in order to save munitions.

U. 34.

The argument that the shot was fired, despite the small chances of a hit, merely because it was the last opportunity for an attack which the cruise would offer is a **totally mistaken** one.

U. B. 27, U. 32, Leader of Submarines. The case of U. B. 34 is a perfect example of this.

In any case you see more than with the naked eye.

Magnification 6 × would reduce the light to such an extent that you would see nothing at all. Compare B. II. 2.

B. NIGHT ATTACK

I. Possibilities of Attack.

1. Night attack submerged, awash (*halbgetaucht*), or on the surface, according as the degree of visibility permits, offers good prospects of success.

2. **Do not** attempt a night attack on the surface with a bright background (sunset).

3. In a **sea way** it is inadvisable to fire when on the surface.

4. Clear twilight offers very favourable conditions for a shot submerged, so long as there is just enough light to see through the periscope.

The morning twilight is the best.

With a favourable background (with reference to clouds and moon), a submarine on the surface could not be seen at a distance of 300–400 m. [328–437 yds.]. This was the case with U. 38, even on a clear night.

U. 63.

Otherwise the boat will certainly be sighted before getting within range.

In bright moonlight and with a **dark** background a submarine on the surface approached within 1,000 m. [1,094 yds.] of an enemy yacht without being sighted.

U. 28.

Just before firing the boat may be thrown off her course by a sea.

It is doubtful whether, in case of necessity, the boat would be able to dive quickly enough (air bubble).

U. 48.

There is then no chance of the periscope being sighted by the enemy.

U. 19.

The look-outs will be tired after a previous night watch.

U. 24.

II. Special Notes.

1. At night, **disregarding** the usual rule for preservation of the torpedo matériel, have 2 torpedoes ready for firing when proceeding on the surface.

2. When proceeding submerged in the twilight use magnification $1\frac{1}{2}\times$.

Otherwise a favourable opportunity for a safe shot may be missed, because it takes too long to get the torpedoes ready for firing.

U. 63, III Submarine Flotilla.

On a bright night, or in the twilight, the ship's hull will be better

defined by this magnification, which lets in plenty of light.

Lights also can be more easily made out with magnification $1\frac{1}{2}\times$.

All night glasses are fitted with **low** magnification in order to let in as much light as possible.

U. 19, U. 21, U. 63, III Submarine Flotilla.

3. When firing from conning-tower, in the twilight or at night, have **all** lights out.

Trice up a flag abaft the conning-tower compass so as to screen the light from the compass.

Light up the scale of degrees and the zero mark by means of an electric torch; have a second one ready in case of accident.

Otherwise your eye will be dazzled.

4. Only use the illuminated zero wire when the target is showing bright lights.

5. When using navigational lights as the point of aim, endeavour to make out their positions in the vessel.

Submarine School, II Submarine Flotilla and Flanders Submarine Flotilla.

Otherwise the light of the zero wire will completely blind you, and you will see **nothing at all.**

A trawler with lights extinguished suddenly displayed sidelights and a steaming light at the jackstaff to simulate the appearance of a large steamer.

U. C. 7.

6. *General Note:* At night always use a director when firing.

Submarines **must** procure one for themselves.

You are much surer of yourself than without a director.

The substitutes mentioned under 9 and 10, and the use of the jumping wire stanchions and such-like, are only suitable as a last resource.

II Submarine Flotilla.

7. For a night shot on the surface it is advisable to use a director with luminous sights (radium).

An alternative is the pocket director with white fore and back sight.

A **simple** wooden instrument, which can be made on board, is better than all the elaborate mechanical directors.

It gives the best chance of accurate shooting.

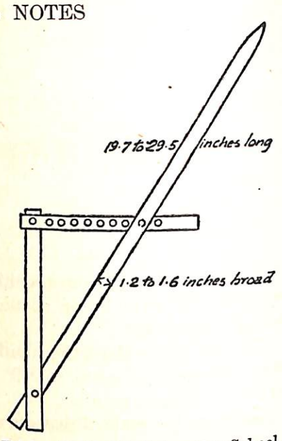
U. B. 27.

With this instrument the torpedo arm is fixed.

The enemy arm permits of setting for every 2 knots. For this purpose it is fitted with holes, the size of one's finger, which you can feel and count with your fingers.

The line of sight, a longer and pointed lath, is painted white with ordinary enamel.

The pivots should **not** work too easily.



Trials with U. 9 in Submarine School.

9. When a director was **not** to be had, a successful night shot on the surface has been made by firing over the clenched fist with the arm extended to its full length.

A deflection of 12° is thus represented (between the two sides of the fist), corresponding to the average speed of a cargo steamer (10 knots). (This is similar to the rule-of-thumb method employed for estimation of distance.)

The torpedo runs 300 m. [328 yds.] in 16 seconds; in this time the target has steamed on 95 m. [104 yds.] and consequently the torpedo hits nearly amidships.

10. Another rough rule is to fire a quarter of the ship's length ahead of the bow.

This assumes close ranges not exceeding 300 m. [328 yds.], moderate speed, i. e. about 12 knots, ship's length about 100 m. [328 ft.], speed of torpedo 38 knots.

With this method use the periscope and the stem as your line of sight.

Destroyer shot.

11. If unable to get your shot in, or if you miss, endeavour to make a fresh attack on the surface by hauling out for some distance.

The short range at which the boat is visible and her high speed render a second attack possible. It is necessary to make a wide detour, as otherwise the boat may be heard.

The Diesel engine may easily be heard.

U. 19.

12. On a night with calm sea and no wind, or when to windward of the enemy, for a short attack proceed on the surface with your electric motors.

13. In the twilight on the surface, and at night when submerged, **force** yourself not to get in too close.

(After firing turn away towards the enemy's stern!)

In the endeavour to make out things exactly the submarine **always** gets in too close.

Danger of ramming.

Danger of a miss underneath.

C. SINGLE SHOT.

I. Direct Stern Shot.*

The direct stern shot is the best of shots.

It is the simplest form of attack, providing an easy shot from the technical standpoint, as only the deflection has to be considered. Delay in order-transmission and parallax due to the distance of the tube abaft the periscope practically cancel one another, their effects being in opposite directions.

This enables the enemy's course to be ascertained exactly by taking a bearing of his masts in line, which also gives the position in which the lateral distance of the submarine from the line of the enemy's course = 0.

Provided the periscope is properly used, there is no danger of the submarine getting too nearly on to an opposite course beforehand.

U. 27.

2. In **every** case therefore endeavour fully to utilize the advantages of the stern shot, i. e. place yourself **right** ahead of the enemy.

Otherwise the submarine may be compelled to proceed at high speed when the enemy is no longer very distant, and the necessary occasional showing of the periscope may result in her being sighted.

3. As long as the enemy is at a **considerable distance,** proceed energetically, i. e. at high speed and as nearly as possible on a perpendicular course, in order to place yourself ahead of him. Then turn on to an opposite course to the enemy at your lowest speed, using the periscope sparingly, so as to remain unseen, and keeping his masts exactly in line.

The firing range may easily become too great.

If you are late in turning away, you can always send the shot after the enemy with acute, i. e. favourable track angle.

If the submarine proceeds on a **parallel** course, the enemy at short

4. **Do not** turn away too soon.

5. **It is better** to approach the enemy on an opposite course than to proceed on a smiliar course to his.

See A. VII.

The moment for turning away depends upon the speed of closing,

* Evidently the direct shot with bow tube is meant.—Tr.

an eye and judgement for which must be acquired.

The best procedure after making out the enemy's course, is to proceed towards him on a course inclined at an angle of 45° to the direction from which he is approaching.

6. By the time you notice that the range requires re-adjustment, only drastic measures will have any effect.

II. Direct Bow Shot.*

1. The direct bow shot is the shot most frequently used.

From the technical standpoint it is just as simple as the direct stern shot.

2. The **attack** for firing a bow shot is by far the most difficult of all attacks.

A good bow attack at **close** range is always proof of an eye and understanding for the handling of submarines.

3. It is impossible to lay down hard and fast rules for the bow attack.

Principle: At long distances close at high speed on the correct course (80° track angle) until the bearing remains unchanged.

Then proceed at such speed that a **decrease** of speed remains possible, and constantly observe the bearing of the enemy (see A. V. 5*d*).

4. There are 4 distinct types of bow attack:

range alters his bearing even at moderate speed faster than the submarine can turn. The track angle will accordingly tend to be obtuse.

The submarine soon opens up the whole length of the enemy and gets a view of his stern (for estimation of speed and change of bearing) and also is in a better position to regulate the range, which may easily become too great or too small if the helm is only put over once from the right-ahead position.

Closing or opening the range on a course inclined at an angle of less than 30° to the enemy's track is of no use, in view of the low submerged speed.

For the same reason as was given in the case of the stern shot, the only correction to be applied is the deflection for course and speed of enemy.

The difficulty or the art involved lies in estimating the distance correctly

This estimation again depends upon having an eye for the correct rate of change of bearing of the target.

In order by alterations of speed to regulate the change of bearing of his stern and consequently obtain the best range (200–300 m. [219–328 yds.], **neither** too close **nor** too far away.

* Evidently the direct shot with bow tube is meant.—Tr.

(*a*) When the enemy is sighted the submarine is 2½–3 points on his bow: **at once** attack at high speed. The method described in A. VIII. 3 *a* is suitable in this case (*see* also A. VII, cases 1–4).

If the enemy is sighted at a great distance (12–14 miles) by the submarine detecting smoke or the tops of his masts over a clear horizon, proceed on the surface at your best speed on a course at right angles to the bearing of the enemy and dive only when the enemy's tops appear.

The submarine's masts must be down and periscopes lowered, and there should only be a few men on the bridge and these in grey clothing.

(*b*) When the enemy is sighted, the submarine is ½ point on his bow: the submarine **waits** until the angle on the bow has become about 1½ points, the exact amount varying with the speed of the enemy, and then turns in to attack. Meanwhile the stern should be turned towards the enemy (*see* A. VII) and his bearing should be observed with the compass (also whilst under helm, *see* A. V. 5 *c*.).

By applying the angle on the bow to the compass bearing, you obtain the **fundamental bearing,** i. e. the direction from which the enemy is approaching.

When the bearing differs 15° or 18° from the fundamental bearing turn in to attack.

This type of bow attack is the most difficult of **all bow attacks**

Otherwise, should the enemy be proceeding at high speed, it is doubtful if you will get a shot in.

In order to reach the zone of attack at high speed, which is not always possible submerged. In addition, this procedure saves the battery. As long as the tops are not in sight the submarine cannot be seen. There will be observers in the tops.

U. 19.

The **more nearly ahead** the boat is, the more accurately the angle, on the bow can be estimated. Turn to attack on the strength of the bearing which fixes a certain instant, and not on the strength of estimation of the angle on the bow at the moment, which with the increase of this angle naturally becomes less exact.

63887—18——5

and requires the highest degree of seamanlike understanding.

It does not lead to the quickest opportunity for firing (*see* C. IV, 6 *c.* α and β), but it does lead to a short-range shot and a **certain** hit.

Example: Compass bearing = 55° angle on the bow = 7° to port. Enemy accordingly moves to the left round the compass. Fundamental bearing = 55°+7° = 62°.

The compass bearing becomes smaller in accordance with the rule given in A. V. 5 *d;* accordingly turn in when the bearing differs 15° to 18° from 62°, i. e. when it equals 44° to 47° (45° is given in the sketch).

(α) *Decision to turn in:*

Correct estimation of distance plays an important part in deciding the moment to turn in.

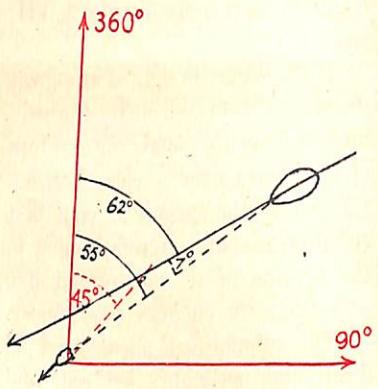
A good guide for turning in at medium and long distances is an angle of 15°–25° on the bow, which can be read off on the periscope; at shorter distances an angle of 20°–25° on the bow; varying according to the speed of the enemy.

From this it follows that, at 5,000 m. distance, with an intended firing range of 400 m. and average speed of the submarine (slow speed = 4 knots), and angle of 1½ points on the bow is a good average amount for giving the moment at which to turn in with an average speed of enemy of 15 knots (1,000 m. in 2 minutes).

(β) *Speed during Bow Attack:*

Endeavour to use **slow speed** as your normal speed during a bow attack (*see* C. II. 3 and A. IV).

90 per cent of hits on active service and in the Submarine School.

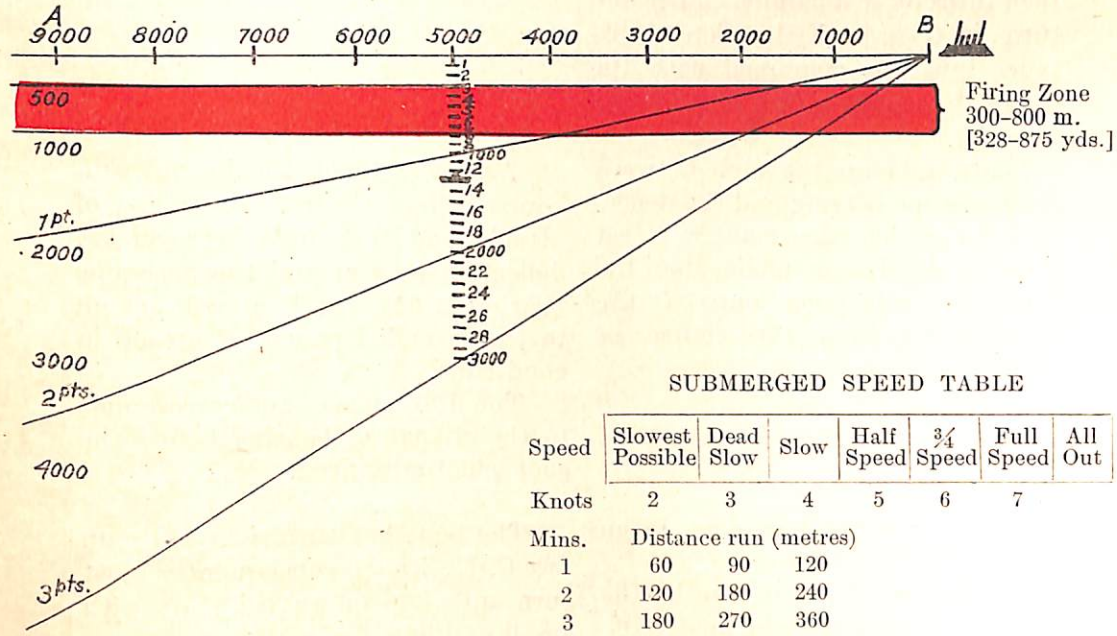


The diagram given on p. 47, which is easy to construct, provides a basis for choosing the speed with different angles on the bow, distances firing ranges, &c., and shows that it is **not** a matter of indifference whether with the same angle on the bow the distance is great or small.

Where the distance is great, the speed of attack must be higher, as the space traversed by the torpedo between entering the water and reaching the target is a very small proportion of the whole space traversed during the attack; whereas where the distance is small, the limit of the useful firing zone may be reached at the moment of turning in for a short bow attack.

If a bow attack is commenced at a lower speed (particularly in the case of a long-distance attack), it is often necessary to resort to an angled shot, as no further decrease of speed is possible and slight errors of estimation may result in the submarine getting in too close.

For a few moments, just before firing, reduce of course to the **lowest possible** speed.



Turning Circle Submerged = 400 m. [437 yds.]
Rate of turning about 4 min. for 90° or 3 min. if already under helm.

SUBMERGED SPEED TABLE

Speed	Slowest Possible	Dead Slow	Slow	Half Speed	¾ Speed	Full Speed	All Out
Knots	2	3	4	5	6	7	
Mins.	Distance run (metres)						
1	60	90	120				
2	120	180	240				
3	180	270	360				
4	240	360	480				
5	300	450	600				
6	360	540	720				
7	420	630	840				
8	480	720	960				
9	540	810	1080				
10	600	900	1200				

and so on according to type of boat

Mnemonic Rule:

Lateral Distance for small angles on the bow.

For every 5° of the angle on the bow it equals $\frac{1}{10}$ the measured or estimated range.

Example: 10° angle on the bow = 2×5°; therefore lateral distance = 2×$\frac{1}{10}$, i. e. $\frac{1}{5}$ the range.

With larger angles on the bow each 5° corresponds to $\frac{1}{12}$ the range.

Example: 30° angle on the bow = 6×5°, therefore lateral distance = 6×$\frac{1}{12}$, i. e. $\frac{1}{2}$ the range.

(*c*) RUNNING OUT AND RUNNING IN.

Requires a good deal of time.

Is the easiest form of bow attack.

From a position right ahead of

Sine } 5° = about $\frac{1}{10}$.
Tangent }

Up to 15°, the critical angle on the bow, this can be used in practice without appreciable error.

Sine 30° = $\frac{1}{2}$.

the enemy, the boat runs out about 800 m. [875 yds.] by table and watch at right angles to the enemy's course, then turns on to a **parallel** course and turns in to fire. Estimation of distance must be combined with the use of the compass, the latter being essential.

Turn in before the angle between the periscope bearing and the deflection for which the pointer is set becomes equal to or smaller than the angle by which your course at the time differs from the course of attack.

Example: If, on turning in, your course differs 45° from the course of attack, and the angle between the deflection pointer and the periscope bearing is 55°, the boat will get on to the intended course of attack in good time.

The difference of 10° corresponds to the change of bearing before the shot is actually fired.

(*d*) (α) Angled bow shot in an action on similar courses.

N. B. Do not forget to order the angular adjustment to be made!

If you notice that, in spite of having considerably reduced speed, you are getting in too close, or if it is impossible for you to reduce speed **any further,** make up your mind in good time, i. e. when 1,500 m. [1,640 yds.] distant **at the latest,** to turn up for an angled shot with small parallax.

No half measures!

The boat has turned in too soon (*see* C. II. 4 *b* α), consequently must turn up* for an angled shot with small parallax.

Otherwise you may run into danger, as the submarine may easily get in too close, or you may get a miss **underneath** the target.

If at 1,500 m. [1,640 yds.] distance you are running dead slow with one main motor and the bearing is not changing at the rate anticipated, an angled shot with small parallax is the **best** measure you can adopt (*see* C. III. 8).

(β) Angled stern shot in an action on opposite courses.

Condition: If attacking a valuable target, both bow and stern tubes must be loaded.

This is more favourable than an angled bow shot.

Note: The angled **stern** shot whilst turning **away** has been mentioned here, as it arises out of the bow attack and is the counterpart of the angled **bow** shot whilst turning **up.**

The boat has commenced her bow attack too soon, as under (α), and consequently must turn away† for an angled shot with small parallax.

Since it tends to result in the track angle being acute (*see* C. III. 5).

* i. e. towards a similar course.—Tr.

† i. e. towards an opposite course.—Tr.

III. Angled Shot with Large and with Small Parallax.

1. The only angled shot which in general need be considered is that with a setting of 90° (except in the case of salvo firing, *see* D. II).

We may further confine ourselves (except in the case of salvo firing, D. III. 9) to the angled shot with **small** parallax, i. e. bow 90° setting with similar courses, stern 90° setting with opposite courses.

This means the use of only such angled shots as require the allowance for parallax to be made **aft.**

2. *Aid to memory* regarding the application of large or small parallax:

If the torpedo before turning goes in the **same** direction as the enemy, you have small parallax.

If the torpedo before turning goes in the **opposite** direction, you have large parallax.

When the position is changing rapidly, you must know which tube you will have to use in order to obtain **small** parallax, or, in other words, with which tube the torpedo before turning will run in the **same** direction as the enemy.

3. When firing an angled shot, you should face the enemy, looking in the direction of the intended track of the torpedo (after turning).

Supposing the enemy is approaching from the right, the movable pointer for setting the deflection on

It is advisable for the submarine Captain to make the conditions as simple as possible for himself; if intermediate steps are used in angling, the conditions become unnecessarily complicated and the sense of direction suffers. A further consideration is that mistakes less easily occur when the tube's crew are only practised in adjusting for 90° or 270°.

The deflection for **large** parallax is **very difficult** to estimate, and at a **good** firing range (about 200 m. [219 yds.]) is too large for the field of the periscope.

Small parallax implies a pleasant shot, and the meaning of allowing aft for it cannot be mistaken.

The aid to memory can at once be verified by the eye. It saves consideration of whether the courses are similar or opposite, which may easily give rise to mistakes, particularly when passed on to the Navigating Warrant Officer, who cannot have a complete view of the situation.

This rule is necessary **only** during the **first** School firing, when the necessary perception and correct sense of direction are lacking, and where it serves to prevent mistakes which would otherwise frequently occur in adjusting for deflection.

63887—18——6

the periscope must be moved to the **left** of the graduation corresponding to the intended track of the torpedo (the latter being indicated by the fixed pointer.)

And vice versa.

Short Rule:

Enemy from the right, pointer to the left, and vice versa.

This rule also applies for a direct bow or stern shot.

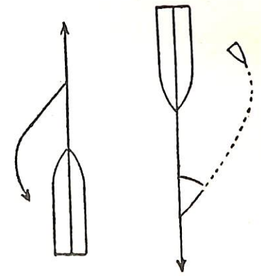
4. With small parallax, for which you have to aim aft, you can get a good idea of the amount of allowance to be made by counting how long the enemy takes to pass the zero wire.

5. With small parallax, if you have got in too close (e. g. when in the case of too close a bow attack you have turned away too late for an angled stern shot), you can still fire a shot * with acute track angle.

Example:

The enemy is 100 m. in length. For small parallax aim 120 m. abaft his centre:

Supposing you count 7 between his centre and his stern crossing the wire, then you must again count 7 + a small addition for the extra 20 m., i. e. count 9 in all.



Owing to the action of the angling gear the torpedo turns in until it reaches the target. *See* A. V. 3.

6. In obtaining the deflection for an angled shot with **large** parallax, the amount of deflection given by the director (over 200 m., even with medium speed) must be increased by an arbitrary amount of about 30 m., which is found by experience; it must be expressed in terms of the length of the target.

Owing to the large deflection, the target is seen in a projection which much reduces its apparent size (by half in the case of 60°). The distance to be traversed by the target up to the moment of firing, which is also seen in the same projection, steadily increases. If this correction, which represents the average amount, were

* I. e. an angled shot with bow tube. Tr.

When aiming aft for small parallax (the most favourable form of angled shot), the projection in which the target is seen is of no practical consequence.

7. In the case of an angled shot with large parallax at medium distances, it is advisable to use as zero wire the limiting wire on the side of the periscope field furthest from the target and to increase the deflection by 15° (the distance of the centre wire from the limiting wire).

8. Appreciation of the shot with **small** parallax as single shot:

It has **great** tactical advantages and is the natural resource in the case of a bow attack which has failed through getting in too close.

not applied, you would fire too late and thus get a hit aft or miss altogether.

The allowance aft is small in amount and is opposite in direction to the deflection for speed, and accordingly the target will be nearly beam on.

This results in adding 15° to the field of view necessary and available for the large amount of parallax, and at medium distances it will then be easily possible to get the allowance for parallax within the field.

(*a*) The enemy observer, who sees the swirl and the initial track of the torpedo, at close range **always** perceives the angled track of the torpedo **too late**, as, in view of the first bearing being so far aft, he is **not** prepared for the new direction.

This is the experience which has been obtained again and again in the Submarine School with new target ships.

(*b*) By allowing the enemy to cross the zero wire, you have another opportunity to correct for speed of enemy by aiming ahead or astern.

(*c*) If, from the commencement, the attack is made with the intention of firing an angled shot, it is particularly deliberate, certain and simple.

The position throughout on the enemy's bow involves no risk if the periscope is properly used.

(*d*) Too close range (under 70 m. [77 yds.] need not be considered) **does not** result in a miss underneath, as the torpedo will largely take up its depth during the time occupied in turning.

See A. V. 3.

IV. Approach to the Quickest Opportunity for Firing.

1. The submarine must endeavour not only to approach unseen and sufficiently close, but also to obtain her hit as soon as possible.

The compromise must be:

What is the **best and quickest** method of getting the shot in.

2. Instruments and tables, which give the course for the quickest shot, are **not** necessary on active service.

Destroyer escorts and the enemy zigzagging render it necessary as much as possible to shorten the time up to the moment of hitting, since otherwise the opportunity for attack may be lost for ever.

U. 52. III Submarine Flotilla.

Too many instruments disturb the submarine Captain during his attack and lead to errors.

The course for the quickest shot can be obtained by simple consideration of the position and, like the whole of the submarine attack, is a matter of seamanlike vision.

If, when the bearing has been taken several times, it does not change, you are steering a collision course.

In practice this is sufficient.

Otherwise, at long distances, errors will creep in which cannot later be made good.

3. Disregarding the space traversed by the torpedo, the course for the quickest shot is the course which would lead to collision.

In order to remain unseen.

If the attack is detected, the course for the quickest shot becomes an illusion.

4. Make sure of the collision course by constantly taking bearings (necessary also **whilst** under helm, *see* A. V. 5*c*).

To take a bearing stop for a moment.

The conditions being a serviceable track angle and the invisibility of the attack.

5. The course to the quickest opportunity for attack applies only to the first part of the attack, i. e. the approach (*Fernanlauf*).

Within 2,000 m. [2,187 yds.] you must naturally proceed as for any good attack.

6. There are 3 cases to be considered:

(*a*) Stern shot:

The approach is similar to that for a normal stern attack, except that the initial speed is higher and consequently the course differs less from the enemy's fundamental bearing.

From a position right ahead, proceed out at right angles for 100 m. [109 yds.], thus opening up the enemy's masts.

Then proceed on an opposite course at high speed until at 2,000 m. [2,187 yds.] distance.

Then reduce speed and gradually turn away as for the ordinary unseen stern attack.

An angled stern shot is likewise **favourable.**

(*b*) Bow shot in the case of an angle on the bow of over 15°.

First steer at right angles to the initial bearing and see if the enemy's bearing moves aft.

Then turn inwards gradually (10° at a time) until the bearing does not change (taking bearings also when under helm).

Within a distance of 2,000 m. [2,187 yds.] proceed as for the ordinary bow attack at low speed.

Gradually turn in by the amount of the former angle on the bow, according to the change of bearing, so as to obtain a serviceable track angle.

(*c*) Bow shot in the case of the angle on the bow being smaller and the distance being **great:**

(*α*) The submarine proceeds at high speed on a course differing by 45° from the fundamental bearing of the enemy, until the angle on the enemy's bow becomes 8°–12°, varying according to his speed.

Obtain the angle of 8°–12° by **taking bearings** and **not** by estimation alone.

Then turn **in** on to the course of attack and observe which way the bearing moves.

If the bearing moves aft, turn in towards the enemy 10° at a time until the bearing does not change. Inside 2,000 m. [2,187 yds.] proceed as for the ordinary attack.

(*β*) Small boats, which are quick on their helm, may proceed towards the enemy on a course slightly to one side of his and, at a distance of 3,500 m. [3,828 yds.] (speed of enemy

See C. III. 8.

If the bearing does not change you are already on the collision course. If it moves forward you can still get a shot in up to a track angle of 45°.

Whilst endeavouring to obtain the quickest opportunity for firing, the submarine must nevertheless take care to keep at a reasonable lateral distance, in order to have room to turn in and time to take the necessary bearings for obtaining the course of attack.

Small boats with a turning circle of 200 m. [219 yds.] and a turning period of 3 minutes for 3 quadrants.

For large boats with a turning circle of 400 m. [437 yds.] and a

20 knots), they may turn away on to their course of attack.

A very uncertain form of attack!!!

7. The course for the quickest bow shot has great disadvantages:

(*a*) High speed.

Makes it difficult to take bearings.

Renders the attack very easy to detect.

Makes dead reckoning difficult, as it is constantly necessary to reduce speed in order to take bearings.

This easily leads to an obtuse track angle if the tendency of the bearing is recognized too late.

(*b*) The obtuse collision course which is steered.

In most cases you can accept the risk involved in loss of time.

Conclusion: The procedure given for a normal attack under C. II. 4 b is better.

8. In the case of getting in too close owing to an error in the plan of attack, the only resource is an angled stern shot.

There are no objections to this shot.

9. It is possible to determine the period and direction of zigzag courses pretty exactly by taking bearings and ranges of the enemy at the moment of his altering course.

First base your attack on the general course which every ship is obliged to steer; on getting closer, head for your assumed position for attack before the enemy's final alteration of course.

Owing to the long duration of the war even men-of-war frequently zigzag from force of habit at fixed intervals of time.

After plotting several tacks, the Captain of a submarine was able to say half a minute in advance when and in which direction the enemy's next alteration of course would take place.

V. Procedure for Attacks when the Compass Installation Breaks Down.

1. *Bow shot:*

In the first place keep the enemy bearing 90° or 270° by periscope and increase speed until the estimated angle on the bow commences to get below 20°. Then gradually reduce speed, adjusting it so as to keep the angle on the bow 18° to 20° or, in the case of high speed of enemy (over 17 knots), about 15°.

The procedure is the same as when using the compass for the attack, except that the submarine Captain must possess a better eye for the angle on the bow and must personally give orders for working the helm a degree at a time.

When in his manner the distance has come down to 2,000 m. [2,187 yds.] turn in towards the enemy until

$$\text{Periscope bearing} = \begin{cases} 90° - \text{estimated angle on bow} \\ 270° + \text{estimated angle on bow} \end{cases}$$

= 70° to 72° or 288° to 290°. Then by reducing speed allow the angle on the bow gradually to increase.

Turn slowly in again, taking care to keep the enemy constantly bearing by periscope.

$$\left.\begin{matrix} 90° - \\ 270° + \end{matrix}\right\} \text{the angle on the bow at the moment,}$$

in order to obtain a 90° track angle.

To guard against obtuse track angles, it is well to use the periscope bearings 100° or 260° in place of 90° or 270°.

It would be unseamanlike to attempt a bow attack at close range (250 m. [273 yds.]) without using the compass.

It is very much easier to give a steady when you are taking your bearings on deck and have land in sight.

This procedure has been actually tested, and with practice and seamanlike understanding leads to a serviceable shot at the intended firing range of 400–500 m. [437–547 yds.].

Owing to the periscope being continually in use, the submarine will not remain unseen. There is no means of quickly checking the enemy's change of bearing. Unintentionally the firing range may easily become too short, even if you aim at 400–500 m. [437–547 yds.].

2. *Stern shot:*

In the first place get the enemy right ahead or on the periscope bearing 90° or 270°, then turn away or run past as when using the compass.

As soon as you are definitely clear of the enemy's track, make the periscope bearing

$$\left.\begin{matrix} 90° + \\ 270° - \end{matrix}\right\} \text{angle on the bow}$$

and proceed at low speed.

3. *Angled shot:*

In a similar manner keep the enemy on the periscope bearing 180° or 360°, applying the angle on the bow with the appropriate + or − sign.

VI. Special Remarks Regarding the Single Shot.

1. When firing at a ship at anchor, allow for tide, as when firing at a ship under way.

2. A ship lying at anchor is best attacked at a distance of about 700 m. [766 yds.].

3. **If possible** have both bow and stern tubes ready.

4. In the case of vessels in tow, sink the towing vessel **first** on principle, if the tow is **not** escorted.

Otherwise sink that vessel whose loss will entail that of the others.

5. Supposing that shortly before attacking, the boat strikes the bottom in 9 m. [30 ft.], being out of her reckoning, she will be right to break off the attack.

The tide may run as much as 5 knots, i. e. slow speed.

U. 39.

In order to approach as far as possible unseen and when half way in to be able to fire a second shot if necessary.

In order to be prepared for any alterations of course by the enemy if he is zigzagging.

U. 28.

A damaged vessel, which is being towed, then at once becomes the submarine's prey.

U. 27.

Principle: Rather destroy a few vessels than damage many.

II Submarine Flotilla.

Probably there are other shoal spots between the boat and her target, and there is consequently a risk of the torpedo striking the bottom and destroying the boat.

U. B. 17.

D. DOUBLE SHOTS, SALVOES AND FIRING IN FORMATION

I. Double Shot.

1. **Valuable** targets should be attacked with a **double** shot, even at short ranges. The tracks of the torpedoes should be arranged to diverge by a certain percentage of the length of the target on either side of its centre, the amount varying with the range.

Mnemonic Rule:
At 800 m. [875 yds.] 80 per cent.
At 500 m. [547 yds.] 50 per cent.
At 300 m. [328 yds.] 30 per cent.

Not above 90 per cent.

2. It is necessary to fire a fan-shaped salvo by slight use of helm without materially altering the track angle (*see* A. IX. 2).

The chances of a miss are thereby reduced.

Example: At 800 m. a 38-knot torpedo has a 42-seconds run.

With a target 100 m. in length and a salvo with a spread of 80 m., 50 per cent. of hits will be obtained, even when the speed has been estimated 4.3 knots in error.

A boat on active service fired a bow shot at 700 m. [766 yds.] with track angle of 90° at an auxiliary cruiser of 16,000 tons and **missed**. Solely on account of the range becoming too great, no second shot could be fired.

In order to be certain not to miss on either side of the target.

The shots are fired in quicker succession and thus the submarine is less likely to be hampered in her attack.

Otherwise the second torpedo would follow in the wake of the first, and, should the enemy succeed in avoiding one of them, he would automatically escape the other also.

II. Triple Shot (High-speed Shot under 2,000 m. [2,187 yds.]).

In the case of a single boat fitted with 4 torpedo tubes attacking modern capital ships, the following procedure has been found advisable:

Three torpedoes are fired: the 1st torpedo, unangled, at the stem; the 2nd torpedo, unangled, at the stern;

In order, if possible, to obtain two hits and to ensure the ship sinking.

The spread between the shots of the salvo is half the length of the ship.

With high speed it is not possible to fire all 3 torpedoes unangled, even

63887—18——7

the 3rd torpedo angled for 15°, fired after the ship at her centre.

Fire the last shot on the target crossing the side wire, without applying parallax, and aim ahead to allow for the more acute track angle.

by turning up sharply after the ship (danger of the boat breaking surface).

The interval between the shots must be at least 5 seconds, in order that the torpedoes may not strike one another and spring a leak, and in order that the one may not detonate the others on hitting the target.

The acute track angle of the third torpedo, i. e. $90° - 15° = 75°$, is entirely favourable.

The parallax involved, i. e. about 5 m. [16 ft.] is of no practical consequence.

The points of aim given for the 3 torpedoes are simple and certain.

III Submarine Flotilla.

III. Quadruple Salvo.

1. The quadruple salvo is only permissible in the case of modern capital ships, large mail steamers or squadrons in close formation.

2. At ranges over 3,000 m. [3,280 yds.] this method of attack is not applicable. An intentional spread at long ranges would be a mistake from the technical standpoint.

A really valuable target, which will repay the expenditure of munitions.

(*a*) On the firing range, the spread of the torpedo due to variations in its speed and to the gyro amounts to one per cent of the distance.

At 3,000 m. [3,280 yds.] under unfavourable conditions there is a natural spread of as much as 60 m. [197 ft.] on either side of the zero line.

Torpedoes fired so as to diverge to 90 m. [295 ft.] may therefore under unfavourable conditions be 210 m. [689 ft.] apart on reaching the target, solely owing to the natural spread.

(*b*) At long ranges, the more acute the angle at which the target is seen, the more difficult it is to aim the torpedo correctly at the submerged portion of the target, the extent of which must be in doubt.

3. It therefore **cannot be** sufficiently emphasized that in this case also you should strive for the double shot at close range (250 m. [273 yds.]); or, failing this, if at all possible, a high-speed triple or quadruple shot at medium range (up to 2,000 m. [2,187 yds.]).

Only when this is hopeless, resort to a long-range shot, and then **not over 3,000 m. [3,280 yds.]**.

The adjustment of the speed of the torpedo can, if necessary, be made from outside the tube.

Remember to alter the deflection!

4. In the case of squadrons, never aim the salvo at wing ships.

5. By taking ranges and bearings, ascertain course and speed of the enemy (*see* A. V. 5 *f* α and A. VI. 5).

6. Guide as to speed of enemy formations:

Cruising speed of battle squadrons is usually at least 15 knots, of cruiser squadrons at least 20 knots.

In action the speed will be still higher.

Such emphasis is laid on this point in order to prevent submarine Captains from at once deciding on a salvo at long range whenever they sight a valuable target or a squadron.

The high-speed shot has relatively greater chances of hitting than a long-range shot, in the proportion of 38 (40):27.

The quadruple high-speed shot, therefore, with the proper amount of spread, reduces the likelihood of the enemy avoiding the torpedoes on sighting their tracks and **appreciably** increases the chances of hitting.

Therefore once again:

Get close in!

In order that, should the whole salvo be out for line, another vessel in the squadron may be hit.

U. 65.

You have time and opportunity for this.

Range-finding is necessary on account of the limit of range for which the torpedo is set to run (whether **over** or **under** 2,000 m. [2,187 yds.]).

It is **by no means** sufficient to rely on estimation by eye, which with different conditions of light may prove **very** deceptive. Only proper determination of range can ensure at least **one** hit out of a salvo, even with the most favourable natural spread at 3,000 m. [3,280 yds.], leaving out of the question any errors of aim.

In view of constant danger from submarines, highest speed of the slowest ship.

Leader of Submarines.

7. In the following paragraphs hints for firing a quadruple shot are given in the utmost detail, merely because, by most carefully applying the conclusions reached in a long series of experiments made in the Submarine

School, it is possible so far to reduce the natural defects of the long-range quadruple shot that, with luck, 25 per cent. of hits may be obtained at a maximum range of 3,000 m. [3,280 yds.].

8. Spread of quadruple shot as under D. I. 1.

The amount of spread must be dependent on the range and track angle; a safe margin should be allowed for the latter.

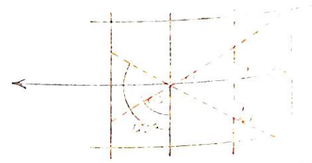
Example:

Length of target = 170 m.

Spread of salvo at the target = 120 m.

Intended points of impact = 180 m. and 60 m. before centre; 60 m. and 180 m. abaft centre.

Any track angle, other than that shown for the shot, would cause the tracks of the torpedoes to diverge more (see sketch).



With track angle 90° $a\,b$ = 120 m.
With track angle 60° or 120° $a\,b_1$ = 140 m.

9. Either 4 bow shots (direct) or 2 angled bow shots and 2 angled stern shots.

10. (*a*) Firing under helm is possible **only** with the 4 bow shots, and even then the boat must turn only 1° between shots.

This must be allowed for in the track angle.

(*b*) When firing 4 angled shots steer a **steady** course and do not allow the boat to **yaw**. Speed to be about 5 knots.

(*a*) A very slight use of helm is necessary in order that the 4 torpedoes shall not run approximately in one another's wake (spread due to gyro—not spread due to variations in speed of torpedo; in this case one measures slight variations in direction).

Otherwise, should one torpedo be successfully avoided, the ship would automatically escape the other 3 torpedoes also.

If **more** helm is used, the divergence at 3,000 m. will be too great to be corrected by differences in aim.

(*b*) The use of helm, which has a **very** bad effect upon the aim, is in this case not necessary as the divergence of the 4 torpedoes is sufficient for each pair of tubes by their different positions forward and aft

11. (*a*) For both forms of salvo the rule applies, that the torpedoes must be fired when the target crosses the wire in the periscope and **not** by time.

If you attempt to fire by time, a **uniform** divergence of the tracks becomes impossible should the boat yaw only a few degrees. The tracks may cross each other, and so on.

Any original error in estimation of speed will influence all the shots alike; e. g. if the speed is underestimated, the points of impact will be too far apart.

This means that the principle of the spread will not be attained.

The periscope will **not** in any case be detected by the enemy at such long range.

(*b*) An undisturbed aim is ensured whether the shots are angled for 90° or unangled.

(*c*) The following points apply to angled shots:

(*α*) Two shots must be fired with large parallax and two with small.

As regards which tubes should be fired first in an action on opposite courses and which on similar courses, in order that all 4 shots may be fired: it will be found that **the order of firing** the tubes with opposite courses is the reverse of that adopted with similar courses, but that the points at which torpedoes should be fired are the same in both cases.

(*β*) The points at which the tubes should be fired, allowing for parallax, must be determined beforehand in accordance with speed of enemy, track angle, and speed of torpedo.

Tables should be constructed by purely mathematical methods.

If the firing data are the same, the sum of the amounts of large and small parallax remains constant.

Large parallax increases proportionately with speed of enemy.

Small parallax decreases proportionately with speed of enemy.

Example:

Large parallax = 200 m.

Small parallax = 90 m.

Intended points of impact = 180 m. and 60 m. before centre; 60 m. and 180 m. abaft centre.

Then, when firing, only the correct order of firing need be considered.

The best method is to have a picture in your note-book, giving the tubes and firing points, or to take a sheet out of Weyer's Naval Pocket-book for ready use.

It is advisable to have a similar picture for high-speed shots.

Action on opposite courses:

Tube I: 60 m. abaft, 200 m. before = 140 m. before.

Tube III: 180 m. before, 90 m. abaft = 90 m. before.

Tube II: 180 m. abaft, 200 m. before = 20 m. before.

Tube IV: 60 m. before, 90 m. abaft = 30 m. abaft.

Action on similar courses:

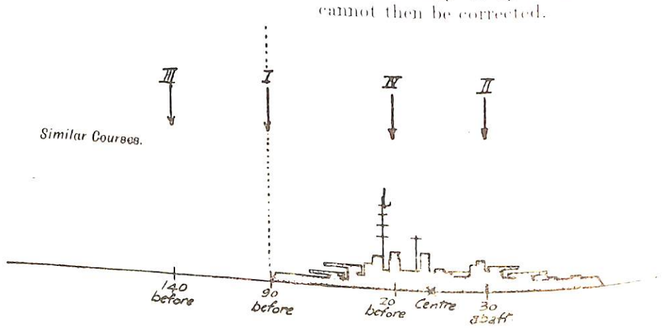
Tube III: 60 m. abaft, 200 m. before = 140 m. before.

Tube I: 180 m. before, 90 m. abaft = 90 m. before.

Tube IV: 180 m. abaft, 200 m. before = 20 m. before.

Tube II: 60 m. before, 90 m. abaft = 30 m. abaft.

If you do not beforehand write down the order of firing the tubes, a mistake may easily occur which cannot then be corrected.



Similar Courses.

Opposite Courses.

(γ) An action on opposite courses is more favourable than one on similar courses.

You get your shot off more quickly owing to the higher relative speed.

(δ) The intervals on the target between the firing points are **not** equal. The interval between the two torpedoes first fired is always equal to the interval between the two last fired, but the interval between the 2nd and 3rd torpedoes is generally either larger or smaller.

Interval between the firing points for the bow torpedoes = interval between the firing points for the stern torpedoes = the intended spread at the target.

The order of firing the tubes likewise depends upon the amount of spread desired, but, as mentioned above, a simple sequence can be laid down for it.

This must be remembered if you wish to have the firing points closer together or further apart.

There is, nevertheless, still sufficient time for taking careful aim.

The following tables afford proof of this fact, the explanation of which lies in the sum of large and small parallax remaining constant.

Data:

1. Large parallax = 200 m.
   Small parallax = 90 m.
2. Action on opposite courses.
3. Varying amounts of spread.

Spread 30 m.

I. 185 before } 30
II. 155 before }
200
III. 45 abaft } 30
IV. 75 abaft }

Spread 60 m.

I. 170 before } 60
II. 110 before }
110
III. Centre } 60
IV. 60 abaft }

Spread 90 m.

I. 155 before } 90
II. 65 before }
20
III. 45 before } 90
IV. 45 abaft }

Spread 97 m.

I. 151.5 before
III. 55.5 before } 97
II. 54.5 before }
IV. 41.5 abaft

With 97 m. spread the order of firing the tubes changes.

Spread 120 m.

I. 140 before } 50
III. 90 before }
70
II. 20 before } 50
IV. 30 abaft }

Spread 145 m.

I. 127.5 before } 0
III. 127.5 before }
145
II. 17.5 abaft } 0
IV. 17.5 abaft }

Spread 150 m.

III. 135 before } 10
I. 125 before }
140
IV. 15 abaft } 10
II. 25 abaft }

Above 145 m. the order of firing the tubes again changes.

The intervals between the firing points and consequently the points of impact is ensured most exactly with a spread of 145 m. [158 yds.] (assuming the accuracy of the corrections for parallax, which you must obtain yourself on the basis of the speed, &c.)

12. If the range exceeds 3,000 m. and you intend, nevertheless, to risk a shot, the only method is to fire 2 torpedoes at the centre of the ship or centre of the water-line, using the data which you believe to be correct: if necessary, the shots may be angled at 15° and fired after the ship.

In view of the length of the intervals between ships nowadays, it is highly inadvisable to attempt massed fire on a larger scale.

Firing at a single ship need not be considered at all.

With a spread of 145 m. [158 yds.] one stern shot will be fired **simultaneously** with each bow shot, as though they were connected, because the spread equals half the sum of large and small parallax.

Consequently you need only take aim at the target twice, and the possibility of errors in aim is reduced to a minimum.

At long ranges a submarine, in spite of her low speed, may keep to the centre of the target as the point of aim.

The natural spread of the torpedoes and unknown errors in aim (uncertainty as to the precise point of aim) ensure that the torpedoes will diverge considerably before reaching the target; and thus the possibility of a hit is somewhat increased, though it naturally remains extraordinarily small in view of the proportion between the length of the ships and the length of the intervals between them.

Torpedo Inspection.

Inexcusable expenditure of munitions.

Torpedo Inspection and Torpedo Experiments Committee.

IV. Special Remarks.

1. It is necessary to have precise and unmistakable designations for the tubes which are ready to fire or which are to be fired.

The following system, which must be **practised**, is recommended:

Otherwise, with longer orders and a breakdown of the electric firing gear, the delay in order transmission becomes too great.

Misunderstandings which are particularly liable to occur with quadruple shots and cannot afterwards be made good, become impossible if suitable vocal differentiation is adopted.

Two separate Words.	*One Word.*
Tube I: One—ready	Onefire.
Tube II: Two—ready	Twofire.
Tube III: Three—ready	Threefire.
Tube IV: Four—ready	Fourfire.
Tube V: Five—ready	Fivefire.
Tube VI: Six—ready	Sixfire.

Note:

(*a*) Whenever firing torpedoes: **silence in the boat.**

(*b*) When firing a single torpedo, adhere to the procedure laid down in the Torpedo Manual.

2. The principle of obtaining your hits on the enemy as far as possible on the same side is correct.

3. When firing in formation at **long ranges** over 15,000 m. [16,400 yds.], use magnification.

4. The view is occasionally expressed that a massed torpedo fire, directed at ships in quarter line offering an apparently continuous target, must invariably produce hits.

This view is erroneous.

In order to cause the ship to capsize.

U. 9, U. 24.

As you will accomplish nothing without **measurement** of the range; range **estimation** (only possible with magnification 1½ ×) need not be considered. An exact aim and correct spread of the salvo at the target are only attainable with sixfold magnification.

It depends upon whether the quarter line is disposed **towards** or **away from** you.

If it is disposed **towards** you, a torpedo which passes across a ship's bows will not strike the next ahead; and if the torpedo passes astern of a ship it is gone for ever.

If the quarter line is disposed **away from** you, a single torpedo which misses any ship in the line should in theory hit the next astern or the ship next astern of that, and so on down the line. Whether it eventually hits or not becomes a question of the range of the torpedo and the length of the line.

Consequently, even with the most favourable chances of hitting, do not attempt **random drum fire** against ships in quarter line disposed **towards** you; but, following a **definite method,** strive for the most secure results.

Given luck — and luck goes with skill — you will not fail to be rewarded by hits.

1. In unrestricted submarine warfare against seaborne commerce, the gun, when used at long ranges, plays an important part.

2. Given the choice between the destruction of a man-of-war and a steamer, choose the **latter.**

3. When making a torpedo attack, whether by day or by night, endeavour to fire at **short range!**

4. In the war on commerce particularly, bear in mind the hints given on firing by day and by night.

5. Do not attempt long range shots (with reducer up) at merchant vessels.

Least of all, of course, when firing at night!

At long ranges the torpedo is logically replaced by the shell.

Only exception: triple or quadruple salvo at large armed transports

(*a*) Steamers, which cannot be reached by an attack submerged, may thus be forced to stop in order that they may then be sunk by a **safe** torpedo shot.

(*b*) When dealing with small ships it is **impossible** to score many tons with torpedoes **alone.**

Boats carrying very few torpedoes, on the other hand, have made big bags in tonnage.

(*c*) As a general rule, torpedoes must be reserved for valuable steamers (say 3,000 tons gross) and for steamers suspected of being traps.

U. B. 31 and other boats have allowed small steamers to pass them after having pushed home a submerged attack sufficiently close to recognize the character of these vessels.

In the present war of commerce destruction, a steamer of any average carrying capacity is the more valuable of the two to the enemy.

Results in the Submarine School give an average of 90 per cent. of hits.

With careful handling the torpedo **matériel** may be firmly relied on.

See previous chapters.

For reasons, *see* A. V. 4 and E. 4

See D. III.

or large mail steamers; but even then **not** at ranges exceeding 3,000 m. [3,280 yds.].

6. It is advisable to make constant use of the book of 'Views of Merchant Vessels', issued by the Admiralty Staff.

Reference to the pictures and comparison of these with the actual vessels encountered will improve your powers of estimating the angle on the bow.

If the angle on the bow is **over**-estimated, an **obtuse** track angle results.

The golden rule for torpedo firing from submarines is:

Better 75° than 95°.

7. Depth setting against merchant vessels:

(*a*) With a **calm** sea and the certainty of **reliable** depth keeping, a depth setting of 2 m. [6.6 ft.] is recommended, even against the **largest** steamers.

In any case against an ordinary cargo steamer.

(*a*) A hit near the surface frequently tears open the upper deck, thus allowing the air to escape, which will result in the ship sinking or turning turtle more quickly.

Cargo steamers which are well battened down and which have no vent for the air leading upward, will float on the air bubbles formed in the holds.

In this case, vents for the air must be produced artificially by means of gunfire. Look out meanwhile for enemy submarines!

(*β*) The decks form the main stiffening connexions of a ship; if they are destroyed, vessels will often break in two or collapse inwards.

This depth setting is also useful against grain steamers (so-called trunk steamers) and steamers loaded with flour, which, in spite of vents for the air, either will not sink or will not sink quickly, because the hole produced by the explosion becomes blocked up by grain or some similar cargo which becomes sticky when mixed with water.

U. 38.

(*γ*) The nearer a hit is to the water line, the more effective it will be against living targets.