O.D. 453

9 Sheets

Sheet 1

ILLUSTRATIONS

DESCRIPTION

of

Submarine Attack Course Finder Mark I Mod. 3

Examined

U. S. Navy Gun Factory,
Washington, D. C.

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In charge of Division.

G.C.T. 5/2/22
Checked.

3 May 1922

R. K. Turner Lt. Comdr., U.S.N.
By direction of Superintendent.

(B) Reproduction of O. D. 453, Dated March, 3, 1921 -
See Revision No. 26410

Revised at "C" and reproduced. Plate II under revision letter "D"-
See revision No. 26509.

Revised Sheets #4, 5 & 6, revision letter "E" and reproduced them under letter "F"
see revision no. 28337

* Reconstructed from posting at http://www.hnsa.org/doc/attachfinder by T. E. Thompson, April, 1, 2014.

Submarine Attack Course Finder Mark I Mod. 3

Plate I - Diagram of Course Problem
Plate II - Diagram of Speed Problem
Plate III - Setting of Instrument for Course Problem
Plate IV - Setting of Instrument for Speed Problem
Plate V - Photograph of Course Finder Neg. 6742 a
Plate VI - Photograph of Speed Omnimeter Neg. 6743 a
Plate VII - General Arrangement Drawing 95060

PURPOSE - (Plates V and VI).

1. The Submarine Attack Course Finder Mark I Mod. 3 comprises two devices for use in making a submerged approach. The device on the obverse side is a form of the well known "Is-Was", or submarine attack course finder devised by Captain Nasmith, Commander, R.N. That on the reverse side is a form of circular slide rule or speed omnimeter arranged to solve for enemy speed with data secured during the approach.

2. The course finder is a very simple device for assisting the submarine to reach most quickly a favorable firing position or to ascertain whether or not such a position can be reached. The basic principle involved is that a submarine or any vessel desiring to intercept another vessel of probable superior speed will stand the best chance of success if it brings the other vessel abeam and steams at maximum speed. Naturally, if the other vessel is on a diverging course, intercepting by this method will be impossible and the fact soon will be rendered evident to an observer on theintercepting vessel; but if the courses are converging it is a fact susceptible of mathematical proof that the intercepting vessel will more nearly intercept a speedier vessel by following this procedure than by any other. A graphic demonstration may be had by inspecting any Torpedo Control Graph (See Sk. 15751 For 30 knot speed torpedo), assuming the intercepting submarine to start at the "enemy initial position" and the other vessel to start from the "firing point". It will be noted that straight lines drawn from the "firing point" are tangent on a course at 90° to the line of sight to the various eccentric circles which represent speeds of the vessel starting from the "enemy initial position". After the intercepting submarine has been steaming an appreciable time on its course at 90° to the line of sight, an observation of other vessel will indicate the probable success of intercepting. If the other vessel has drawn abaft the beam, intercepting is assured unless it should alter course or speed, and it **may be hastened** by altering the submarine's course gradually toward the other

vessel until the bearing of the latter is held constant. If the other vessel has drawn ahead, actual intercepting by the submarine will not be possible, but it might prove possible to reach a position within torpedo range as the enemy crosses ahead, in which case the intercepting submarine should maintain the course and steams at highest speed. An experienced submarine commander noting the rate of change of bearing, the angle on the bow of the other vessel, and the range, will know whether or not it worth while to continue with the approach under these conditions.

DESCRIPTION (Plate VII).

COURSE FINDER

Identification Marks (See Plates V & VII).

"A" - Azimuth circle (base disc) represents own ship, for reading relative bearing with periscope pointer.

"B" Compass rose (middle disc) for reading compass course of own and enemy ship.

"C" - Enemy Card (top disc) represents enemy ship, for reading relative bearing on enemy bow and track angle.

Periscope pointers (placed between "B" and "C") represents line of sight, for reading bearings and courses.

3. The course finder consists of three discs of decreasing sizes, and a pointer disc representing the line of sight through the periscope with pointers at right angles to the line of sight, all mounted on the same axis.

(a) The large celluloid disc, or "azimuth card", is graduated to represent the periscope azimuth circle as boresighted with the torpedo tubes in the fore and aft line of the ship, i.e., with the zero graduation aft and the 180 degrees graduation forward. This disc is rotationally free on the spindle. It is graduated in five degree increments clockwise.

(b) The second celluloid disc, or "compass rose", turns about the axis concentric with the azimuth card and is graduated clockwise in five degree increments from 0 to 360 degrees to represent the compass rose. The metal spindle is keyed to and rotates with this disc.

(c) The small transparent disc, or "enemy card", also turns freely about the axis concentric with the periscope azimuth circle and is graduated in five degree increments to represent the "angle on the bow", or the bearing of the submarine from the enemy, i.e., from 0 to 180 degrees to port and starboard. An outline of the enemy is engraved on this disc to facilitate the operation by presenting a visual picture of the relative bearings.

(d) The pointers turn freely about the same axis. When the compass rose is set to own compass course and the pointer marked "Periscope" is set to the bearing of the enemy, as obtained by the Periscope, the pointer at the opposite end will indicate on the rose compass the compass bearing of the enemy. The line joining these two pointers represents the line of sight. The 90° pointers indicate on the compass rose the courses at right angles to the enemy bearing.

(e) On the transparent enemy card is engraved a semicircle marked off into equal squares. On the rear end of the periscope pointer, along its centerline, are a series of transverse marks spaced apart a distance equal to the side of a square, (**Note:** On Submarine Attack Course Finders Mark I Mod. 3 Nos. 301 to 306, these marks occur on both ends of the pointer). Any convenient number of hundreds or thousands of yards may be assigned to each division so that the initial range can be indicated on the periscope pointer by stepping out from the center of the device the requisite number of divisions. Should the point thus arrived at lie outside of the semi-circle, a larger number of yards must be assigned to each division so that the point will come within the semi-circle. By noting the position of the point; (a) with regard to the centerline passing through the enemy vessel there is obtained graphically an estimate of the shortest distance to the track of the enemy vessel, (b) with regard to the line passing through the center of the enemy vessel at 90° to its course there is obtained graphically an estimate of the distance the enemy ship must run to bring abeam own vessel's initial position.

The fifth transverse mark on the periscope pointer is a line engraved across the disc at right angles to the line of sight. This line is graduated in units of measure the same as those on the sight line with sub-divisions of half units; these divisions project above the transverse line only. See O.D. 549 for instructions for modifying instruments not having this line.

4. To use the instrument: (Plates I & III)

(a) Set the Compass rose (2nd disc) so that own course will appear opposite the 180 degree mark on the azimuth card.

(b) Make an observation and determine the bearing of the enemy by periscope and the angle on the enemy bow, i.e., the angle made by the enemy course and the line of sight. Set the periscope pointer to the periscope bearing on the "azimuth card" and read the enemy compass bearing from the compass rose as indicated by the opposite pointer. Set the enemy card to the "angle on the bow" (port or starboard) as measured from the line of sight, and read from the enemy's head on the compass rose the enemy heading by own compass. The 90° arm toward the enemy will indicate on the compass rose the desired heading by own compass to close the enemy on a 90 degree bearing.

(c) To determine the "firing course", turn the Pointers until the periscope pointer is coincident with the desired track angle, as measured on the enemy card; then the other end of the pointer will indicate on the compass rose the desired heading by own compass for the firing course.

5. **EXAMPLE**: Heading by compass 230 degrees. Enemy relative bearing by periscope 315 degrees. Angle on the enemy's port bow 25 degrees. Estimated range 5000 yards. Desired track angle 110°.

SOLUTION: (a) Set the compass rose for own heading, 230 degrees, to 180 degrees on azimuth card.

(b) Set the periscope pointer to the enemy relative bearing, 315 degrees, on azimuth card, and read from the opposite pointer on compass rose the enemy compass bearing, 185 degrees.

(c) Set the enemy card for the angle on the enemy's port bow, 25 degrees, with reference to the line of sight. Read off enemy course from the enemy heading on the compass rose, which is 30 degrees. The range being 5000 yards, the divisions on the line of sight and the squares etched on the enemy card show that the enemy will pass about 2100 yards abeam if a steady course is maintained and the submarine steers a parallel course, or "lies in wait"; also that the enemy must gain a distance of about 4500 yards to draw abeam the initial position of the submarine. The right angular pointer toward the enemy will indicate on the compass rose a course of 95 degrees if the submarine is to steer a course at right angles to the enemy bearing to close the enemy.

(d) Turn the periscope pointer to 110 degrees on the enemy card (port side) and read. off 100 degrees from the compass rose on opposite end of this pointer for the firing course for a 110 degree track angle.

(e) With the Course Finder set as stated in 3(c) above to find the distance to close the enemy, each division on the periscope line and whole division on the fifth transverse line referred to in 3(e) above, will then equal 1000 yards. The interception of the enemy's course with this transverse line will graphically show that the submarine will have to travel about 2400 yards on the collision course before actually crossing the enemy track. Therefore the Submarine may employ its top speed, submerged, keeping in mind the Submarine's advance and transfer, and swing on to the collision course running at top speed totally submerged until about 1400 yards have been covered towards the enemy, this then leaves about 1000 yards to close at slowest speed, thus eliminating the possibility of getting in too close. This permits the submarine to be in a position to push home an attack. In making a submerged run on the collision course, the range keeper may be employed. This is accomplished by setting the courses and speeds of the enemy and own vessels on the range keeper. By setting the range as found by the course finder to 2400 yds. the range keeper will show when the 1000 yard range is reached. The submarine can then come to the surface so as to observe the enemy thru the periscope and then maneuver to make the attack. For description and. operation of the range Keeper Mark II see O.P. 460.

SPEED OMNIMETER

Identification Marks: (See Plates VI & VII)
"Speed Scale" (base disc) outer circle.
"Range Scale" (base disc) inner circle.
"Degree Scale" (middle disc)
"Time Scale" (top disc) pointer attached.

6. The five arguments

(a) Speed of the submarine over the ground
(b) Angle on the enemy bow, (1st observation)
(c) Range of enemy (2nd
(d) Change of bearing of enemy (obser-

which are available on the submarine for calculation of the enemy speed have been used in deriving a formula which gives most weight to those arguments (submarine speed, time interval between observations, and change in bearing) that may be positively determined, and least weight to those (angle on the enemy bow and enemy range)

which are more roughly determined. This formula may be solved readily by the device

on the reverse side of the Submarine Attack Course Finder. It consists of three concentric discs constructed in the form of a circular slide rule. The large disc carries a "speed scale" and a "range scale", the medium disc a "degree scale" and the small disc a pointer and a "time scale".

7. A submarine holding the enemy on a constant bearing may determine the enemy speed from three arguments obtained at the same instant.

(a) Submarine speed over the ground,
(b) Angle on the enemy bow,
(c) Periscope bearing of the enemy.

8. Should the bearing of the enemy not remain constant, the enemy speed may be obtained by applying a "speed correction" to the foregoing. The correction may be calculated when the following arguments are obtained on a second observation.

(a) Interval of time between observations,
(b) Change in enemy bearing between observations,
(c) Range of enemy on second observation.

This correction will be additive, if the enemy draws ahead and subtractive if the submarine draws ahead.

9. To obtain the enemy "constant bearing speed":

(a) Set the angle on the enemy bow, as read on the "degree scale", opposite the submarine speed as read on the "speed scale", using the pointer to obtain the accurate setting.

(b) Opposite the bearing of the enemy by periscope as read on the "degree scale" read from the "speed scale" the speed the enemy will be making if on the same periscope bearing when a second observation is made.

10. To obtain the "speed correction":

(a) Set the "angle on the enemy bow" as obtained from the first observation as read on the "degree scale" opposite the range of enemy obtained on second observation as read on the range scale.

(b) Set the interval of time between observations as read on the "time scale" opposite the change in enemy bearing between observations as read on the "degree scale" and read on the "speed scale" under the pointer the "speed correction".

Note: (a) The accuracy with which the "constant bearing speed" is determined depends entirely upon the ability of the submarine to accurately determine the "**submarine speed**" and the "**angle on the enemy bow**". This part of the problem has formerly been solved by the use of tables based on the same arguments, except that is the use of tables it was necessary to place the enemy on a 90 degree bearing while the device solves the problem for any periscope bearing.

(b) The accuracy with which the "speed correction" is determined depends upon the ability if the submarine to determine correctly the "**angle on the bow**" in the first step of the problem, and the "**range**" in the second step. While range is difficult to determine from the submarine, every effort is being made for improvement in equipment. With present methods and constant practice, range can be obtained closely enough for fair results, much better than a "pot guess" at enemy speed.

(c) The same arguments enter into practically all methods of computing enemy speeds, and if good results are not obtained efforts should be concentrated in improving the methods of obtaining the necessary data.

11. EXAMPLE: (Plate IV)

The following example will illustrate the use of the instrument:

A submarine on a coarse to close the enemy and making a speed of "**8 knots**" (by Forbes log or careful measurement) estimates the "**angle on the enemy bow" as 30 degrees**, when the enemy bears, 90 degrees by periscope. In 11 minutes and 12 seconds another observation is made and it is found that the submarine has drawn **9.5 degrees** ahead of the enemy and that the estimated range is now 7250 yards.

(a) Set 30 on the degree scale opposite 8 on the speed scale.

(b) Read enemy "constant bearing speed" on the "speed scale" opposite the "bearing by periscope" on the "degree scale" = 16 knots.

(c) Set 30 on the "degree scale" opposite 7250 on the "range scale".

(d) Set 11 minutes, 12 seconds on the time scale opposite 9.5 on the "degree scale".

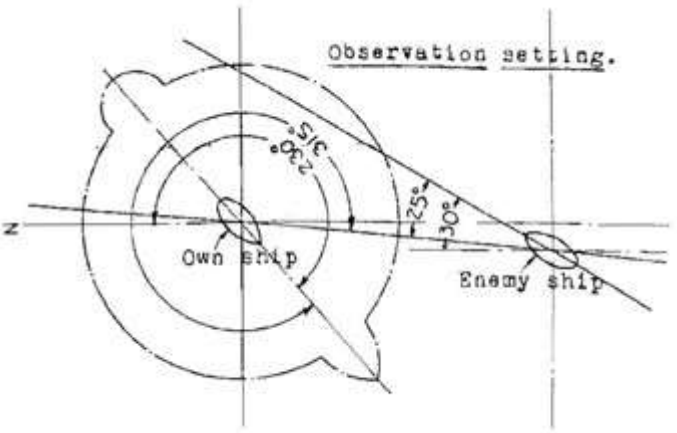
(e) Read under pointer on "speed scale" 6.3 which is the "speed correction".

Since the submarine has drawn ahead, the enemy true speed is 16 - 6.3 = 9.7 knots.

Note: Since the instrument is constructed as a slide rule, the decimal point must be placed having regard to the rapidity of the change in bearing.

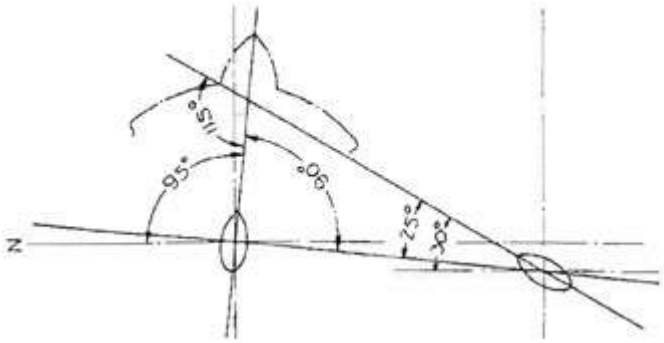
DIAGRAM OF COURSE PROBLEM

230° = Own ship's course
315° = Enemy bearing from own ship.
25° = Own ship on enemy port bow.
30° = Enemy ship's course.



Determine own course to bring enemy bearing 90° on own starboard beam.

90° = Enemy bearing on own ship's starboard beam.
95° = Own Ship's course.
25° = Own ship on enemy port bow.



Determine own course and bearing on enemy bow to bring enemy bearing 90° on own starboard beam for 110° track angle.

100° = Own ship's final course for track angle of 110°
20° = Own ship on enemy port bow (final).

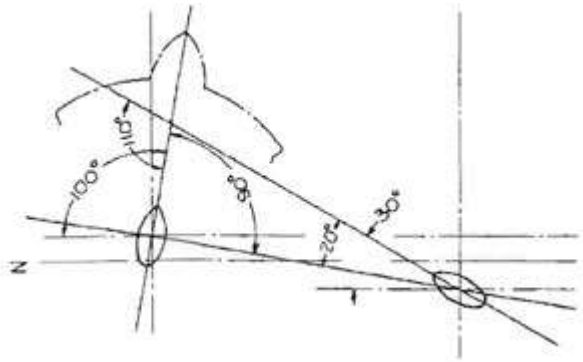
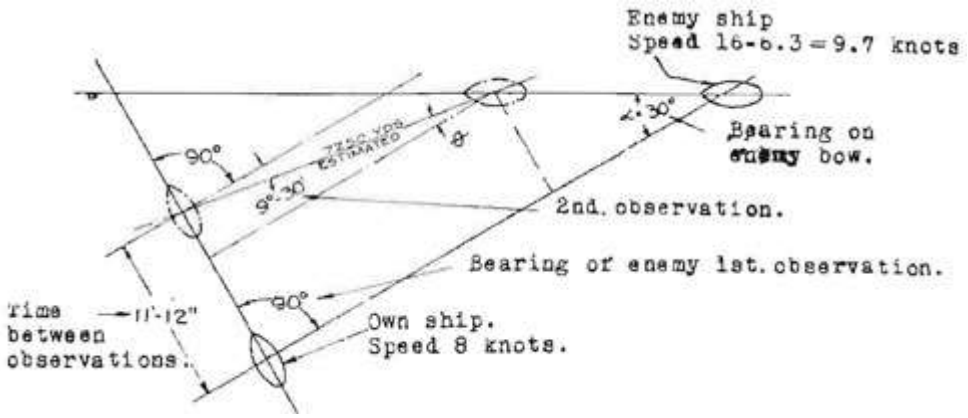


Plate I

SPEED OMNIMETER
DIAGRAM OF SPEED PROBLEM

Estimated range 7250 yds. and angle on enemy bow (30°). Enemy speed should be 16 knots if own ship's speed is 8 knots, to keep enemy on constant bearing of 90°.



Summation - Own speed must be 9.7/2 = 4.85 knots for 90° constant bearing of enemy.

TO CALCULATE ACTUAL RANGE OF ENEMY

Assuming angle on enemy bow, and enemy speed (as found by speed omnimeter) is correct.

1 knot = 6080 ft. or 2027 yds.

8 knots = 2027 x 8 = 16216 yds. per hr.

11'-12" = (11 1/5)/60 = 14/75 hrs.

16216 x (14/75) = 3027 yds. travel of own ship in 11'-12".

9.7 knots = 2027 x 9.7 = 19662 yds. per hr.

19662 x (14/75) = 3670 yds. travel of enemy ship in 11'-12".

a = sinαc = log 3670 = 3.5646661
log sin 30° = 9.6989700
3.2636361=1835 yds.

Therefore 3027 - 1835 =1192 yds.

c = a/sinθ = log 1192 = 3.0762763
log sin 9°30'= 9.2176092
3.858671 = 722 yds.

Estimated range 7250
Actual range 7222
28 yds. error in estimate.

PLATE II

(D) Reproduction of Plate II - See Revision No. 26509.

O. D. 453.

SETTING OF INSTRUMENT FOR SPEED PROBLEM.

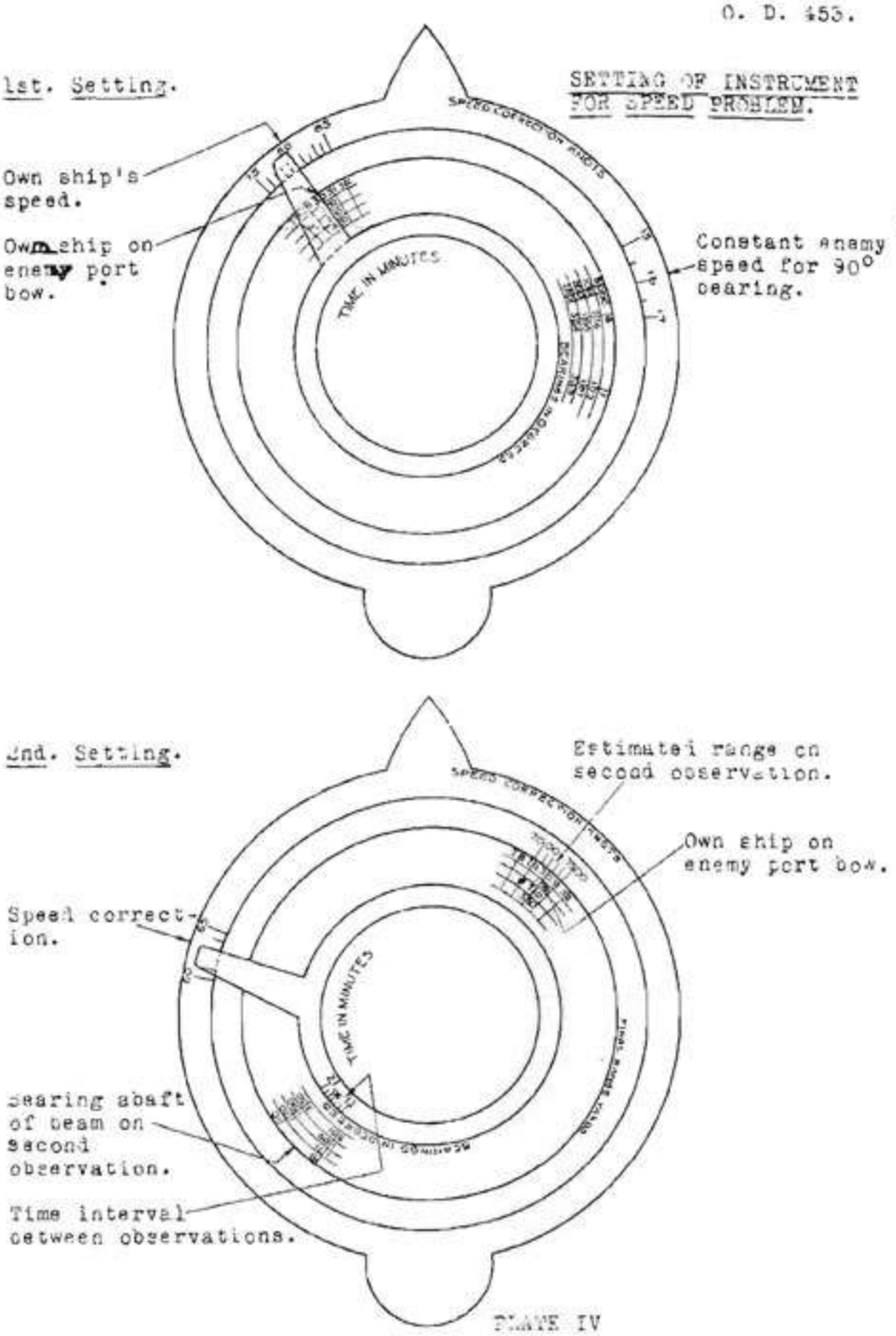


PLATE IV

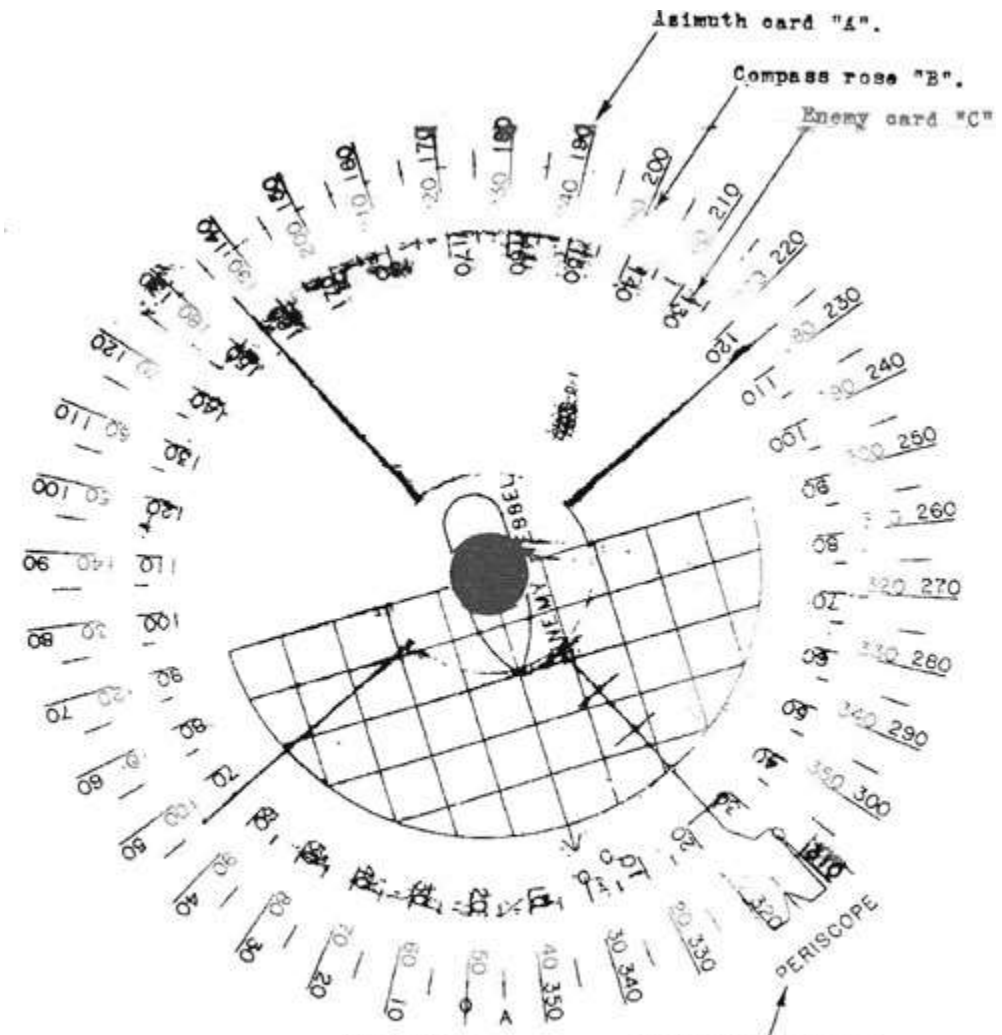


Plate V

Nav.67428,N.C.P.

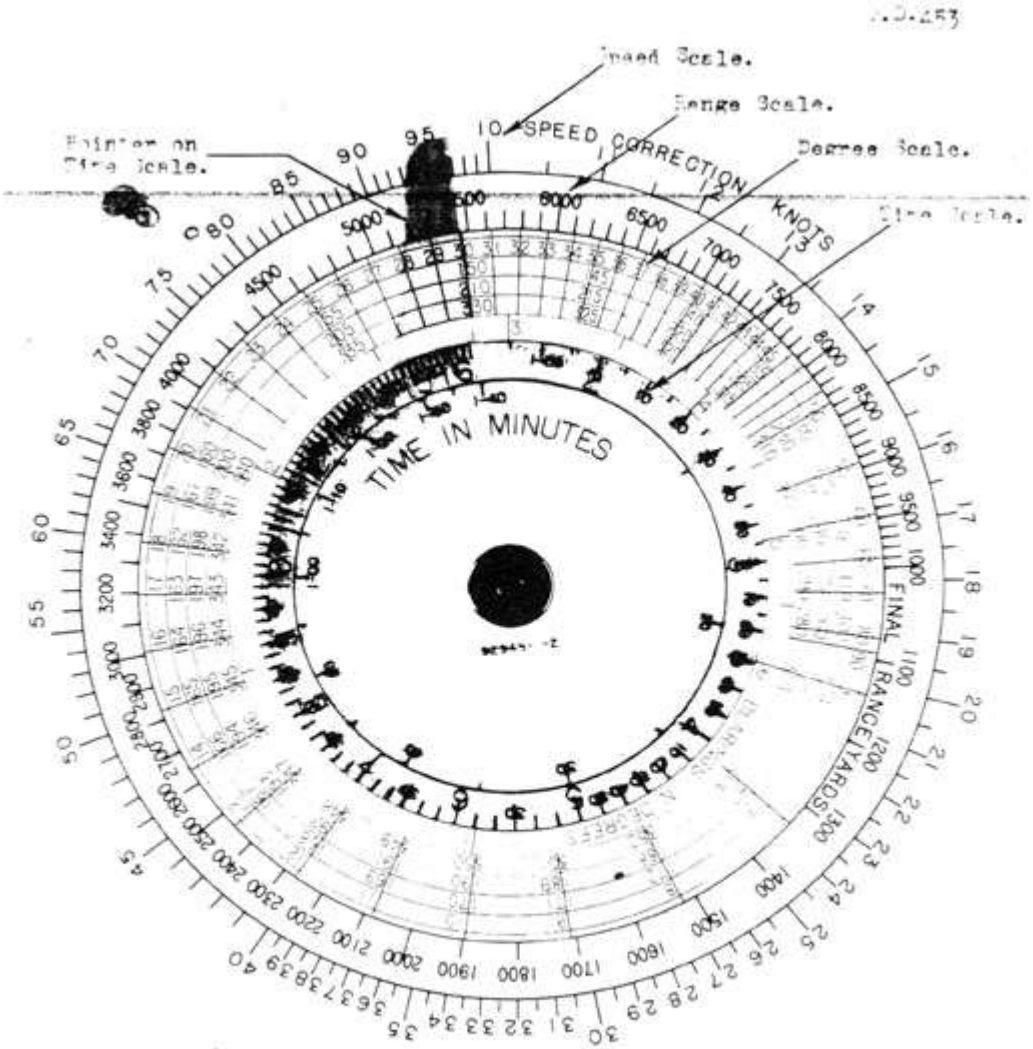

Speed Scale.
Range Scale.
Pointer on Fire Scale.
Degree Scale.
Fire Scale.
SPEED CORRECTION
KNOTS
TIME IN MINUTES
FINAL RANGE IN YARDS
U. S. NAVAL GUN FACTORY
1922
SUP'T. J.H.D. INS'P J.H.H.
S.

Plate VI

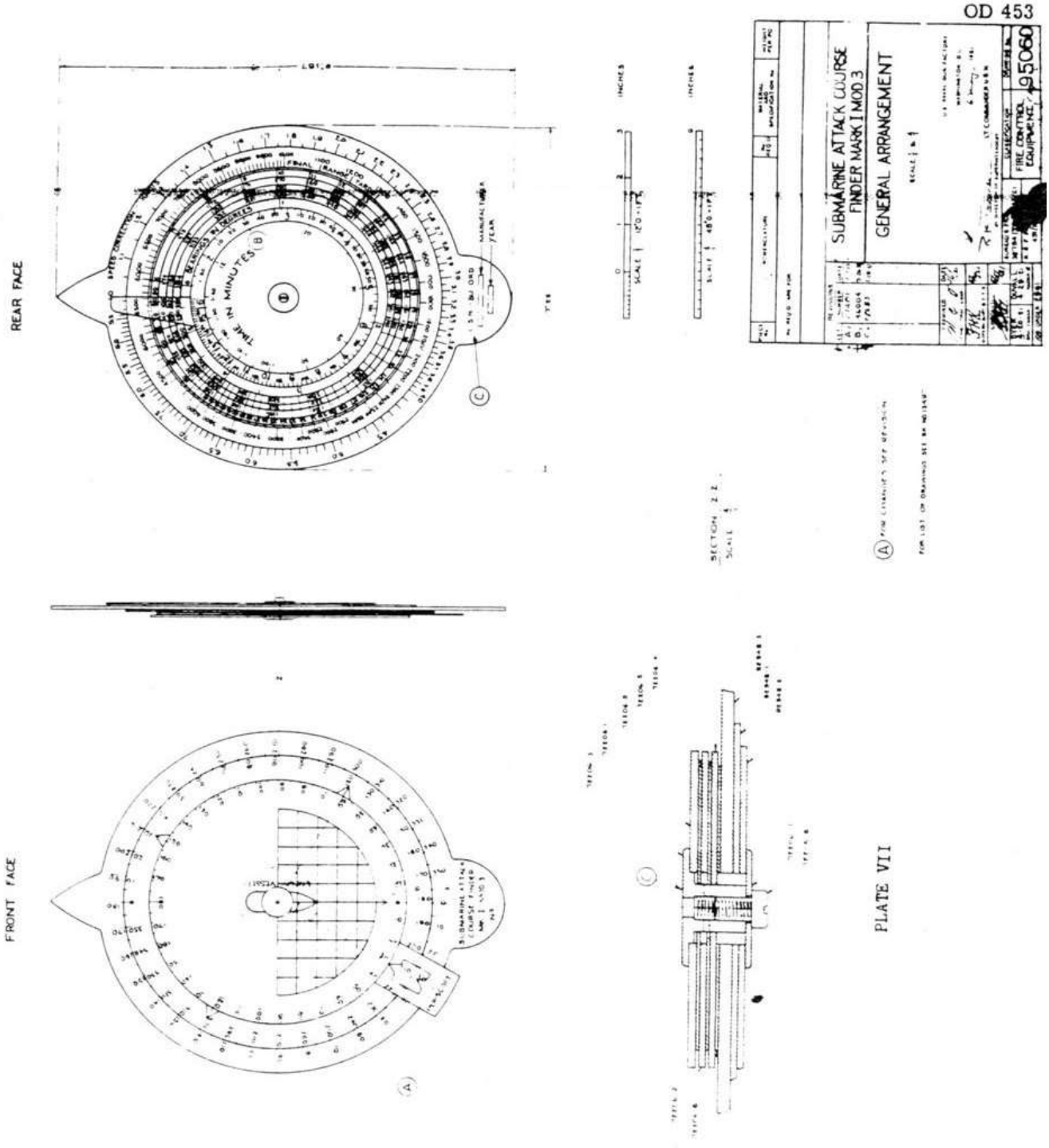


PLATE VII

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