c. An intense rainstorm can be detected at a distance of 25 miles.

5. Multiple echos.

a. Caused by the reflection of the signal between own ship and the target one or more times before it finally returns to the scanner.

b. More than one target will appear on the same bearing, equidistantly spaced.

c. Succeeding echos are weaker.

d. First echo is the true one.

e. This will occur only on short range.

f. May be eliminated by reducing the receiver gain.

6. Indirect echos.

a. These are caused by the reflection of the outgoing pulse against part of own superstructure (funnel or mast) or against a building, cliff, riverbank or bridge nearby, and returning in the same path.

b. Target is said to be shown on scope via a mirror.

c. Occurs only at close range.

d. May disappear when you change course.

e. By reducing receiver gain, you will sometimes correct this condition.

7. Blind spots.

a. These are formed by obstructions in the path of the radar beam, such as crosstrees, funnel and masts.

b. Blind spots may be observed in a light sea return. They will form a wedge-shaped pattern on the scope.

c. Blind spots may be determined by swinging your ship close to a buoy and noting the sector in which the buoy is not shown on your scope.

d. Blind sectors should be determined and then posted by the radar set.

e. It is essential during reduced visibility to weave around the course (slightly more than half the extent of the blind spot) in order that targets may be detected if they are in the blind sectors.

(1) The wheelsman should alter course several degrees, alternately to starboard and port, each time the fog whistle is blown.

8. Azimuth spread or beam width.

a. All targets will be distorted to the left and right so that they will fill the entire radar beam.

b. This introduces 1/2 beam width error to the left and right for all tangent bearings.

c. Targets will appear larger the farther away they are.

9. Pulse length. If a radar has a 1 microsecond pulse, then its pulse length would be 328 yards. This would show all targets with a depth of at least 164 yards (½ the pulse length).

10. Side echos.

a. These are found on short range only.

b. They are caused by imperfect construction of the scanner.

c. Targets are picked up by the side lobes.

d. Correct by reducing the gain or increasing the suppressor or anti-clutter.

11. Ice. Carefully conducted tests by the International Ice Patrol during the 1959 season showed that radar cannot provide positive assurance for iceberg detection. An iceberg is only one-sixtieth as good a radar reflector as a comparable sized ship. Sea water is even a better reflector than ice. This means that unless a berg or growler is observed on radar outside the area of sea "return" or "clutter" on the scope, it will not be detected by radar. Furthermore, the average maximum range of radar detection of a dangerous size growler is four miles.

G. Maintenance and Precautions.

1. The three most dangerous points in the radar set are:

a. High voltage around the CRT - 12,000 volts.

b. High voltage in the magnetron (Transmitter House) - about 15,000 volts.

(1) Before attempting to work on the set, pull the fuses and ground-out all parts.

c. Implosion of the CRT.

(1) Make sure the CRT is well protected when working on or near it.

2. Test meter.

a. Enables you to do a limited amount of testing.

b. It checks the various out-put voltages, crystal current and magnetron current.

(1) When the radar set is functioning properly, rotate switch and note readings. Use these readings to compare with future tests.

3. Radar log.

a. A log of operating time and maintenance details is required in all licensed vessels. It includes:

(1) Number of hours of use while the ship is in operation.

(2) Number of service failures and their duration, nature and cause.

(3) Performance under abnormal weather conditions.

(4) Unusual incidents, including cases in which radar may have aided or hindered safe operation of the vessel.

4. Scanner maintenance.

a. Before starting to work on the scanner, secure all switches on the power supply, pull the fuses on the power supply, also the fuses to the heating circuit if they are on a separate circuit.

b. Change the oil once a year.

c. Check the heater; maintain 50 degrees inside the scanner.

d. Paint all but the face of the horn and weep hole in the horn elbow.

V. TEST & APPLICATION

A. Test. Use these and additional questions for review and as an oral quiz.

1. Q. What phrase did the word RADAR originate from?

A. Radio Detection and Ranging.

2. Q. What are the three basic units of a radar set?

A. Scanner, indicator, transceiver.

3. Q. What are the 3 units of the Transceiver?

A. Transmitter, modulator, receiver.

4. Q. What is horizontal bearing resolution?

A. The ability of a radar to resolve targets at the same range in bearing.

5. Q. By what is horizontal bearing resolution determined?

A. Horizontal beam width - wave length and size of reflector.

6. Q. What is range resolution?

A. The ability of a radar to resolve targets at the same bearing in range.

7. Q. What is range resolution determined by?

A. Pulse length/width - or pulse duration.

8. Q. What is the vertical beam width?

A. The angular measurement of the height of the vertical beam.

9. Q. If the gain control (master gain-receiver gain) was set too high, what would happen?

A. You would get too much amplification, too much echo, sea return, rain return; the picture would be blurred.

10. Q. What may happen if the anti-clutter controls are set too high?
A. You would eliminate some targets, perhaps all.

11. Q. If the fixed marker rings and the variable marker do not agree, which would you assume to be correct?
A. Always assume the fixed markers to be correct, they are much more reliable than the variable ones.

12. Q. Where is the heading flasher on a relative radar?
A. Always at the top of the scope.

13. Q. Where is the heading flasher on true presentation (gyro-stabilized) radar?
A. At the ship's true heading - with true north at the top of the scope.

14. Q. When you change course on a relative radar, what happens to the picture, to the heading flasher, to the relative bearing, and to the true bearing?
A. The picture turns an equal amount in the opposite direction and smears. The heading flasher remains fixed at the top. The relative bearing changes. The true bearing remains the same.

15. Q. When you change course on a true presentation (gyro-stabilized radar, what happens to the picture, to relative bearings, to the heading flasher, and to the true bearing?
A. The picture remains the same. Relative bearing changes. The heading flasher moves to the new heading. The true bearing remains the same.

16. Q. What is the cause of super refraction?
A. Warm air over cold air or passing over cold water.

17. Q. Would you be likely to experience either sub or super refraction during a hurricane?
A. No, this occurs in calm weather only.

18. Q. What type of refraction causes second trace echos?
A. Super refraction.

19. Q. How would you recognize a second trace echo?
A. Element of surprise. Distortion. Change pulse length and it will disappear.

20. Q. What is clutter?
A. Any undesirable echo. Anything that obscures the scope.

21. Q. What are multiple echos caused by?
A. Radar pulses reflecting back and forth between two ships.

22. Q. What causes indirect echos?
A. Radar reflecting off some portion of your own ship's structure, then out to the target and back via the same crooked path.

23. Q. How would targets caused by indirect echos appear compared to true targets?

A. Distorted, at greater range, not as conspicuous.

24. Q. What is a blind spot?

A. An area where there is no radar energy and therefore no echos returning to the set.

25. Q. What causes blind spots?

A. Some part of own ship structure is in front of the reflector and blocks the radar wave.

26. Q. What can you do to ensure complete radar coverage if your ship has a blind spot?

A. Relocate the antenna or swing the ship 1/2 of the blind spot to port and 1/2 to starboard every few minutes to scan across the blind sector. This will depend on the visibility and your speed.

27. Q. Why does a ship at 10 miles appear larger in azimuth on your scope than the same ship at 3 miles?

A. Beam width distortion is greater at 10 miles.

28. Q. Why do all ships, regardless of range, appear to have the same depth (radially) at any one time?

A. Pulse length distortion.

29. Q. Why are all tangent bearings always in error?

A. Because of 1/2 beam width error - sweep line in center only.

30. Q. How much is this error?

A. 1/2 beam width.

31. Q. What are side echos caused by?

A. Imperfect antenna construction. Inadvertent damage to the reflector or the horn by shifting relative positions will also cause side echos.

32. Q. What are the three most dangerous parts of any radar set? May they be lethal?

A. High voltage in modulator, high voltage on CRT and implosion of CRT. All may be lethal.

33. Q. What precautions would you exercise concerning these three dangers?

A. Shut off power. Pull fuses. Ground out by hand. Caution men to be careful. Stand on rubber mat/wooden grating. Keep dry. Cover CRT with cushion.

34. Q. What is the purpose of the test meter?

A. To allow a limited amount of testing without knowledge of circuitry, and permit basic repairs.

35. Q. Where would you look for maintenance instructions?

A. In manufacturer's operator's manual for own set.

36. Q. May the wave guide be painted or chipped?
A. Painted - Yes, Chipped - No.

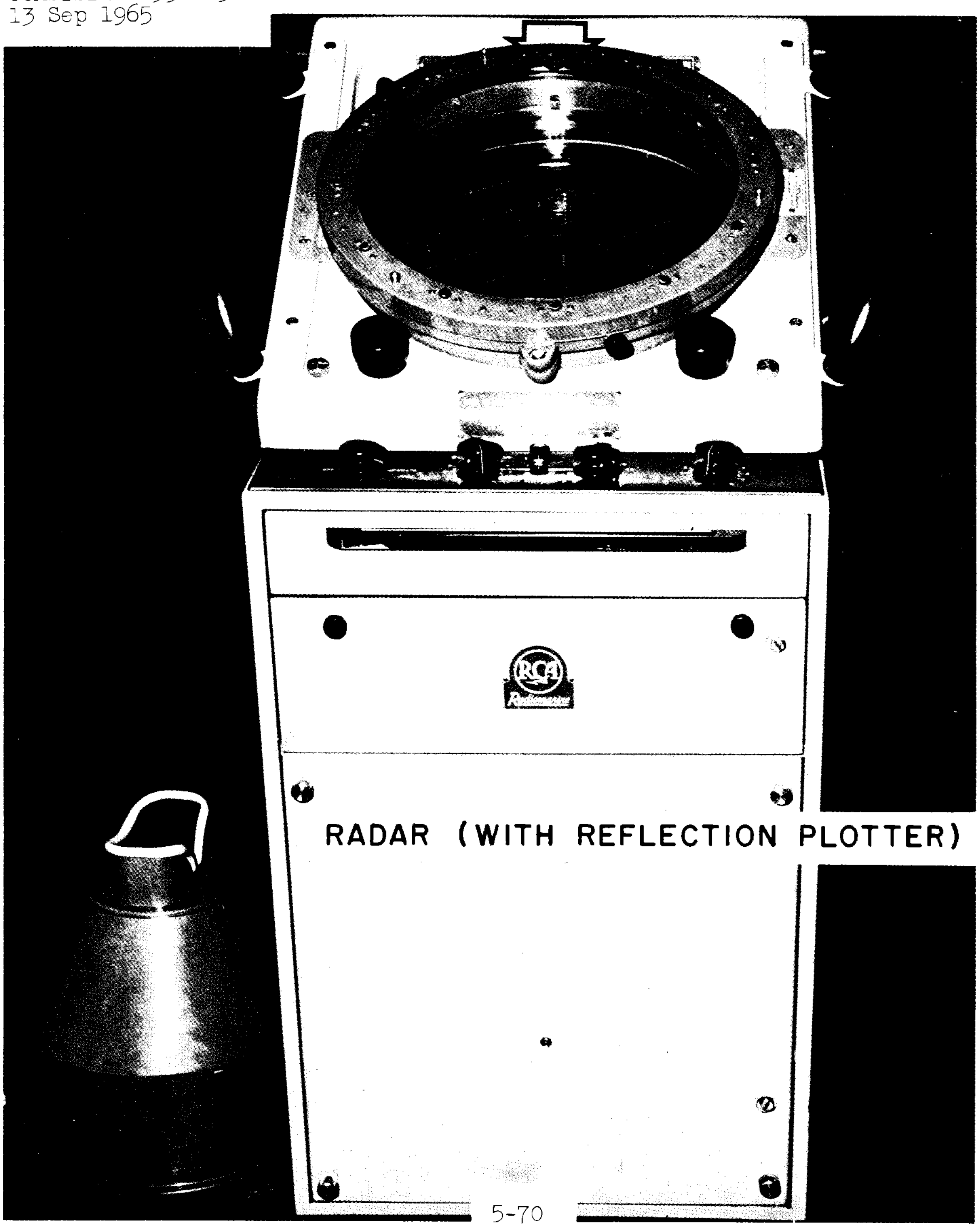
37. Q. May there be more than one power supply to the antenna assembly?
A. Yes.

38. Q. Does a radar-equipped ship have an additional liability that a ship without radar would not have?
A. Yes - it must use it when necessary and must plot other ships.

39. Q. What plotting must be done in order to be considered proper operation of a radar set?
A. Relative plot. True course and speed. New course and speed, if a course change is necessary.

40. Q. Does radar provide positive assurance of iceberg detection? Explain.
A. No. An iceberg is only one-sixtieth as good a radar reflector as a similar size ship. Even sea water is a better reflector than ice. Unless a berg or growler is observed on radar outside the area of sea return or clutter, it will not be detected. Furthermore, the average maximum range of radar detection of a dangerous size growler is four miles.

B. Application. Demonstrate the controls, operation, and maintenance of ship's radar set(s) and give each person an opportunity to name and describe the function and operation of each control, to operate the radar to obtain ranges and bearings of available targets, to demonstrate his knowledge of special effects observed, and to indicate proper maintenance procedures.



RADAR (WITH REFLECTION PLOTTER)

CHAPTER 5

EMERGENCY SEAMANSHIP - For Deck Personnel (Lesson Plans)

SECTION 5.7

RELATIVE MOTION PLOTTING

(Prepared by LT. O. M. Edwards, USNR)

I. OBJECTIVES

A. To instill in deck officers an understanding of the necessity of radar plotting for safe navigation.

B. To give deck officers a thorough understanding of relative motion plotting.

C. To enable deck officers to develop skill in making rapid relative motion plots in accordance with paragraph 5.d. of COMSTS INSTRUCTION 3530.1.

D. To prepare deck watch officers for the Coast Guard examination as radar observer.

II. MATERIAL

A. References.

1. Practical Radar Plotting by Thayer.

2. American Practical Navigator, Bowditch, pages 325 to 329.

3. Dutton's Navigation & Piloting, Chapter XXXV, pages 561 to 656 (explanations and appropriate problems).

4. Radar Plotting Manual, H. O. Pub. No. 257.

5. PRACTICAL RADAR PLOTTING, THAYER

B. Films.

1. MN-8144A, Relative Motion and the Maneuvering Board - Relative Motion, 12 minutes, B&W, sound.

2. MN-8144B, Relative Motion and the Maneuvering Board - Practical Use of the Maneuvering Board, 22 minutes, B&W, sound.

C. Handout Material.

1. Maneuvering Board plotting charts HO-2665A or B, or HO-2556 (24").

III. INTRODUCTION

A. Introduce self and subject (Maneuvering Board and Relative Motion Plotting).

B. Background. Because of the similarity to a radar screen and because of the rapidity with which graphic solutions may be obtained, a maneuvering board is especially desirable for radar plotting.

C. Types of Problems. There are three fundamental radar navigational problems which can be solved on the maneuvering board by relative motion plots, quickly and accurately. These are:

1. To determine the closest point of approach, CPA, to another ship.

2. To determine the approaching vessel's true course and speed.

3. To determine your ship's new course and speed to clear other vessel by any desired distance.

D. Unsuitability of Navigational Plot. A navigational plot made by advancing your own ship along the course line, and plotting in other ships in proper relation, is not recommended because:

1. Such a plot is time-consuming.

2. It requires tedious calculations.

3. It is not practical for calculating corrective course measures.

E. Plotting is a Must.

1. Deck officers must make complete plots if they are to rely on radar to avert collisions. "Mental plots" (except in overtaking or head-on situations) are impossible to make.

2. If you do not plot, you are permitting yourself to be trapped into a sense of false security.

3. No deck officer would think of neglecting to work out a sight after he has taken an observation with a sextant. Why then fail to make a plot of radar information? A series of unplotted readings may lead to "radar hypnosis" and disaster.

a. Such a plot on the bridges of both the STOCKHOLM and the ANDREA DORIA would have saved 51 lives, much human anguish, and costly property. Remember, many accidents have occurred because the mate was too busy to plot, but none have occurred because the watch officer was too busy plotting.

F. Legal Obligations.

1. A ship equipped with radar is obligated to use it correctly during periods of reduced visibility.

2. In fog, radar cannot substitute for or detract from the necessity for good judgment, good seamanship, moderate speed, good lookouts, and strict compliance with the Rules of the Road.

IV. PRESENTATION

A. Maneuvering Board. There are several different types. HO-2665A is the old standby; HO-2665B is a new plotting sheet adapted to radar range settings; and HO-2556 is the larger, 24" x 24", maneuvering board. All have these features and instructions regarding their use:

1. A large compass rose:

a. Labeled every 10 degrees.

b. 10 concentric circles equally spaced (4 in HO-2665B).

2. Own ship is always considered at the center:

a. Use largest plotting sheet and scale possible.

b. Scales are used to measure miles, yards, and/or knots.

3. Logarithmic scale:

a. Time on the right point of dividers.

b. Speed and/or distance on the left point of dividers.

c. If speed is known, start with time, 60 minutes in an hour, on the right point of the dividers and speed in knots on the left point.

d. Without changing the spread of the dividers, proceed along the scale with the known factor to find the unknown.

4. Use of maneuvering board with Fraser Luminous Maneuvering Board. Explain use and advantage in night plotting.

5. Use with Reflection Plotter on radar scope. Explain the advantages and similarity of plotting relative motion on the reflection plotter where fitted over the radar scope.

B. Relative Motion.

1. Relative motion is the apparent motion of one moving body in relation to another moving body. (Show film on Relative Motion.)

2. Cite examples - relative wind, moving trains in opposite and same direction.

3. All bearings and ranges are plotted from own ship's position which is maintained at the center of the board.

4. An extension of the relative motion line past the center of board will provide the closet point of approach, CPA.

5. Each maneuvering board problem consists essentially of two separate parts - the relative plot and the speed triangle.

6. NOTE: - The relative motion line is NOT the true course and speed of target ship. The other ship is generally referred to as the target ship. This is only because it is a radar target - don't consider it as a target to be hit but as a target to be avoided.

7. Labeling.

a. Capital letters (M1, M2, etc.) are used to label the relative motion plot. Small letters (e, r, m) are used to label the speed or vector triangle in most textbooks.

b. Own ship's position, in the center of the maneuvering board, is labeled "e" because it is considered tanget to the "earth." Our own ship's true course and speed line is labeled "e-r" because ours is the "reference" ship and the plot indicates our ship's course relative to the earth. The second side of the vector triangle is "r-m", for "relative movement," the motion of the target or maneuvering ship (m) relative to our ship. The third side of the triangle is "e-m," representing the target ship's true course and speed.

c. Any simple system of labeling is appropriate. The one described below has been adopted at Maritime Administration Radar Schools.

d. Simple color-coding will also be found useful, as black or blue for own ship's plot, green for the relative motion plot, and red for the target ship. Additional target ships can be plotted in different colors.

C. Maneuvering Board Procedure.

1. The Relative Plot.

a. Draw in your own ship's true course and speed vector, label it "OSC" and place an arrow at the head. This vector is not actually part of the relative plot but is usually the first line drawn on the paper.

b. Determine the range and bearing of the target by radar, plot its position, and it label "M1" and the time.

c. Plot the target's second range and bearing, about 6 minutes later. Label it "M2."

d. Draw the Relative Motion Line (also called Relative Plot Line or Relative Course Line), from M1 through M2 and extend this line on past the center of the maneuvering board. Label this line "RML" and place an arrow at the head indicating the direction of relative movement.

*e. Draw a right-angle line from the RML to the center of the maneuvering board. Label the point where this perpendicular joins the RML, "CPA;" indicating the closest point of approach.

*f. Find out how far ahead the target ship will be when it crosses your bow. Label this crossing point "CD" for crossing distance. It is measured from the center out on OSC to the intersection of the RML.

g. Measure the distance between M1 and M2 and, with the time run between, compute the speed. This is the relative speed, label it "RS."

h. Measure the distance between M2 and the CPA, using the relative speed as determined above, and compute the time necessary for the target ship to arrive at the CPA. Add this time to the time of M2 and you will have the time of the CPA.

2. The Speed Triangle.

a. Parallel the RML to the head of own ship's course and speed vector. Begin this vector at the head of your own ship's course and speed vector and draw in the direction of relative motion (as indicated by the arrow on the RML). Label this line "Rel. Co. and Spd." and place an arrow at the head.

b. Make the length of the Rel. Co. and Spd. line equal to the relative speed as previously computed from the time and distance between M1 and M2.

c. Draw a line from the center of the board (own ship's position) to the head of the relative course and speed vector. The direction of this vector is the target's true course and the length is his true speed.

* NOTE: Steps e and f cannot be done if on a collision course - The CPA is 0 as is the CD.

3. Procedure for a Course and/or Speed Change.

a. Find the time of the course change. Advance M2 along the RML so as to find the position of the target ship at the time that you plan to change course. Label this position "X" and note the time.

b. Draw a danger circle from the center of the maneuvering board equal in radius to the new or desired CPA.

c. Draw the New Relative Motion Line (label "New RML") from point X so that it is tangent to the new CPA (danger circle), ahead or astern as desired.

d. Parallel the new RML to the head of the target's course and speed vector. This line will be drawn in the direction of relative motion and so that it will end at the head of the target's course and speed vector. The name of this line is the new relative course and speed vector. (Label it "New Rel. Co. and Spd.")

e. Set your dividers or compass at your own ship's original speed, swing a speed circle from the center so that it intersects the new relative course and speed line. The point of intersection indicates the new course. There may be two intersections; one of the two will have the target ship pass you quicker than the other. Either course, if there are two, will give you the same CPA.

f. Draw in the new own ship's course (labeled "New OSC") from the center of the board to the intersection of the speed circle and the new relative course and speed line.

g. New Speed. This means: What speed will I have to change to in order to maintain my original course and still have the new CPA. It is measured from the center of the board to the intersection of your original course and the new relative course and speed line. It has nothing to do with the course change.

4. Labeling. It will be helpful to draw your plot in various colors, as previously described, and to label all parts of the plot properly for ready identification and to avoid errors. For example, use solid green for the relative motion line and relative course line, and broken green lines for the new relative motion line and new relative course line. Similarly, use a blue or black solid line for own ship's course and a dotted blue or black line for new own ship's course line. The target ship's true course and speed line can be in red. It will also be very helpful to draw in your ship symbol, at the center or the maneuvering board, indicating its heading. Then draw in the target ship, in red, at the CPA or CD, indicating its true heading. This will show, at a glance, the relationship of the two ships. In this manner, the relative motion plot can also serve as a graphic portrayal of the ship's relative headings.

V. TEST & APPLICATION.

A. Test. Use the problems below to practice relative motion plotting.

1. Q. A navigator, while steering a course of 000 degrees at a speed of 5.5 knots, observes on his radar scope another ship approaching forward of his starboard beam. At 1000 a bearing and a range was taken from the radar screen and found to be 060 degrees at 9 miles. At 1020 the bearing was found to have changed to 059 degrees, range 7 miles. Since the bearing was not changing very rapidly, it is evident that some action will be necessary. By use of relative plot, find Crossing Distance, Closest Point of Approach, and time of Closest Point of Approach. Also, determine the True Course and Speed of the target ship. In plotting, radar pickup #1 will be called M1, pickup #2, M2.

The navigator wishes to keep all ships at a distance of at least 2 miles. What course change should be made at 1030 for the target ship to clear ahead, in the minimum time, with a Closest Point of Approach of 2 miles? Point of course change at 1030 will be called point X.

A. CPA (Closest Point of Approach) ------------------ 0.5 mile
CD (Crossing Distance) --------------------------- 0.6 mile
RS (Relative Speed) ------------------------------ 6 knots
Time of CPA -------------------------------------- 1130
TC (Target's True Course) ------------------------ 297.5 degrees
TS (Target's True Speed) ------------------------- 6.1 knots
Own Ship's New Course (at same speed) ----------- 032.5 degrees
Own Ship's New Speed (maintaining course) ------- 4 Knots
New CD (Crossing Distance) ----------------------- 2.8 miles

NOTE: In all problems, new speed is calculated on own ship's original course. Answers may vary slightly since very accurate plotting is difficult and is not essential in actual practice.

2. Q. Our ship's course 000 degrees.
Our ship's speed 9 knots.

	TIME	BEARING	RANGE
M1	1100	80 degrees	9 miles
M2	1110	80 degrees	8 miles

Find own ship's new course required for the target ship to clear ahead in minimum time, with a CPA of 3 miles. Time of course change will be 1120. Also determine your ship's new speed, holding original course, to obtain the same new CPA.

A. CPA -- 0 (Collision Course)
RS (Relative Speed) ------------------------------ 6 knots
Time of CPA -------------------------------------- 1230
True Course (target ship) ------------------------ 323 degrees
True Speed (target ship) ------------------------- 9.9 knots
New Course (own ship) ---------------------------- 062 degrees
New Relative Speed ------------------------------- 14.3 knots
New Speed (Maintaining Course) ------------------- 6.3 miles
New CD (Crossing Distance) ----------------------- 4.2 miles

3. Q. Our ship's course 270 degrees.
Our ship's speed 15 knots.

	TIME	BEARING	RANGE
M1	0300	210 degrees	18 miles
M2	0312	211 degrees	14 miles

Find our ship's new course required for the target ship to clear ahead, in minimum time, with a CPA of 3 miles. Course change is planned at 0318. Also determine your ship's new speed, maintaining course, for the same new CPA.

A. CPA -- 1.2 miles
CD (Crossing Distance) --------------------------- 1.4 miles
RS (Relative Speed) ------------------------------ 20 Knots
Time of CPA -------------------------------------- 0354
True Course (target ship) ------------------------ 341 degrees
True Speed (target ship) ------------------------- 19 knots
New course (own ship) ---------------------------- 246 degrees
New speed (maintaining course) ------------------- 11.9 knots
New relative speed ------------------------------- 25 knots
New CD (Crossing Distance) ----------------------- 4 miles

4. Q. Our ship's course 000 degrees.
Our ship's speed 10 knots.

	TIME	BEARING	RANGE
M1	0400	10 degrees	9 miles
M2	0406	10 degrees	8 miles

Find our ship's new course or new speed required for the target ship to clear ahead (on our port side) in minimum time with a CPA of 1 mile. Course change at 0412.

A. CPA -- 0 (Coll. Course)
Relative Speed ------------------------------------- 10 knots
Time of CPA -- 0454
True course of target ship ------------------------- 274 degrees
True speed of target ship -------------------------- 1.7 knots
New course (own ship) ------------------------------ 008.5 degrees
New speed (maintaining course) --------------------- 5.3 knots
New CD --- 6 miles
New relative speed --------------------------------- 10.2 knots

5. Q. Our ship's course 150 degrees.
Our ship's speed 14 knots.

	TIME	BEARING	RANGE
M1	1200	055 degrees	14 miles
M2	1220	056.5 degrees	10 miles

Find new minimum course change required for the target ship to clear ahead with a CPA of 3 miles. Course will be changed at 1230. Also determine your ship's new speed, maintaining course, for the same CPA.

A. CPA -- 1 mile
Relative Speed --------------------------------- 12 knots
Time of CPA ------------------------------------ 1310
TC (target ship) ------------------------------- 186.5 degrees
TS (target ship) ------------------------------- 19.9 knots
New course (own ship) -------------------------- 172 degrees
New relative speed ----------------------------- 7.1 knots
New CD --- 4.5 miles
New speed (maintaining course) ----------------- 10.5 knots

6. Q. Our ship's course 070 degrees.
Our ship's speed 16 knots.

	TIME	BEARING	RANGE
M1	0315	15 degrees	18 miles
M2	0327	16 degrees	13 miles

Find new course or speed required for the target ship to clear ahead, in minimum time, with a CPA of 3 miles. Course change is planned at 0333.

A. CPA -- 1 mile
CD --- 1.1 mile
Relative speed --------------------------------- 25 knots
Time of CPA ------------------------------------ 0358
TC (target ship) ------------------------------- 153 degrees
TS (target ship) ------------------------------- 21.4 knots
New course (own ship) -------------------------- 39 degrees
New relative speed ----------------------------- 31.5 knots
New CD --- 4.8 miles
New speed (maintaining course) ----------------- 10.5 knots

7\. Q. Our ship s course 080 degrees.
Our ship's speed 9 knots.

	TIME	BEARING	RANGE
M1	1000	150 degrees	9 miles
M2	1018	152 degrees	6 miles

Determine the smallest course change necessary for the target ship to clear astern with a CPA of one mile. Course change will be made at 1024.

A. CPA --- 0.6 mile
Relative speed ---------------------------------- 10 knots
TC (target ship) -------------------------------- 018.5 degrees
TS -- 10.4 or 10.5 knots
New course (own ship) --------------------------- 067 degrees

8\. Q. Our ship's course 010 degrees.
Our ship's speed 9 knots.

	TIME	BEARING	RANGE
M1	0955	089 degrees	7.5 miles
M2	1017	086 degrees	4.9 miles

Determine the speed change necessary, maintaining your ship's course, for the target ship to clear ahead with a CPA of 1.5 miles. Speed change will be made at 1029.

A. CPA --- 0.8 mile
Relative speed ---------------------------------- 7.1 knots
True course (target ship) ----------------------- 330 degrees
True speed (target ship) ------------------------ 11 knots
New speed of own ship, maintaining same course -- 7.4 knots

9\. Q. Our ship's course 342 degrees.
Our ship's speed 11 knots.

	TIME	BEARING	RANGE
M1	0905	287 degrees	21 miles
M2	0935	288 degrees	12 miles.

Determine our ship's new course required for the target ship to clear astern with a CPA of 3 miles. Our ship will increase speed to 15 knots. Time of course and speed change will be 0945.

A. CPA --- 0.5 mile
Relative speed ---------------------------------- 18 knots
True course (target ship) ----------------------- 068 degrees
True speed (target ship) ------------------------ 15 knots
New course at 15 knots -------------------------- 008 degrees or 007 degrees

10\. Q. Our ship's course is 340 degrees.
Our ship's speed is 12 knots.

	TIME	BEARING	RANGE
M1	0420	320 degrees	18 miles
M2	0430	321 degrees	14 miles

Determine the new smallest course change necessary for the target ship to clear astern with a CPA of 3 miles. Time of course change will be 0435.

A. CPA ------------------------------------ 1 mile
Relative speed -------------------------- 24 knots
True course (target ship) --------------- 117 degrees
True speed (target ship) ---------------- 13.8 knots or 14 knots
New course ------------------------------ 024 degrees or 023 degrees

11. Q. Our ship's course is 252 degrees.
Our ship's speed is 16 knots.

	TIME	BEARING	RANGE
M1	0308	195 degrees	20 miles
M2	0328	194 degrees	14.5 miles

Determine course change required for the target ship to clear astern with a CPA of 3 miles. Course will be changed to 0340.

A. CPA ------------------------------------ 0.9 mile
Relative speed -------------------------- 16.5 knots
True course (target ship) --------------- 317 degrees
True speed (target ship) ---------------- 15 knots
New course ------------------------------ 270 degrees

12. Q. Our ship's course 035 degrees.
Our ship's speed 14 knots.

	TIME	BEARING	RANGE
M1	1130	050 degrees	17 miles
M2	1138	049 degrees	14 miles

Determine the new course required for the target ship to clear ahead, port to port, in minimum time, with a CPA of 3 miles. Course will be changed at 1142.

A. CPA ------------------------------------ 1.3 miles
Time of CPA ----------------------------- 1215
Relative speed -------------------------- 22.5 knots
True course (target ship) --------------- 261 degrees
True speed (target ship) ---------------- 10.4 knots
New course (maintaining speed) ---------- 049 degrees

13. Q. Our ship's course is 020 degrees.
Our ship's speed is 7 knots.

	TIME	BEARING	RANGE
M1	0700	090 degrees	10 miles
M2	0715	090 degrees	8 miles

Problem A:
What would be the result if our ship's course was changed to 340 degrees at 0730?

Problem B:
If, instead, we changed our ship's course to 060 degrees at 0730, what would be the result?

A. Closest Point of Approach (CPA) ------------- 0 (Coll. Course)
Relative speed (RS) ----------------------------- 8 knots
Time of CPA ------------------------------------- 0815
True course (target ship) ----------------------- 319.5 degrees
True speed (target ship) ------------------------ 8.6 knots

Problem A:
New CPA -- 0 (Collision Course)
New relative speed ---------------------------- 3.2 knots

This course change would still result in a collision course, but time of CPA would be much later, 0921 instead of 0815.

Problem B:
New CPA -- 1.5 miles
New relative speed ----------------------------- 12 knots

This course change will permit the other ship to pass ahead, with a CPA of 1.5 miles. It will also increase the relative speed and thus speed up the time of CPA, now 0759.

14. Q. Our ship's course is 160 degrees.
Our ship's speed is 5 knots.

	TIME	BEARING	RANGE
M1	0500	260 degrees	10 miles
M2	0510	260 degrees	8.7 miles

Problem A:
What would be the result of changing our ship's course to 180 degrees at 0520?

Problem B:
If, instead, our ship's course was changed to 220 degrees at 0520, what would be the result

A. Closest point of approach (CPA) ------------------ 0
Relative speed ------------------------------------ 7.8 knots
Time of CPA --------------------------------------- 0616
Target ship's true course ------------------------ 109.5 degrees
Target ship's true speed ------------------------- 10 knots

Problem A:
New CPA -- 0 (Collision Course)
New relative speed ------------------------------ 9.6 knots

This is still a collision course, with an increased relative speed and an earlier time of CPA, 0607.

Problem B:
New CPA -- 1 mile
New relative speed ------------------------------ 12.6 knots
Time of CPA -------------------------------------- 0554

The other ship will now pass ahead with a CPA of 1 mile, relative speed is increased, and time to CPA is shortened.

15. Q. Our ship's course is 180 degrees.
Our ship's speed is 16 knots.

	TIME	BEARING	RANGE
M1	0406	182 degrees	18 miles
M2	0412	182.2 degrees	16 miles
M3	0418	182.6 degrees	14 miles

Determine our ship's course change for the target to clear ahead, port to port, in minimum time, with a CPA of 3 miles. Our ship's course will be changed at 0424.

A. Closest point of approach ------------------- 0.6 mile
Relative speed ------------------------------ 20 knots
True course of target ship ------------------ 000 degrees
True speed of target ship ------------------- 4 knots
New course of our ship, maintaining
same speed ------------------------------- 202 degrees

16. Q. Our ship's course is 310 degrees.
Our ship's speed is 18 knots.

	TIME	BEARING	RANGE
M1	1100	310 degrees	15 miles
M2	1110	310 degrees	12 miles

Determine the following:
Closest point of approach (CPA)
Relative speed
Time of CPA
True course of target ship
True speed of target ship
What action would you take, assuming your course change at 1120 and a CPA of 2 miles?

A. Closest point of approach --------------- 0 (Collision Course)
Relative speed -------------------------- 18 knots
Time of CPA ----------------------------- 1150
True course of target ship -------------- None, stationary
True speed of target ship --------------- None, stationary

Note that our ship's speed and the relative speed are both 18 knots and that our ship's course and the relative course are reciprocals. Therefore, the target must be a stationary ship or object. Haul off to pass well clear, depending on sea room. Check the chart carefully for a lighthouse etc. in the area. For a CPA of 2 miles with 9 miles to run and changing course at 1120, 13 degrees to either side, preferably to the right if searoom, will put you 2 miles off. New course 323 degrees.

17. Q. The ANDREA DORIA was on true course 268 degrees, speed 21.8 knots when she picked up the STOCKHOLM by radar as follows:

1045	272 degrees	range 17 miles
1051	274 degrees	range 13 miles

Course change will be made at 1054.

Determine the new course for the DORIA to steer in order to clear the STOCKHOLM, port to port, with a CPA of 3 miles.

A. CPA -- 2 miles (at 1111)
Relative speed ------------------------------ 39 knots
STOCKHOLM's true course ---------------------- 081.5 degrees
STOCKHOLM's true speed ----------------------- $17\frac{1}{4}$ knots
DORIA's new course for CPA of 3 miles ------- 315 or 314 degrees maintaining 21.8 knots speed

18. Q. The STOCKHOLM steering 091 degrees true, speed 18 knots, picked up the ANDREA DORIA on her radar scope as follows:

1054	bearing 089 degrees	range 12 miles
1100	bearing 087 degrees	range 8 miles

Determine the new course for the STOCKHOLM to steer in order to clear the DORIA, port to port, with a CPA of 3 miles, changing course at 1103.

A. CPA ---------------------------------- 0.9 mile (at 1112)
Relative speed ------------------------- 40 knots
New course ----------------------------- 141 degrees, maintaining 18 knots speed

19. Q. The SANTA ROSA on true course 010 degrees, speed 21.5 knots picked up the VALCHEM on her radar scope as follows:

2:52	bearing 018 degrees	range 4.9 miles
2:55	bearing 020 degrees	range 3.0 miles

Determine the SANTA ROSA's new course necessary, at 2:55, to clear the VALCHEM, port to port, with a CPA of 2 miles.

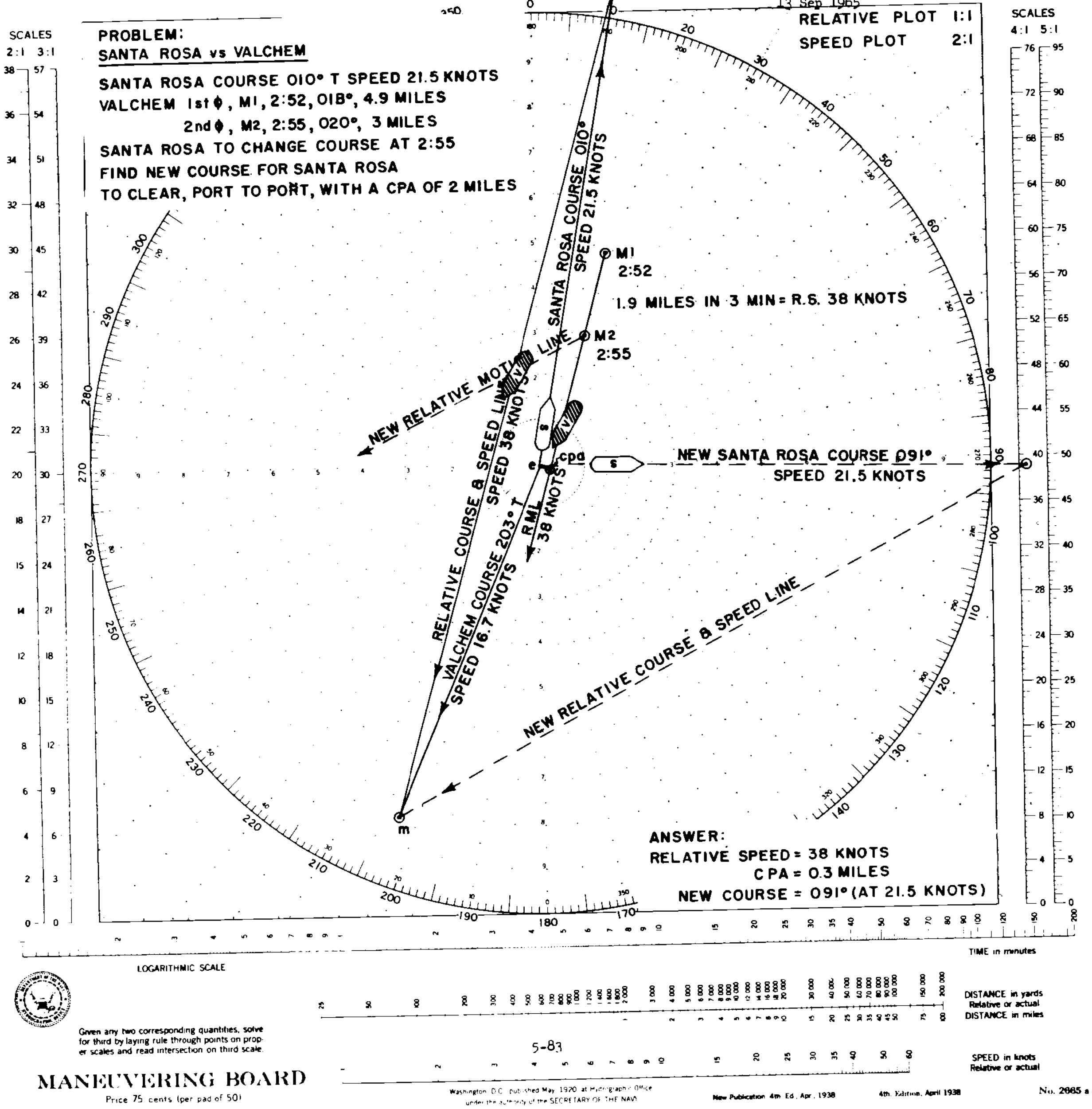
A. CPA ---------------------------------- 0.3 mile
Relative speed ------------------------- 38 knots
New course ----------------------------- 091 degrees, maintaining 21.5 knots speed.
(See plot on pages 5-83.)

B. Application. Have the group take and plot ranges and bearings of any ships encountered and determine all appropriate data. Demonstrate and have the group use the Fraser Luminous Maneuvering Board and the Reflection Plotter, where so equipped.

VI. REFLECTION PLOTTER (MSTS Magazine Sept. 1958 Reprint)

(See page 5-84.)

NOTE: Studies are being made to develop and test a radar data computer which would be used to store information on a number of radar targets and to compute the course and speed, the CPA, and time to the CPA for each target as well as to give warning when danger of collision exists.


PROBLEM:
SANTA ROSA vs VALCHEM
SANTA ROSA COURSE 010° T SPEED 21.5 KNOTS
VALCHEM 1st ϕ, M1, 2:52, 018°, 4.9 MILES
2nd ϕ, M2, 2:55, 020°, 3 MILES
SANTA ROSA TO CHANGE COURSE AT 2:55
FIND NEW COURSE FOR SANTA ROSA
TO CLEAR, PORT TO PORT, WITH A CPA OF 2 MILES
RELATIVE PLOT 1:1
SPEED PLOT 2:1
SCALES
2:1 3:1
4:1 5:1
SANTA ROSA COURSE 010°
SPEED 21.5 KNOTS
M1
2:52
1.9 MILES IN 3 MIN = R.S. 38 KNOTS
M2
2:55
NEW RELATIVE MOTION LINE
RELATIVE COURSE & SPEED LINE
SPEED 38 KNOTS
VALCHEM COURSE 203° T
SPEED 16.7 KNOTS
RML
38 KNOTS
cpa
NEW SANTA ROSA COURSE 091°
SPEED 21.5 KNOTS
NEW RELATIVE COURSE & SPEED LINE
ANSWER:
RELATIVE SPEED = 38 KNOTS
CPA = 0.3 MILES
NEW COURSE = 091° (AT 21.5 KNOTS)
TIME in minutes
LOGARITHMIC SCALE
DISTANCE in yards
Relative or actual
DISTANCE in miles
SPEED in knots
Relative or actual
Given any two corresponding quantities, solve for third by laying rule through points on proper scales and read intersection on third scale.
MANEUVERING BOARD
Price 75 cents (per pad of 50)
New Publication 4th Ed., Apr., 1938
4th Edition, April 1938
No. 2665 a

Reflection Plotter Helps Prevent Collisions at Sea

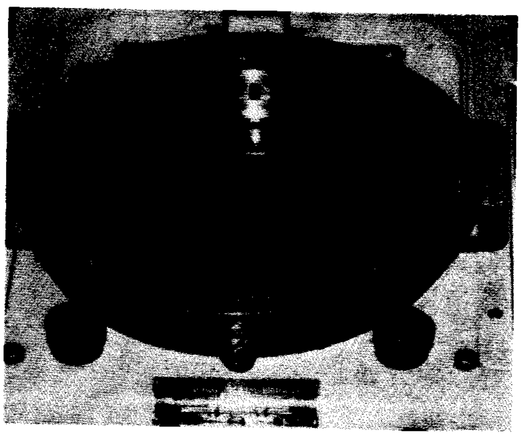
(MSTS MAGAZINE SEPT 1958)

Material presented in the following 4 pages was prepared by MSTS Pac Area's Training Branch under the direction of Gordon W. Crawford. Our special thanks go to Mr. Crawford and his staff for making this article possible.

The increasing frequency of collisions at sea—with the resulting loss of lives and ships—has promoted a number of recent investigations by maritime authorities.

When the findings in various cases were compared, one of the factors most often cited was the failure of many deck officers to use properly their radar equipment. Recommendations have been voiced that greater emphasis be placed on the training of deck officers as radar observers.

Beginning 1 January 1959, the Coast Guard will require that deck officers be qualified as radar observers. The new regulation applies both to applicants for original licenses and candidates for increase in scope of license or raise in grade.



REFLECTIVE PLOTTER fits directly over the scope. Plots are made with grease pencil on a clear plastic surface (arrow).

To provide basic training in radar operation for deck officers, the Maritime Administration now offers 1-week courses at New York, San Francisco and New Orleans.

Numerous articles have been published on the proper use of radar. All these facts point up the widespread concern over the failure of many deck officers to use their radar intelligently to avoid tragedy.

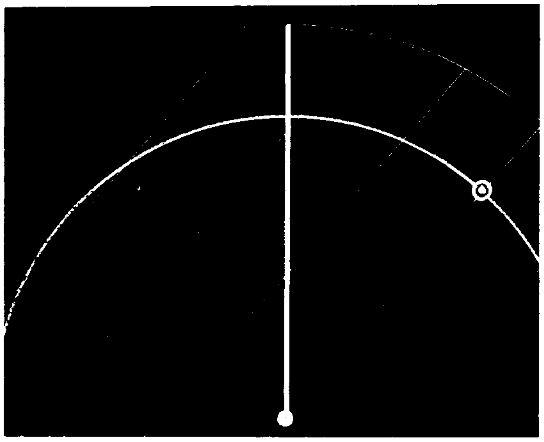
Proper use of radar not only means being sure of what you see, but it also means taking accurate ranges and bearings and plotting all objects in the path of the ship.

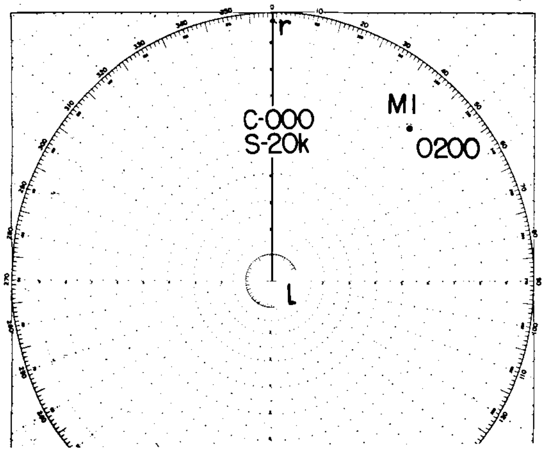
One of the most practical means for making radar plots is to transfer radar information to a maneuvering board. This method is accurate and quite adequate for plotting during daylight hours. There are several disadvantages, however, to plotting by maneuvering board at night in ships with only one officer on the bridge: (1) Unless a "night" light is rigged, the officer must impair his night vision by lighting up the board; (2) He may forget an important bit of information enroute to the chart room; (3) He may fail to observe a dangerous situation developing during his absence from the scope.

These disadvantages can be overcome by using a "reflection plotter," a raised transparent plotting surface fitted directly over the scope. Plots made with a grease pencil on the surface are reflected downward, giving the appearance of being on the scope itself.

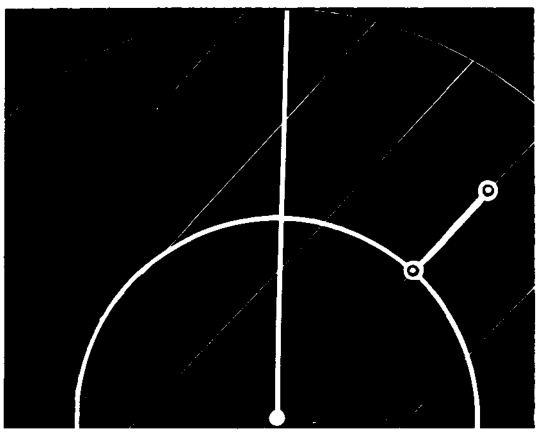
A reasonably accurate "reflection" plot can be made without leaving the set. Plotting on the scope also relieves the monotony of just watching. And too, it's possible to plot a number of targets so long as your course and speed remain constant.

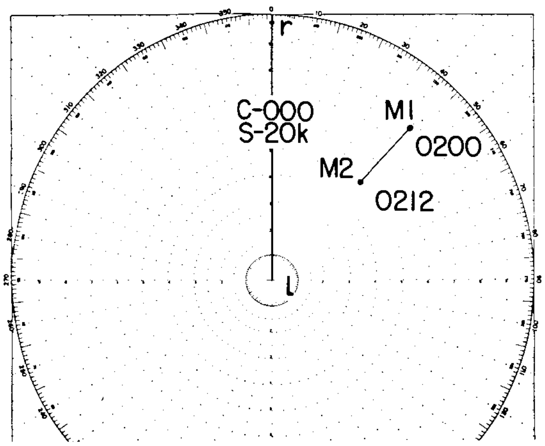
Step-by-step use of the reflection plotter is illustrated at right.





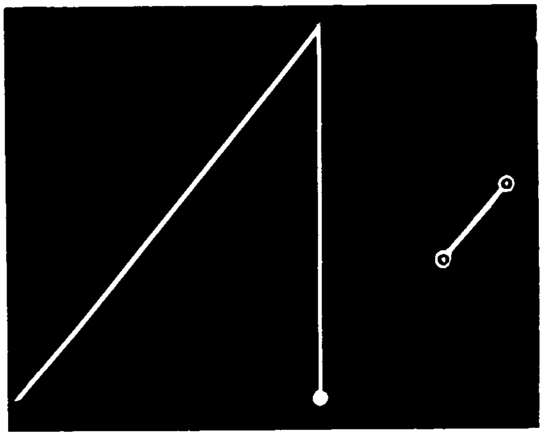
Navigation problem involving 2 ships on a collision course is solved in these 5 sets of illustrations. The radar scope, fitted with transparent reflection plotter, is represented in the drawing on the left in each set of pictures. To make the problem easier to follow, each step also is plotted on a maneuvering board, shown on the right. Summary of the problem: During a night watch, your ship is on course 000 T, speed 20 knots, when a pip is sighted bearing 042 degrees T, 15.4 miles distant. Your radar is set on the 20-mile scale. A second fix 12 minutes later shows the target to be 10 miles away—still bearing 042 T. Obviously, your ship is the burdened vessel. Assume there is sea room to pass astern with a closest point of approach of 2 miles. Using these facts, try solving the problem on your own before reading further. (The second fix is shown in the radar scope and maneuvering board drawings pictured below.)

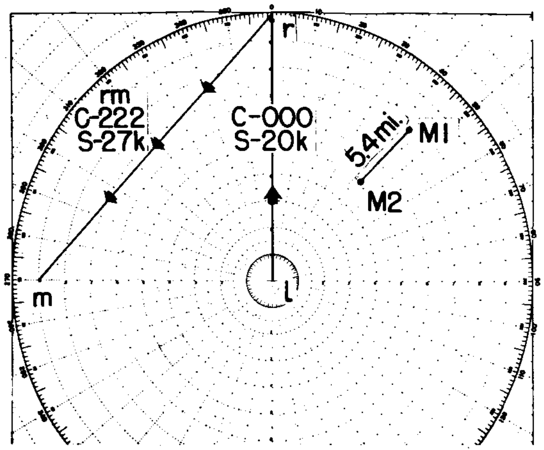




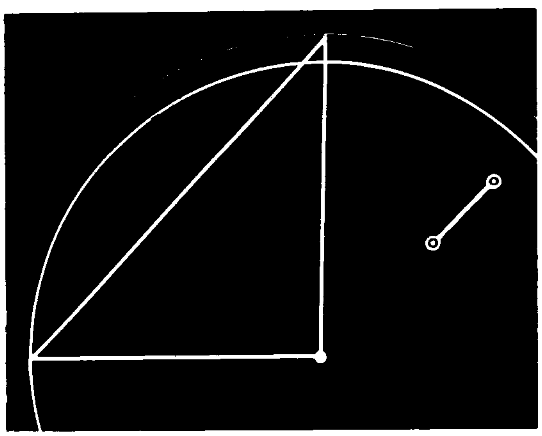
Sample Solution—The problem stated above can be solved in the following manner: First, determine the bearing of the target by turning the cursor until the center parallel is on the target. In this case, target bearing is 042 degrees T. Range is determined by adjusting the variable range marker until it intersects the pip. The range indicator shows the target is 15.4 miles away. Place a mark over the pip. Repeating these steps 12 minutes later, you find that the other ship still bears 042 T and now is 10.0 miles away—CLOSING. Mark the second fix on the scope. Then draw a line connecting the two marks. This line represents the direction and speed of the relative motion line for 12 minutes. Since neither ship has changed course, it is obvious that the target is on a danger bearing. *Constant bearing plus closing range equals: a collision course.*

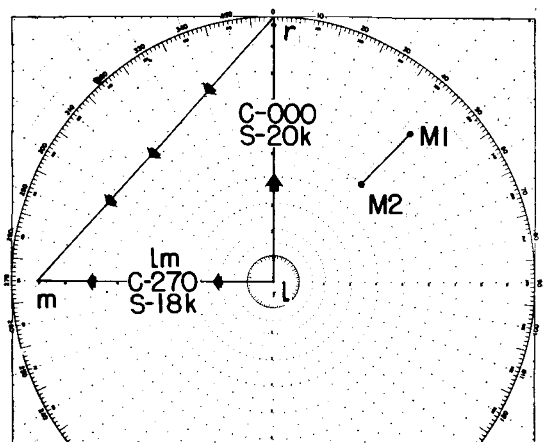
(Continued on next page.)



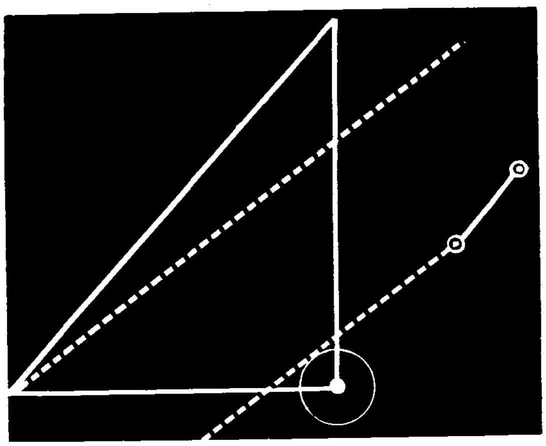


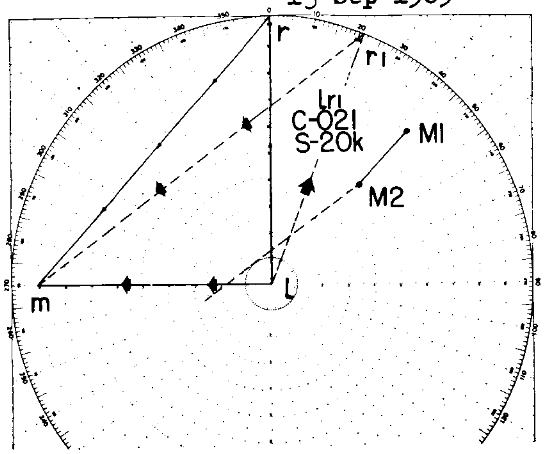
Target ranges already plotted are used to determine the speed of the relative motion line for a 1-hour period. Since the range reading for the first fix was 15.4 miles and the reading for the second fix was 10.0 miles, the speed of the relative motion (r. m.) line is 5.4 miles in 12 minutes, or 27 knots. Measure off 27 miles with a rubber-tipped divider or ruler by adjusting the range marker at 7 miles. Then span the distance from any point on the outside of your scope to the center (20 miles) plus the additional 7 miles. The next step is to draw in the r. m. line. Your ship still is making 20 knots on the 20-mile range setting, so the complete heading flasher is your course and speed. Start the r. m. line from the top of the heading flasher and extend it for 27 miles. (Point r to m on maneuvering board.) Be sure to keep the relative motion line parallel to the line connecting the 2 pips.





Target course and speed are determined by completing the triangle, called a "vector diagram." First, swing the cursor and adjust the variable range marker until both intersect at the point where the relative movement line joins the projected course/speed line of the other ship (point "m" on maneuvering board illustration). Next, draw a line from the center of the scope to the end of the r. m. line (point "m"). Using rubber-tipped dividers, measure the distance of the target's course/speed line. This is the other ship's speed—18 knots. Its course, 270 degrees T, is read off the radar scope. There still is time to plot a safe passing course—even at these relatively high speeds. You are navigating the burdened vessel, obliged to yield the right of way. You decide to let the privileged ship pass ahead of you with closest point of approach not less than 2 miles.





Collision is averted by the change of course indicated in the new vector diagram shown on the maneuvering board. To determine the change of course necessary, set the range marker at 2 miles. Then draw a new relative motion line from the last point of contact (second pip) tangent to the 2-mile circle on the scope. Using the parallel cursor, transfer the new r. m. line to the end of the target course/speed line (point "m"). Extend the r. m. line to your 20-mile speed circle (at rl). Complete the triangle by drawing a line from the center of the scope to the unjoined end of the r. m. line (at point rl). This dotted line represents the course (021 degrees T) you must steer, at 20 knots, to pass astern of the target. The privileged ship will cross ahead of you and will be at its closest point of approach, 2 miles, when bearing 325 degrees T. (See *Plotting Pointers* below at left.) □

Plotting Pointers Worth Remembering

With only a little practice any deck officer can solve problems similar to the one stated in the preceding article. It only takes a few minutes to make the computations required for an intelligent decision. *Nearly always, there is time to plot.*

The well-known fact that 2 constant bearings with closing range mean a collision course is worth repeating. The time to begin plotting the target's relative course and speed is as soon as the *second* bearing is established. If it is necessary to change course, the change should be made early enough and large enough so there can be no doubt of your intention.

After you have changed course, several more bearings and ranges should be plotted to verify your new relationship to the target. The other ship may have changed course at the same time, "checkmating" your move and creating another collision course.

Realizing that there is no substitute for good seamanship the alert watch officer always is ready for the unexpected.

Fluorescent Maneuvering Board Tested

NIGHT PLOTTING is made easier by fluorescent maneuvering board demonstrated for deck officers in USNS *Rose* by inventor, LCDR Arthur J. Fraser, USMS, Electronics Instructor at U. S. Merchant Marine Academy. Placed next to radar set, the board is illuminated with ultraviolet light. Plotting sheets are printed in luminous ink. Dividers and protractors also are luminous. An identical maneuvering board is being tried out in USNS *Kelley*.

Section 5.7

VII. PLOT—FOR SAFETY

(Reprinted from Proceedings of the Merchant Marine Council, USCG, April 1957)

By Captain L. M. Thayer, USCG

THERE is little doubt that most of our ships' officers fail to make a plot of radar information. The reasons may be that they have found the concept of relative movement too elusive, and they have not had proper instruction. They navigate, however, even though they are not entirely proficient in the spherical trigonometry involved. In the same way, they could plot radar information even though they might not fully understand relative motion.

The eight steps listed below refer to the example on the facing page. If you follow them you can make a practical, usable plot of your radar information.

1. After you have set your course and speed at sea, plot them to scale on the maneuvering board. In the diagram, the course is 000 degrees true, speed 15 knots; and they are represented by the arrow e—g. In this case, 1 space on the maneuvering board equals 2 knots.

2. When you get a pip, start a stop watch, and then record: (a) the ship's time (4 figures); (b) the target's true bearing; and (c) the range in miles and tenths. On the diagram, the first reading was taken at 1100, at which time the bearing was 012 degrees true, and the range was 10.0 miles. The scale used is 1 space equals 1 mile. In regard to selecting a scale: If the first range is between 10 and 20 miles, let 1 space equal 2 miles; if it is 10 miles or less, let 1 space equal 1 mile.

NOTE: The scale you use to represent speed in knots, and the one you select to represent range in miles are independent of each other. You might just as well have used 1 inch to represent 2 knots, and 1 centimeter to represent 1 mile; but you use *spaces* on the maneuvering board because they are more convenient. The only thought to remember is that all plots involving speeds must be made to the same scale; and all plots involving distances must be made to a common scale.

3. After 3 minutes by stop watch, take, record, and plot another reading; label it 03. Repeat after another 3 minutes, and label it 06.

4. Fair a line *carefully* through the three points just plotted, and extend it beyond the center of the board. This is the *Relative Movement Line—RML.* It is the line 1100—a, in the diagram.

5. Measure the distance between the point at 1100 and at 06; multiply the distance by 10. The product is the *Relative Speed.* (The distance in the diagram is 1.2 miles, the relative distance the target has moved in 6 minutes; and since 6 minutes is 1/10 hour, the relative speed equals 1.2×10, or 12 knots).

6. From *g* draw a line parallel to *RML*, in the direction of the relative movement, and long enough to represent the relative speed to scale. Label the end of the line *m*.

7. Draw a straight line between *e* and *m*. *This* line, e—m, represents (a) the true course of the target, 311 degrees in the diagram, and the speed of the target, 5.6 knots in the diagram.

8. Draw a line from *e* at right angles to *RML*. Where the line (e—x in the diagram) cuts the *RML* is the target's closest point of approach to you, provided there is no change in course or speed by either vessel. The closest point in the example is 1.4 miles on bearing 290 degrees true.

It is that easy. This is the basis of solution to all plotting problems, even though some of them are more involved. Surely anyone qualified to be in charge of a watch can do it. The practical value of it is this: You continue to take, record, and plot radar readings; and as long as both vessels proceed without a change in course or speed or both, all readings will plot along the *RML*, ((b) and (c) in the diagram). Conversely, if you hold your course and speed, and the readings *do not* plot on the *RML*, you may be sure that the target has made a change; and you will know quickly, from your plot, what the change has been. Assume, however, that the points plot along the *RML:* You can predict, then, in the example, that the target will pass ahead of you 4 miles, and that he will be 1.4 miles from you when he bears 290 degrees true. Suppose now that you decide to give him a wider berth, by changing your course. It is obvious from your plot that you should change to the right and not left. Another practical value of the plot is that if your bearing does not change as the range closes, you know you are on a collision course. If you *already* know the course and speed of the target, you will be able to make a seamanlike change *before* the situation becomes an emergency. Unfortunately the records of collision cases reveal clearly that maneuvers, designed to avert collision, but based upon unplotted radar information, are apt to be pure guess work.

Without solving for the target's course and speed in the example, many mariners—perhaps the vast majority of them—would have concluded that the target was coming toward them. That is, they would have thought the vessel to be on some course such as 200 degrees true, and, to avoid a dangerous situation, they would have "come left a little." And this is how collisions are born.

Pride in his profession should demand that every deck officer know how to plot radar information. But, and perhaps ever more demanding is the fact that the courts have made this decision in regard to collision cases: A vessel is at fault if she fails to make proper interpretation of radar information. Proper interpretation results from the use and understanding of a plot.

ABOUT THE AUTHOR:

A 1933 graduate of the U. S. Coast Guard Academy, Captain Thayer has been assigned as Officer in Charge, Marine Inspection, in Portland, Oregon, since December 1953. This article is excerpted from Captain Thayer's new treatise entitled "Practical Radar Plotting."

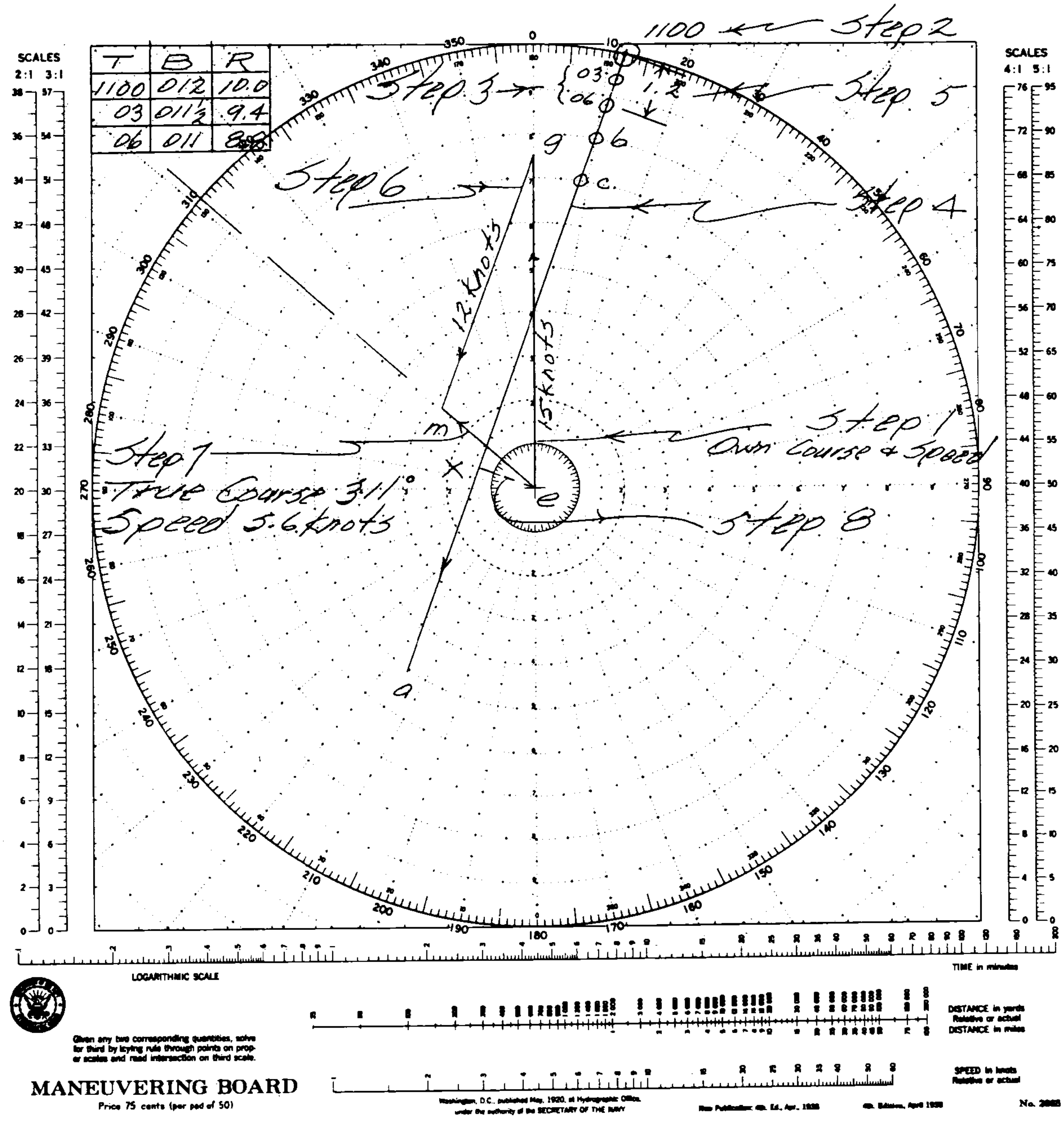
RECORD SMASHER

Chalking up records in almost every department, the SS *United States* recently completed her 100th round-trip between the United States and Europe.

On July 3, 1952, she smashed the North Atlantic speed record with a 3-day, 10-hour and 40-minute crossing between Ambrose Lightship and

Bishops Rock for an average of 35.5 knots. On the return crossing to New York she made the distance in 3 days, 12 hours, and 12 minutes for a westbound entry in the record books.

The ship has carried 312,878 passengers during the first 4½ years of service and has traveled approximately 637,824 miles between lightships—almost 26 times around the earth—at the remarkable average speed of 30.64 knots.



(Reprinted from Proceedings of the Merchant Marine Council, USCG, April 1957)