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. <u>Maneuvering Board Procedure</u>.

1. <u>The Relative Plot</u>.

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. <u>The Speed Triangle</u>.

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

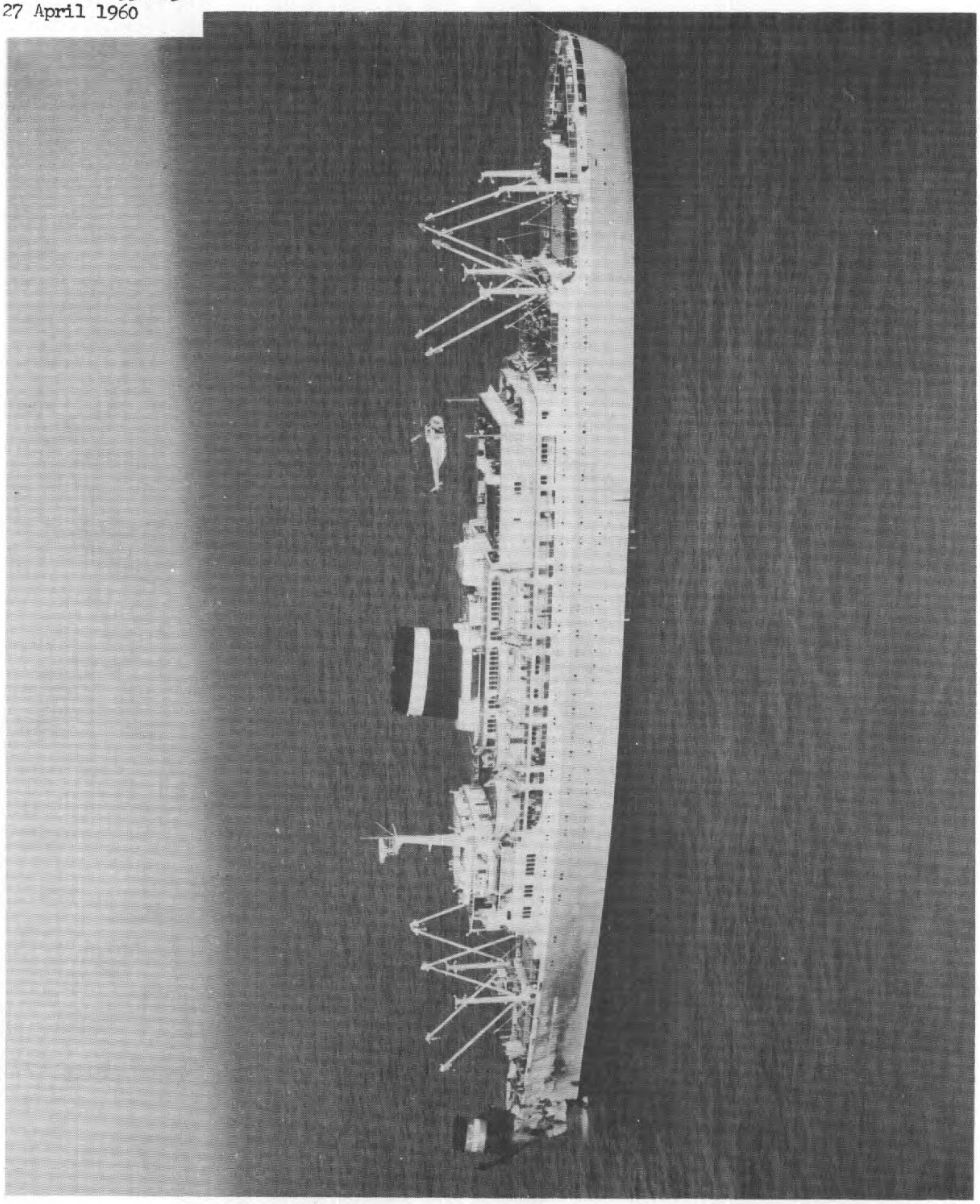
(See plot on pages 5-128 and 7-87.)

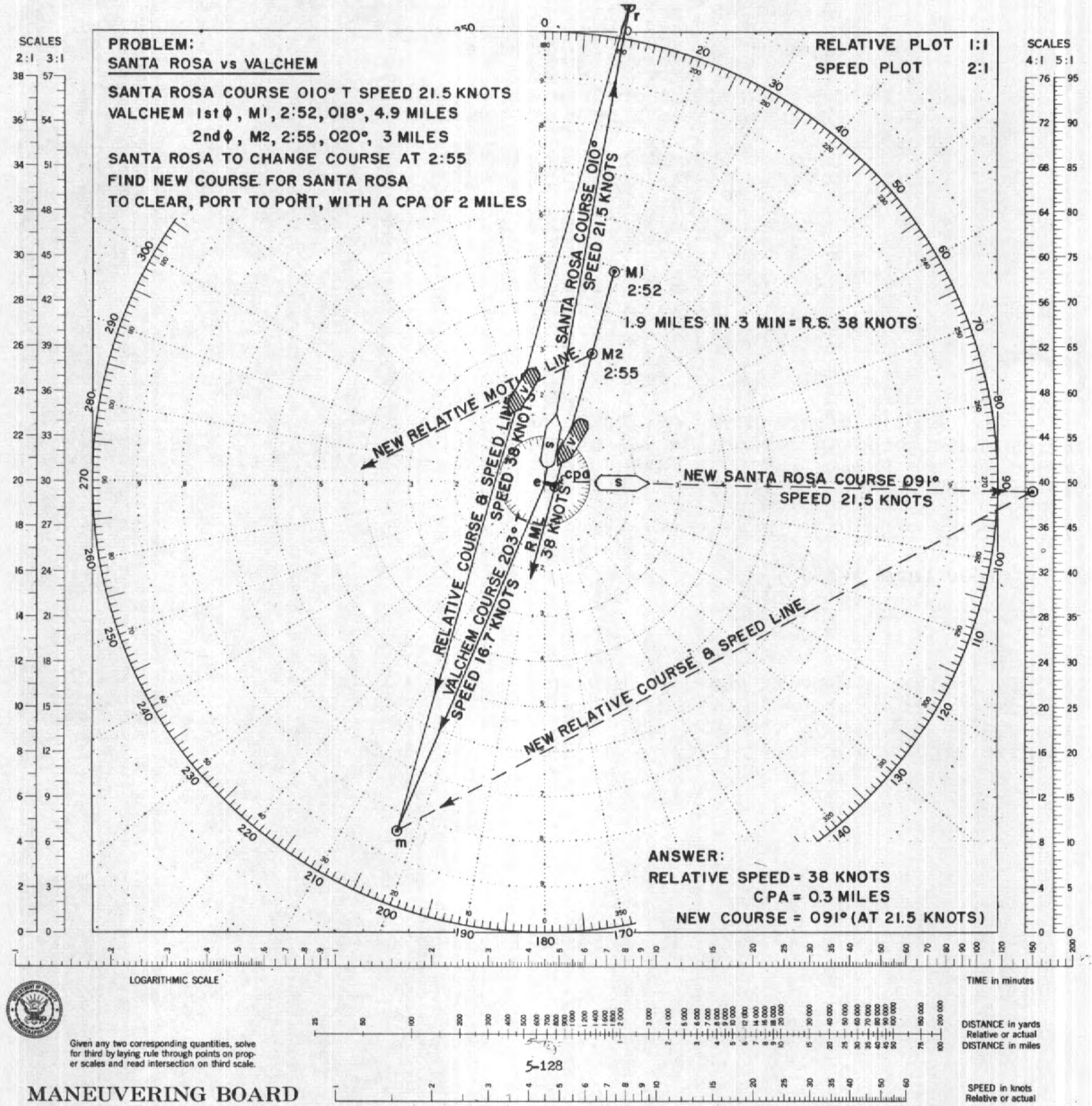
B. Application. Have the group take and plot ranges and bearings of any ships encountered and determine all appropriate data. Demonstrate and have the group use the Fraser Luminous Maneuvering Board and the Reflection Plotter, where so equipped.

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

(See page 5-130.)

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
M1
2:52
M2
2:55
1.9 MILES IN 3 MIN = R.S. 38 KNOTS
SANTA ROSA COURSE 010°
SPEED 21.5 KNOTS
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)
LOGARITHMIC SCALE
TIME in minutes
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)
Washington, D.C., published May, 1920, at Hydrographic Office, under the authority of the SECRETARY OF THE NAVY
New Publication: 4th. Ed., Apr., 1938
4th. Edition, April 1938
No. 2665 a

# Reflection Plotter Helps Prevent Collisions at Sea

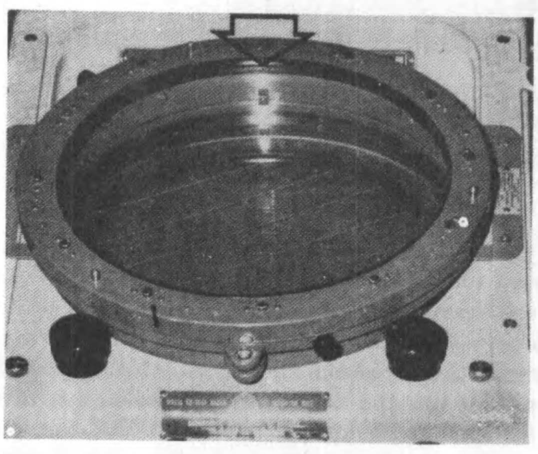
**(MSTS MAGAZINE SEPT 1958)**

*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.

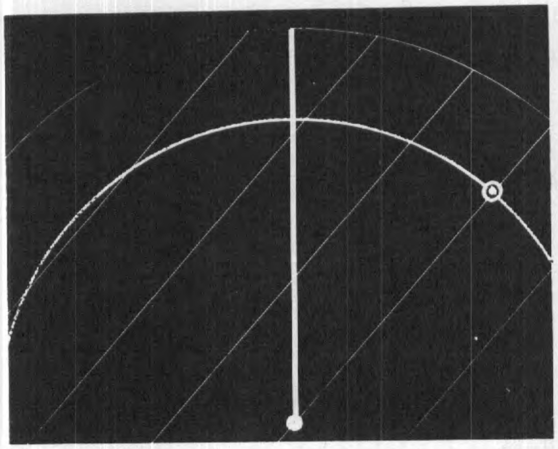
Proper use of radar not only means being sure of what you see, but it also means taking accurate ranges and bearings and plotting all objects in the path of the ship.

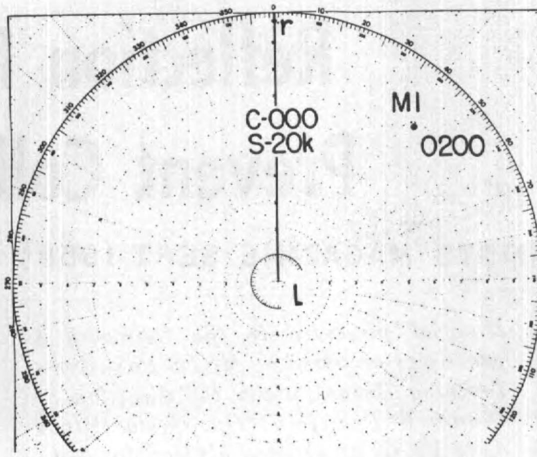
One of the most practical means for making radar plots is to transfer radar information to a maneuvering board. This method is accurate and quite adequate for plotting during daylight hours. There are several disadvantages, however, to plotting by maneuvering board at night in ships with only one officer 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.

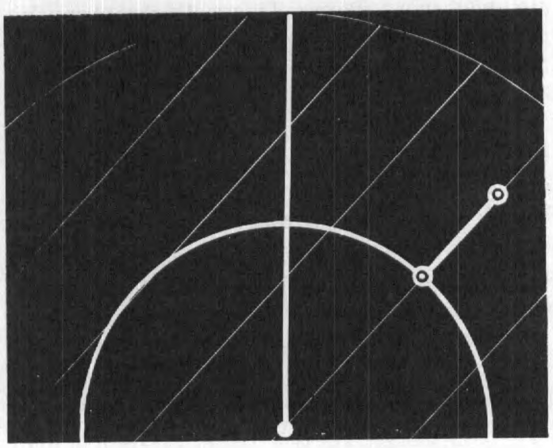
A reasonably accurate "reflection" plot can be made without leaving the set. Plotting on the scope also relieves the monotony of just watching. And too, it's possible to plot a number of targets so long as your course and speed remain constant.

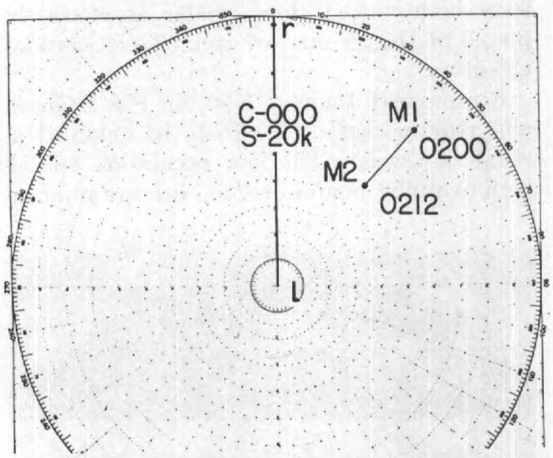
Step-by-step use of the reflection plotter is illustrated at right.





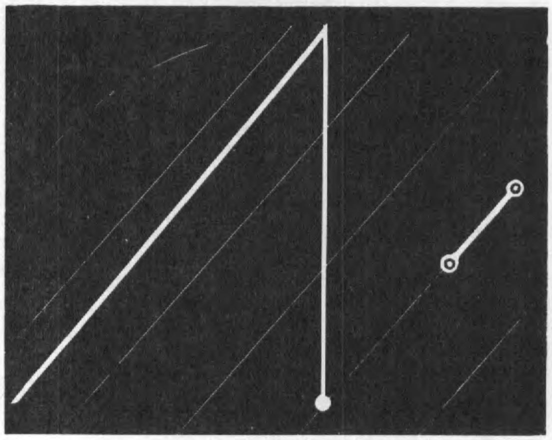

**Navigation problem** involving 2 ships on a collision course is solved in these 5 sets of illustrations. The radar scope, fitted with transparent reflection plotter, is represented in the drawing on the left in each set of pictures. To make the problem easier to follow, each step also is plotted on 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.)

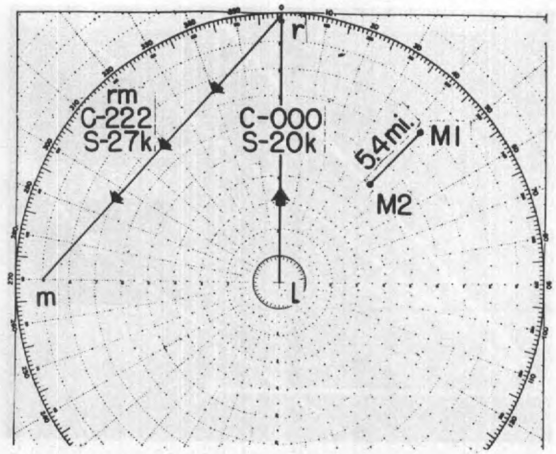




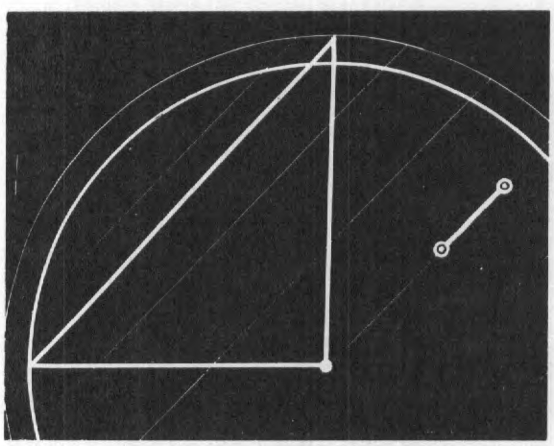

**Sample Solution**—The problem stated above can be solved in the following manner: First, determine the bearing of the target by turning the cursor until the center parallel is on the target. In this case, target bearing is 042 degrees T. Range is determined by adjusting the variable range marker until 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.*

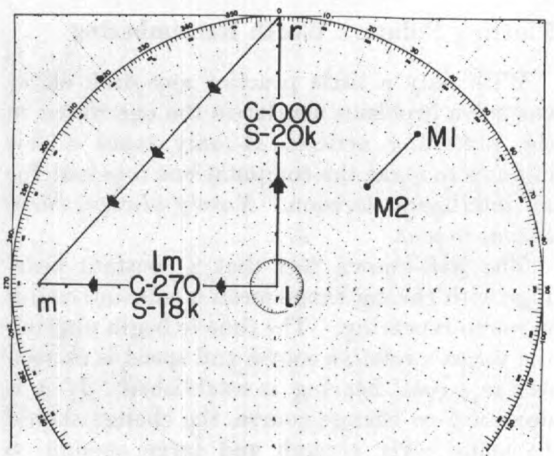
(Continued on next page.)



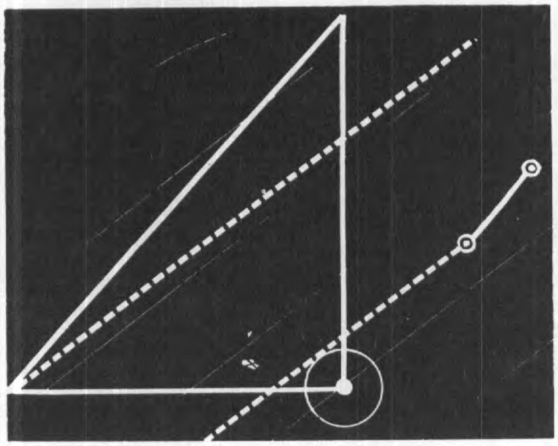


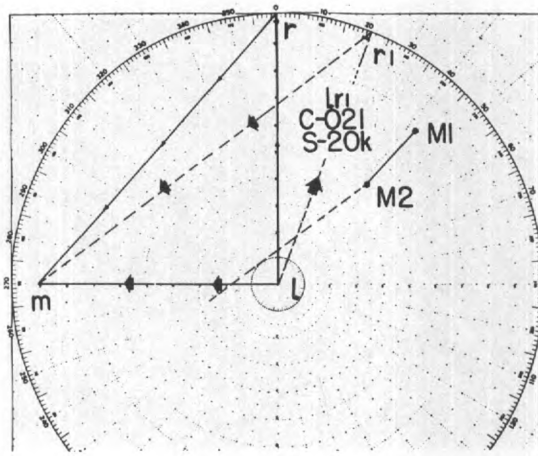

**Target ranges** already plotted are used to determine the speed of the relative motion line for a 1-hour period. Since the range reading for the first fix was 15.4 miles and the reading for the second fix was 10.0 miles, the speed of the relative motion (r. m.) line is 5.4 miles in 12 minutes, or 27 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."

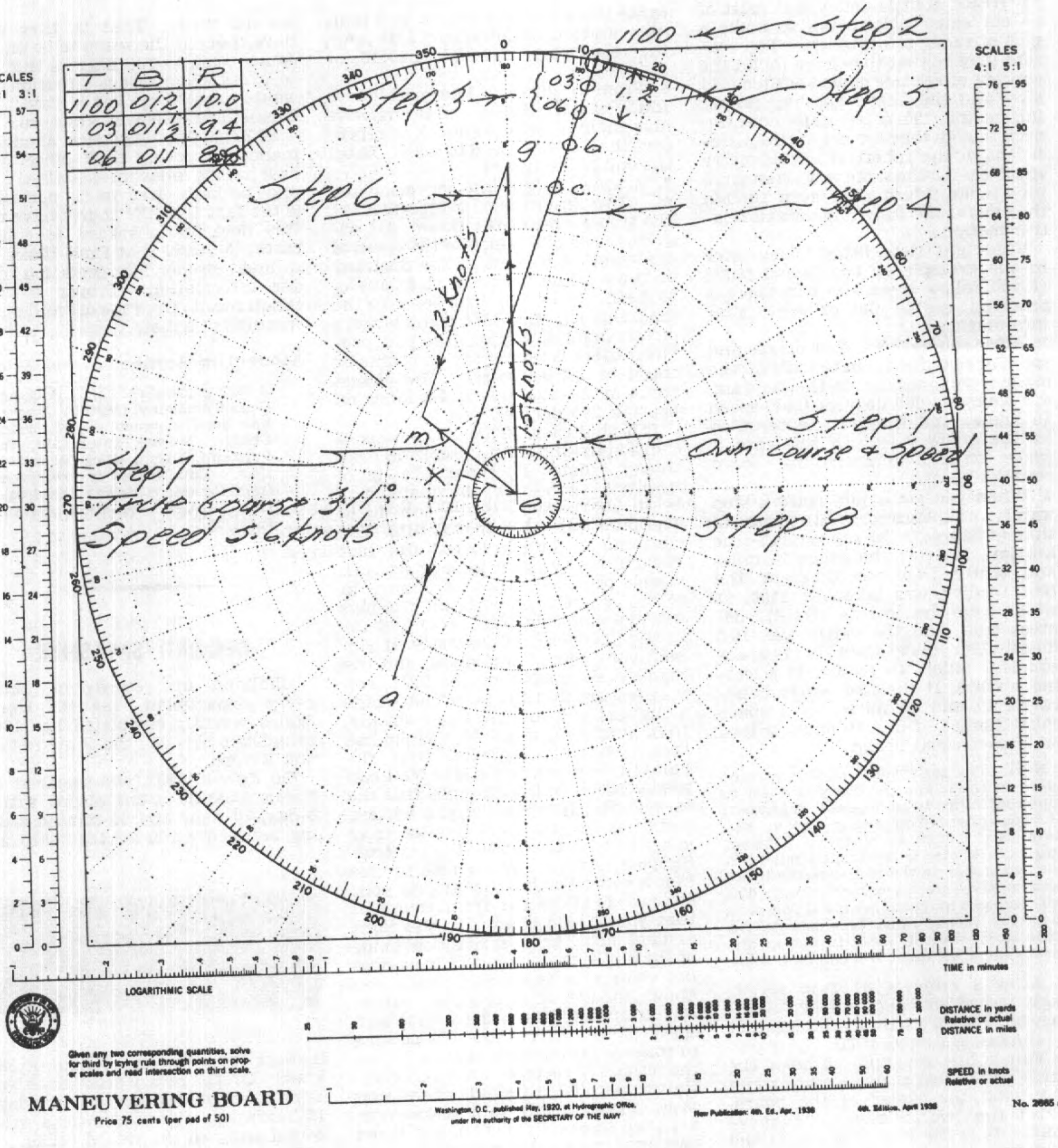
## RECORD SMASHER

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

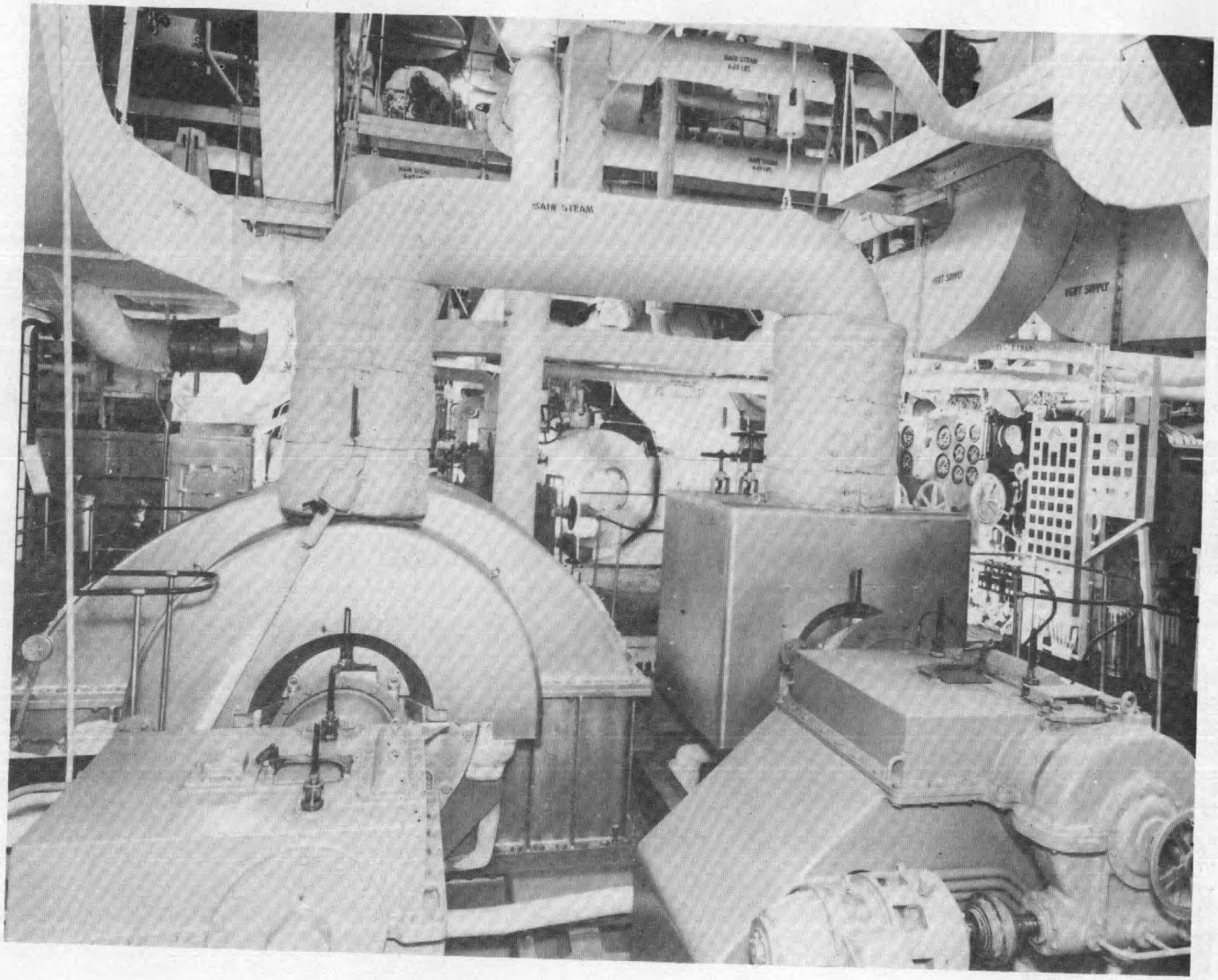
On July 3, 1952, she smashed the North Atlantic speed record with a 3-day, 10-hour and 40-minute crossing between Ambrose Lightship and

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)




BARRETT - CLASS
STEAM TURBINE PROPULSION PLANT

# CHAPTER 6

## ENGINEERING CASUALTY CONTROL - For Engineering Personnel (Lesson Plans)

# CHAPTER 6

## ENGINEERING CASUALTY CONTROL - For Engineering Personnel (Lesson Plan)

## Section 6.1

## INTRODUCTION TO ENGINEERING CASUALTY CONTROL



I. OBJECTIVES.

A. To develop an understanding of the principles relating to engineering casualties.

B. To stress the importance of engineering personnel's responsibilities in the prevention and control of engineering casualties.

C. To aid responsible engineering personnel plan practical engineering casualty control exercises and drills.

II. MATERIALS.

A. Training Aids.

1. Ship's standard station bill.

2. Chief engineers' organization manual.

3. Machinery and equipment operating instructions.

4. Machinery history and record cards.

5. Engineering log and machinery operating data record sheets.

6. Engineers' work books.

7. Ship's training log.

B. References.

1. COMSTS INSTRUCTION P3120.2B, Chapter 2, Section 8.

2. BUSHIPS Manual, Chapters 41, 42, 51, 60 to 65 inclusive, and Chapter 88, Section III.

3. COMSTSPACAREA Engineering Casualty Exercise Book.

4. Manufacturers' Instruction and Operating Manuals.

5. Section 1.6, Engineering Casualty Bill.

III. INTRODUCTION.

A. Introduce self and subject (Introduction to Engineering Casualty Control).

B. Define "Engineering Casualty Control" as action to prevent or to minimize and correct those failures of the main and auxiliary machinery, and the electrical and piping systems of the ship which can be controlled and repaired at sea.

C. Outline the scope of Chapter 6 as:

6.1 Introduction to Engineering Casualty Control.

6.2 Boiler and Boiler Feeding Machinery Casualties.

6.3 Casualties of Engine Room Machinery.

6.4 Electrical Casualty Control.

D. Outline scope of lesson.

1. Objectives of engineering casualty control.

2. Aids for controlling engineering casualties.

E. Arouse interest.

1. The main reasons for establishing an engineering casualty control program are to overcome the inattention of engineering personnel to standard operating procedures, and to assure the proper maintenance and operation of equipment and systems.

2. The size of ship and the type of propulsion will determine the amount and size of equipment for which engineering personnel are responsible. Textbooks have not been able to keep up with the developments in marine design and application. For instance, in the early days following the sailing ship era, steam was introduced as a great advancement in ship propulsion. It was thought by many engineers at the time that no other satisfactory means of propulsion could be developed. Then, Diesel motor ships came into the picture and many licensed steam engineers shipped in them solely to gain experience and an additional license. Now, the first nuclear merchant ship, the SAVANNAH, incorporates an entirely new concept of developing steam. This, of course, will require additional training and another license or endorsement for engineering personnel who wish to sail in this type of ship.

3. Experience, licenses and endorsements mean nothing if personnel are inattentive to their duties and responsibilities, for an effective engineering casualty control program is the best insurance for a ship's successful operation.

4. Engineering casualty control reaches its maximum efficiency through a combination of sound design, careful inspection, thorough plant maintenance, and effective training and organization of personnel.

IV. PRESENTATION. Because of the many facets of engineering casualty control, only general aspects will be covered here. For more detail, it is suggested that the references be used as guides.

A. Objectives. The objectives of engineering casualty control are to assure:

1. Proper maintenance of boilers, propulsion and auxiliary machinery, electrical machinery, lighting, interior and exterior communications, firemain supply and miscellaneous services.

2. Prevention or minimizing of personnel casualties and damage to vital machinery.

B. Controlling Engineering Casualties. Knowledge is the keystone of effective engineering casualty control. The details of the engineering installation and thorough instruction in normal operating procedures are important in preventing and controlling engineering casualties. This is accomplished through instruction, demonstrations, and drills. Although drills should be as realistic as possible, the state of training and technical ability of the crew must be taken into consideration. Possible errors and the resulting consequences must also be visualized before attempting simulated drills. To prevent damage, "dry runs" under careful supervision should precede simulated drills which require shutting down of machinery and equipment. Other vitally important aids for controlling engineering casualties are:

1. The chief engineers' departmental organization chart, which delegates individual responsibilities for the operational maintenance of machinery, equipment and systems.

2. The Engineers' Workbook which provides for maintaining records of completed repairs and inspections.

3. Machinery history cards, record cards, manufacturers' manuals and instruction books. These guides show when service and repair have been made to machinery, equipment and systems; also, when next inspection is due, the location of parts and the final assembly.

4. The posting of operating and safety instructions adjacent to machinery, equipment and systems. If these instructions are followed correctly, personnel and engineering casualties should be avoided.

5. The engineering log and operating data sheets for use by engineering personnel to check the overall functions of the operating machinery, equipment, and systems.

C. Action in Engineering Casualties. Engineering casualties occur as a result of either personnel or material failure. If a casualty occurs, immediate remedial action must be taken by the engineering watch personnel as follows:

1. If the ship is operating in open waters, the bridge and the chief engineer must be notified. It is then imperative and permissible to secure the affected equipment before serious damage occurs.

2. If operating in restricted waters, it is imperative that continuity of service be maintained. Damaged units must be removed from service and standby or alternate units put into operation before searching for the cause of trouble.

3. Even though it is expected that the engineering personnel in MSTS ships have the "know how" to cope with all types of engineering casualties, a continuing training program using this chapter and the references listed herein must be used to maintain the high degree of operational readiness for which MSTS is noted.

V. SUMMARY. Review key factors in engineering casualty control.

A. The engineering organization; specific responsibilities of individuals covering maintenance, inspections, etc.; keeping of records and operational data

B. Engineering operation personnel's knowledge of the engineering plant and systems.

C. Training of operating personnel in engineering casualty control methods.

IV. TEST AND APPLICATION.

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

1. Q. What are the principal objectives of engineering casualty control?

   A. To prevent, minimize or correct the effects of operational failures of the main and auxiliary, electrical and piping systems of ships.

2. Q. How does engineering casualty control attain its highest degree of effectiveness?

   A. Through casualty prevention. By a combination of sound design, careful inspection, thorough plant maintenance, and effective organization and training.

3. Q. What is the purpose of the chief engineer's departmental organization chart?

   A. To delegate responsibilities covering the operational maintenance inspections for various machinery, equipment and systems.

4. Q. For what purpose are machinery history, record cards, manufacturers' manuals and instruction books maintained?

   A. To guide engineering operating personnel as to when machinery, equipment and systems require service and repair, and for location of parts and final assembly.

5. Q. Where should operating instructions for machinery, equipment and systems be posted?

   A. Adjacent to the machinery, equipment, and systems.

6. Q. What two failures contribute most to engineering casualties?

   A. Personnel failures and material failures.

7. Q. When maneuvering in restricted waters, it is imperative that continuity of service be maintained. How can this be done?

   A. Damaged units must be removed from service and standby or alternate units put into operation before searching for the cause of trouble.

8. Q. What are the objectives of engineering casualty control?

   A. (1) The proper maintenance of boilers, propulsion and auxiliary machinery, lighting, interior and exterior communications, firemain supply and miscellaneous services.

   (2) The prevention or minimizing of personnel casualties, and secondary damage to vital machinery.

9. Q. What is considered the "keystone" of effective casualty control?

   A. Complete knowledge of the engineering installation and the normal operating procedures.

10. Q. What considerations and precautions should be taken when conducting a realistic casualty drill?

   A. (1) The state of training and ability of the crew.

(2) Visualize possible errors and the consequences which may result.

(3) Dry runs should always be conducted before actually attempting to simulate any involved casualty, regardless of the state of training of the engineering personnel.

B. Application. Apply these concepts in continuing shipboard engineering casualty exercises and drills.

# CHAPTER 6

## ENGINEERING CASUALTY CONTROL - For Engineering Personnel (Lesson Plan)

## Section 6.2

## BOILER AND BOILER FEEDING MACHINERY CASUALTIES



I. OBJECTIVES.

A. To explain typical boiler and boiler feeding machinery casualties.

B. To instruct engineering personnel in the basic procedures and standards to follow in controlling and minimizing major and minor boiler and boiler feeding machinery casualties.

C. To emphasize the importance of observing sound engineering and safety practices when performing casualty control remedial action.

II. MATERIALS.

A. Training Aids.

1. The chief engineers' organization manual.

2. Engineers' standard watch list.

3. The machinery and equipment operating instructions.

4. Manufacturers' instruction and operating manuals.

5. MSTSPACAREA Engineering Casualty Exercise Book.

6. Ship's blue prints.

B. References.

1. COMSTS INSTRUCTION P3120.2B, latest edition, Chapter 2, Section 8.

2. Section 1.6, Engineering Casualty Bill.

3. BUSHIPS Technical Manual, Chapters 51, 55, and 56.

4. Engineering Operating and Maintenance (NAVPERS 10813-A).

5. Maintenance Manual, MSTSPAC INSTRUCTION 4700.3.

6. U. S. Coast Guard Regulations.

7. Safety Manual for Marine Oil-Fired Watertube Boilers, National Safety Council.

III. INTRODUCTION.

A. Introduce self and subject - Boiler and Boiler Feeding Machinery Casualties.

B. Establish scope of lesson as including the remedial actions to be taken by engineering personnel for the following casualties:

1. Low water in the boiler.

2. Main feed pump failure.

3. Loss of fuel oil pressure.

4. Damaged tube or boiler pressure part.

5. High water in the boiler.

6. Forced draft blower failure.

7. Failure of automatic combustion control.

8. Water in the fuel oil.

9. High salinity in the boiler water while steaming.

10. Broken water gage glass.

11. The brick work or plastic falls out of the boiler furnace wall.

12. Flareback.

13. Stack uptake fires.

14. Boiler casing fires.

C. Arouse Interest. The primary cause of engineering casualties is the inattention of engineering personnel to standard operating procedures and to maintenance of equipment and systems.

1. For instance, because a night relief engineer in the USNS SCHUYLKILL thought he saw water in a gage glass, the Government paid $58,000 for boiler repairs. Had the glass been blown down with steam, this could have been avoided.

2. In another case, the relieving chief engineer did not familiarize himself with the critical condition of the starboard boiler in the USNS MARINE FIDDLER prior to the acceptance of the ship, and the relief night engineer did not ascertain reasons for the rapid drop in the boiler water before lighting off the boiler a second time during the day. The boiler suffered severe damage, resulting in a $96,000 cost to the Government for repairs.

3. Boilers may be compared with the human heart in that both supply energy for propulsion. Therefore, the importance of boiler and boiler feeding machinery casualty control cannot be over emphasized.

IV. PRESENTATION.

A. Initial Action. In the event of a casualty, several initial actions must be taken immediately. These will include:

1. Notifying the bridge via telephone and/or engineroom telegraph if the maneuvering capabilities of the ship are impaired, or if a change of speed is necessary to aid in correcting or minimizing the casualty.

2. Notifying the chief engineer.

3. Controlling the casualty to prevent further damage.

4. Restoring the normal operating effectiveness of the ship as soon as possible by using isolation or bypassing methods, or by utilizing available standby units.

B. Types of Boiler Casualties and the Remedial Procedures Required.

1. Low water in the boiler. This is a major casualty which can seriously damage a boiler. It will require the following remedial procedures to control the casualty:

a. Secure the fuel oil supply to the burners of the affected boiler immediately.

b. Close the feed water check valves.

c. Blow down the water level gage glass to determine the true water level in the boiler.

d. Secure the blower leading to the boiler and secure all steam stop valves of the affected boiler.

e. Reduce the steaming requirements of the engineering plant to the capabilities of the remaining operating boiler or boilers.

f. Relieve the affected boiler of its pressure by the use of the hand releasing gear of the boiler and super heater safety valves.

g. No attempt should be made to put the boiler back in service until it has been inspected for damage from over-heating of the pressure parts.

h. Let boiler cool slowly and carry out instructions of Bureau of Ships Technical Manual, Chapter 51.

2. Main feed pump failure. This is a major casualty because it will affect the water level in a boiler and can result in a boiler failure due to low water. The effectiveness of engineering watch personnel in controlling this casualty can alter its classification from a major casualty to a minor casualty. The following remedial procedures should be taken:

a. Start the standby feed pump, which should have been lined up in advance and readied for immediate use.

b. The capacity of the standby feed pumps must be considered, and the operating load adjusted accordingly.

c. Until the plant is operating satisfactorily, the cause of the casualty to the feed pump is secondary.

d. As soon as possible after the plant is back in normal operation, a thorough check of the pump should be made to determine the cause of the failure, and repairs should be made immediately.

3. Loss of fuel oil pressure. Loss of fuel oil pressure to the burners can result in a shutdown of the boilers and machinery if not corrected immediately. The following corrective action by the engineering watch may prevent a serious casualty from developing:

a. If the fires are out, secure the burner valves and shift the combustion control to manual.

b. Reduce the boiler load to conserve steam.

c. Shift the fuel oil pump suction to the other settling tank.

d. If pump failure, shift to the standby fuel oil service pump.

e. When the fuel oil pressure is restored, the fires may be relighted and combustion control placed on automatic.

f. If the fuel oil pressure cannot be restored at once, it may become necessary to secure the boiler steam stops to prevent the complete loss of steam while the cause is being determined and remedies effected.

4. Damaged tube or boiler pressure part. When a damaged tube or other pressure part of a boiler carries away, a serious casualty will result. Proper control must be employed immediately to prevent secondary casualties and/or injury to personnel. The following remedial action should be taken:

a. Secure the fuel oil to the burners and speed up the blowers for carrying steam up the smokestack.

b. Adjust the boiler load.

c. Secure the boiler stops and release the steam pressure by operating the safety valves by hand.

d. While the boiler is hot, continue feeding to maintain the water level except where the failure was caused by low water level.

e. The blowers may be secured when the pressure has decreased and the steam is no longer escaping into the fireroom.

f. Allow the boiler to cool slowly until a man can enter to determine the extent of damage.

5. High water in boiler. This condition can cause a major casualty to main propulsion turbines and turbine generators. Water carried over with the steam may impinge on the turbine blades causing vibration, slowdown and possible broken blades. Therefore carry-over must not be allowed to occur. The following remedial action should be taken:

a. Close the boiler feed checks.

b. Adjust the boiler load.

c. It may be necessary to cut out the boiler and use the bottom blow to lower the water level. Blow the gage glass frequently to determine the true water level. Never blow down the water-wall headers.

d. Check the feed pump pressure regulator, the water level regulator, and adjust or repair them before returning the boiler to the line.

6. Forced draft blower failure. A loss of air pressure for combustion will cause the boiler to pant and possibly create a casing or boiler mounting casualty. The following remedial procedures should be taken:

a. Secure the oil to the burners.

b. If two blowers are in operation, speed up the unaffected blower and open the crossover dampers, if so fitted. If available, put the standby forced draft blower into operation. Reduce the speed to meet the lower steaming rate.

c. Purge the furnace thoroughly with fresh air and relight the fires using a torch.

d. Where the draft is insufficient for all boilers, secure the affected boiler and operate at a reduced speed.

e. It may be possible to operate the boiler on natural draft for an auxiliary steam supply.

7. Failure of the automatic combustion control. When the automatic combustion control fails, the air-oil ratio may become unbalanced and cause serious secondary casualties. Unless proper corrective measures are taken immediately, the steam pressure will be reduced, possibly resulting in the loss of main propulsion and auxiliary machinery. The following remedial action should be taken:

a. Shift to direct manual control.

b. Regulate the air supply leading to the furnace by use of the hand lever and locking device on the forced draft damper control.

c. Adjust the fuel oil pressure by use of the hand jack on the fuel oil control valve, or through use of the control valve bypass.

d. Regulate the water level in the boiler by use of the feed water control valve hand jack, or by the main or auxiliary feed checks.

e. If the steam pressure is reduced considerably, it may be necessary to slow the main engine until the pressure is restored.

f. Check out the control system thoroughly. When repairs have been made, the unit may again be shifted to automatic control.

8. Water in the fuel oil. This condition may lead to a casualty which will require securing the main propulsion and auxiliary machinery. This may be averted if prompt action is taken by the engineering watch personnel. The following remedial action should be taken:

a. Shift the fuel oil pump suction from low to high suction, or shift to the other settling tank.

b. If the fires continue to sputter or go out, slow the main engine to conserve steam.

c. Put the fuel oil transfer pump on the low suction of the contaminated settling tank and pump overboard if at sea, or into the sludge tank, cofferdam or empty fuel oil tank if in port.

d. Small amounts of water may be burned out if the fires can be kept burning.

9. High salinity in the boiler water while steaming. This condition will result in the severe priming and scaling of the boiler shell and tubes. It may also lead to boiler casualties or secondary casualties due to the carry-over to the main and auxiliary machinery.

a. High salinity may result from salt water leaks in the following:

(1) Main and/or auxiliary condensers.

(2) Salt water cooled air ejectors.

(3) Distilling plants.

(4) Salt water cooled gland exhaust condensers.

b. High salinity may be detected before a casualty occurs, by:

(1) High reading of the salinity indicators.

(2) Loss of superheat.

(3) Chemically testing the boiler water.

c. When high salinity is detected, the following procedures should be followed:

(1) Reduce the boiler load to prevent priming.

(2) Remove the boilers from the line one at a time and freshen up by use of the bottom blow and by feeding with uncontaminated water.

(3) Do not let the water get below a safe level in the water gage glass.

(4) Locate the source of salinity and correct the cause.

(5) Compound the boilers to restore the chemical ratio within the boilers.

(6) The boilers may be put on continuous blow to the evaporators when steaming.

(7) When salinity has been reduced to a safe level, restore the plant to normal operation.

10. Broken water gage glass. When a water glass on a boiler carries away, serious injury may result to personnel close to the gage glass. Remedial action should be as follows:

a. Secure the top and bottom of the water column of the damaged glass by using the quick closing valves. (Pull chains.)

b. Open the drain on the water column of the broken glass.

c. Remove the broken gage glass assembly and replace it with a properly assembled gage glass.

d. Use the other gage glass to maintain the proper water **level**.

11. The brickwork or plastic falls out of the boiler furnace wall. When this casualty occurs, the boiler casing is subjected to overheating, and may result in severe warping. If this condition is noticed in time, a serious casualty may be averted by the following action:

a. Secure the fuel oil to all burners on the affected boiler.

b. Reduce the steaming load on the boiler and cut out the affected boiler.

c. If it is necessary to continue operating the boiler, the burners adjacent to the brick or plastic fall-out should be secured to avoid any possible damage to the boiler casing.

d. When the boiler has cooled sufficiently, the brickwork or plastic may be patched, and the boiler put back on the line.

12. Flareback. This casualty may cause injury to personnel, damage to the boiler and fittings, or fires in the uptakes or casings.

a. This casualty may be the result of:

(1) Temporary interruption of the fuel supply.

(2) Insufficient draft.

(3) Unburned combustible gases in the furnace, uptakes, or air casings.

(4) Pressure in the furnace momentarily exceeding that of the air casing.

(5) Failure to use a torch when relighting a fire.

b. Remedial action should be taken as follows:

(1) Close the quick-closing master oil valve leading to the burner manifold and the burner oil supply valves.

(2) Reduce the load on the boilers and, after carrying out the initial action in paragraph IV.A., cut out the boiler.

(3) Use firefighting equipment if necessary.

(4) Adjust the feed check valves or stop the feed pump as necessary.

(5) Speed up the forced draft blowers to clear the furnace.

(6) Inspect the affected boiler for damage and test it prior to returning it to service.

13. Stack uptake fires. A casualty of this nature will reduce the steaming capacity and will burn out the air heaters and economizers if fitted. It is important that soot does not accumulate in the uptakes. The regular use of soot blowers and the periodic cleaning of the stack and uptakes will accomplish this.

a. Stack uptake fires are caused by:

(1) Poor and incomplete combustion.

(2) Accumulation of soot due to insufficient soot blowing and cleaning of tubes and uptakes.

(3) Defective soot blowers, or the improper sequence of tube blowing.

b. The following procedure should be followed immediately upon detecting a fire in the uptakes:

(1) Secure the oil supply leading to the burners and close the air registers.

(2) Secure the forced draft blower on the affected unit, or close damper.

(3) Reduce the load on the boilers as necessary and cut out the boiler, making sure that the superheater circulating line is open.

(4) Raise the water level as high as is practical to insure that the pressure parts of the boiler are filled with water.

(5) Carefully open the uptake door and smother the fire using $CO^2$ or a hose equipped with a fog spray nozzle. The semi-fixed $CO^2$ system in the fire room may be used.

(6) DO NOT USE THE STEAM SOOT BLOWERS at this time, because severe gas explosion may result.

(7) After the fire is out, inspect the area thoroughly before returning the boiler to the line.

14. Boiler casing fires. These fires are caused by unburned combustible material accumulating in the casing, usually from dripping or leaking burners. The following procedure should be followed in the event of a boiler casing fire:

a. Secure the fires in the affected boiler immediately.

b. Secure the forced draft blower and close the air registers.

c. Reduce the load on the boiler as necessary.

d. Turn on the smothering steam leading to the air casing containing the fire.

e. Cut out the affected boiler, making sure the superheater circulating line is open.

f. After the fire is extinguished, examine the air casing thoroughly to determine the extent of damage before returning the boiler to the line.

g. Determine the source of accumulation of combustible material in boiler casing and take corrective action.

V. SUMMARY. Review key aspects of boiler and boiler feeding machinery casualties.

A. Personnel Failures.

1. Improper maintenance.

2. Inattention to standard operating practices and procedures.

B. Material Failures. Breakdowns by deterioration not due to personnel.

C. Initial Action.

1. Notify the bridge of all casualties requiring speed changes or casualties affecting the maneuvering capabilities of the ship.

2. Notify the chief engineer.

3. Control the casualty.

4. Restore the ship to normal operation as soon as possible.

D. Types of Casualties and Remedial Action. Review briefly the key points of the following boiler and boiler machinery casualties and remedial action:

1. Low water in the boiler.

2. Main feed pump failure.

3. Loss of fuel oil pressure.

4. Damage to pressure part.

5. High water in the boiler.

6. Forced draft blower failure.

7. Automatic combustion control

8. Water in the fuel oil.

9. High salinity in the boiler.

10. The water glass carries away.

11. The brick or plastic falls out of the furnace wall.

12. Flarebacks.

13. Stack uptake fires.

14. Boiler casing fires.

E. Prompt Action. Stress the importance of prompt action and proper procedures in correcting or controlling a casualty. There isn't time, in a boiler casualty, to open the book and determine the proper action. You've got to know this in advance.

VI. TEST AND APPLICATION.

A. Test. Use the following and additional questions as an oral quiz.

1. Q. What is the result of improper maintenance or inattention to standard operating procedures?

   A. Operating failures.

2. Q. What initial action must be taken when an engineering casualty occurs?

   A. (1) If the maneuvering capabilities of the ship are impaired or if speed changes are required when correcting or minimizing the casualty, the bridge must be notified immediately; by telephone and/or the engine order telegraph.
   (2) Notify the chief engineer.
   (3) Control the casualty to prevent secondary effects resulting from the casualty.
   (4) Restore the ship to its normal operating effectiveness as soon as possible by isolating and bypassing methods and/or by using available standby units.

3. Q. Upon the discovery of a loss of water level in a boiler, what is the first action that should be taken?

   A. Secure the fuel oil supply to the burners immediately.

4. Q. How may a main feed pump failure affect the boilers?

   A. A main feed pump failure may cause a low water level in the boilers, resulting in the loss of the boilers from overheating.

5. Q. If the main feed pump fails, what should be done to insure a supply of boiler feed water?

   A. The standby feed pump should be lined up and ready.

6. Q. If the fuel oil pressure to the burners cannot be restored at once, is it advisable to secure the boiler steam stops? Why?

   A. Yes, to conserve steam while the cause is being determined and the remedies effected.

7. Q. When a boiler pressure part carries away, why is it necessary to speed up the blowers?

   A. The blowers must be sped up to carry the steam up the smokestack, thus keeping it out of the fireroom.

8. Q. What is the prime danger of high water level in the boilers?

   A. Water may carry over with the steam and impinge on the turbine blades causing vibration, slow down, and possible broken blades.

9. Q. What condition would indicate a forced draft blower failure?

   A. Low pressure on draft indicator, black smoke and boiler panting.

10. Q. When the automatic combustion control fails, what must be done to regulate the fuel oil pressure?

    A. After shifting to the direct manual control, the fuel oil pressure may be regulated by the use of a hand jack on the fuel oil control valve or by the control valve bypass.

11. Q. When water in the fuel oil is encountered, what initial action should be taken?

    A. Shift the fuel oil pump suction from low to high suction, or shift to the other settling tank.

12. Q. How may salt water contaminate boiler water, and how is it detected?

    A. Salt water may leak into the condensate through the main or auxiliary condensers, salt water cooled air ejectors, distilling plants, or through salt water cooled gland exhaust condensers. It may be detected by the high reading of the salinity indicator, by loss of superheat, or by chemically testing the boiler water.

13. Q. List at least three causes of a flareback.

    A. (1) Temporary interruption of the fuel supply.
    (2) Insufficient draft.
    (3) Unburned combustible gasses in the furnace, uptakes, or air casing.
    (4) Pressure in the furnace momentarily exceeding that of the air casing.
    (5) Failure to use a torch when relighting fires.

14. Q. An accumulation of soot due to insufficient soot blowing and inadequate cleaning of tubes and uptakes may lead to what type of casualty?

    A. Stack uptake fires.

15. Q. Would it be advisable to use steam soot blowers on stack uptake fires? Why?

    A. No. A severe gas explosion may result.

B. APPLICATION. Check engineering personnel's identification of these boiler casualties and ability to control them during required practical engineering casualty control exercises and drills.

# Boiler Fires

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Those who have seen an uncontrolled boiler fire, or its results, know that it is a serious matter. Damage ranges from minor casing distortion up to complete boiler destruction.

Disregarding the controlled firing for which the boilers were built, there are basically two sorts of undesired fires: those contained within the air casing, and those contained within the furnace and gas passages.

Of the first type—in boiler casings—these ordinarily occur as a result of oil accumulations within the casing which originate from burner drips. There are, of course, those exceptions where trash remains under a boiler after workmen leave or where accumulated oil in a furnace actually leaks through floor refractory and defective brickpans. All of these sources can be eliminated by proper inspection.

The greatest offender, burner drip, can be controlled by: proper burner assembly, maintaining clean tips, insuring complete shut off of idle burners and keeping poke holes clear. Air casings are provided with illumination and periscopes where necessary which permit surveillance of the drip area to insure detection of any oil that may accumulate under burners. Of course, failure to maintain these aids in working order is like allowing your insurance to lapse. Innumerable boilers have been observed to have these safety aids so neglected as to make them useless. As an assist to proper viewing of the drip area, white painting of the region is recommended. Aluminum paint is next best.

Extinguishing a casing fire is relatively simple, provided that the installed steam smothering system has been properly maintained. All that is necessary is securing fires in the furnace to permit securing the blowers and turning on the smothering system steam. If your insurance is paid up; i.e., smothering system intact and operable, this will defeat the fire. Stubborn fires that may reflash due to gross accumulations of oil in the casing can be subdued by steam and secured by introducing foam through the various inspection ports on the boiler front.

Obviously the first line of defense must be workable. Smothering lines have a tendency to rust internally and this both weakens the pipe and plugs the distribution holes. Testing at regular 600-hour fireside cleaning intervals should include poking the holes clear with a piece of stiff wire, removal of the cap from the end of each run of distribution piping and blowing through with steam to remove loose accumulations. Follow this by reinstalling the pipe caps and testing the system with full available steam pressure. Mirrors can be used to observe discharge from the distribution pipe and can be best observed if condensate is allowed to accumulate in the steam line before testing. It is simply easier to see water discharge than steam discharge.

A more serious fire is the uncontrolled fire that occurs within the furnace or gas passage. During 1962 there were at least two fires so disastrous as to totally melt the generating tubes and economizers. In one instance, even the mud drum was burned. This fire is believed to have originated in a heavy soot formation which was deposited in gas passages during a protracted period of incomplete fuel combustion.

The other serious casualty also resulted from improper combustion but, in this case, the cause was directly determinable. A burner had been installed with no sprayer plate and simply poured a large quantity of oil onto the furnace deck. Despite heavy black smoke, it took this crew nearly an hour and a half to locate the offender. At this time, burners were secured but the fire continued. Assuming that this was a casing fire, the boilerroom crew wrapped up the boiler—fuel, blowers, feed stops, steam stops and all. Since the fire continued to rage within the boiler and no cooling fluid (water/steam) could flow through the tubes, the boiler naturally burned down.

*These fires were preventable. Even after fires started, major boiler damage was preventable.*

**Prevention of Fire**

The fires were preventable in that proper combustion can be maintained in all Naval boilers. Admittedly, someone has to check on furnace conditions from time to time. Black smoke is certainly a strong indication that the boiler is not digesting its fuel properly. Black smoke is a soot maker. Soot will burn like coke and if allowed to accumulate in the upper reaches of a boiler, it may burn where there is no refractory to contain it. Routine

(REPRINTED FROM BUSHIPS JOURNAL, JUNE 1963)

observations of stack discharge, and smoke periscopes and through furnace peep holes can be relied upon to detect improper combustion. Correction, however, must be more prompt than the occasion where it is reported to have taken an hour and a half to find a burner with no tip installed.

Cleanliness in boilers is essential, not only for economy and good operation but to eliminate sources of fire. Economizers should always be inspected and cleaned following any period of known bad combustion.

**Prevention of Damage**

There is bound to be some damage from an uncontrolled fire. It is even possible that more damage will result from firefighting than from the fire. However, it should be possible to minimize the damage by prompt and proper treatment.

Experience has shown that economizer (soot) fires invariably occur immediately after a boiler is either lit-off or secured. These are periods when the economizer tubes may be dry due to failure to test feed-pump line-up prior to light off or drainage of the economizer to the steam drum after securing. So long as water remains in the economizer tubes, it is practically impossible to attain the necessary ignition temperature.

Similarly, with uncontrollable fire in a furnace, fluid flow must be maintained through the waterside circuits to prevent tubes from reaching destructive temperatures.

The use of blowers must be decided by the location of the fire. If in economizer or uptakes, blowers should be stopped so as to help smother the fire. If the fire is from an oil bath in a furnace, a moderate air supply should be maintained to prevent soot formation in the economizer area. If the fire is in the boiler casing, blowers should be secured. In any case, however, feed water flow should continue. If the boiler has pressure, continue to extract steam. Steam may be delivered to the normal system, to the superheater protection system, to high pressure drains or even to bilge. If there is no pressure on the boiler, drains to bilge can be opened to maintain a flow of water through the waterside circuits even though superheaters are flooded. So long as water is kept within the tubes, they cannot be damaged by the fire (provided, of course, that watersides are not so heavily scaled as to prevent heat transfer).

In controlling a boiler fire, the most immediate problem is to locate the fire. Having done this, the method of attack is as follows:

- *Casing.* Secure fires and blowers. Maintain water/steam flow. Use steam smothering followed by foam application if required.
- *Economizer.* Secure fires and blowers. Maintain water/steam flow. Attack fire with water through uptake access next above the economizer. After wetting as thoroughly as possible by this means, use soot blowers to assist with steam from below. Premature use of soot blowers will simply stir up more soot and may create an explosive mixture.
- *Furnace Fire.* Secure oil supply and minimize air supply. Maintain flow of water/steam. Allow accumulated fuel to burn off.

# CHAPTER 6

## ENGINEERING CASUALTY CONTROL - For Engineering Personnel (Lesson Plan)

## Section 6.3

## CASUALTIES OF ENGINE ROOM MACHINERY



I. OBJECTIVES.

A. To describe typical casualties of engine room machinery on turbine, turbo-electric and Diesel-powered ships.

B. To instruct engineering personnel in procedures to control or minimize engine room machinery casualties.

C. To emphasize the importance of observing safe engineering practices during casualty control.

II. MATERIALS.

A. Training Aids.

1. The Chief Engineers' Organization Manual.
2. Engineers' standard watch list.
3. The machinery and equipment operating instructions.
4. Manufacturers' instruction and operating manuals.
5. MSTSPACAREA Engineering Casualty Exercise Book.
6. Ship's blue prints.

B. References.

1. COMSTS INSTRUCTION P3120.2B, Chapter 2, Section 8.
2. Section 1.6, Engineering Casualty Bill.
3. BUSHIPS Technical Manual, Chapters 41 and 43.
4. Engineering Operation and Maintenance (NAVPERS 10813-A).
5. Maintenance Manual, MSTSPAC INSTRUCTION 4700.3.
6. U. S. Coast Guard Regulations.

III. INTRODUCTION.

A. Introduce self and subject, Casualties of Engine Room Machinery.

B. Establish scope of the lesson. Personnel failures are the prime factors that cause casualties. This is generally due to the improper maintenance of equipment and the inattention of engineering personnel to standard operating practices and procedures. The following engineering casualties and remedial procedures for coping with them will be covered:

1. Loss of or low lubrication oil pressure.
2. Loss of vacuum on the main unit.
3. Jammed main engine throttle.
4. Leak in the main condenser.
5. Main turbine vibration.
6. Propeller or shaft damage.
7. Hot bearings.
8. Deaerating feed tank casualty.
9. Oil in the condensate system.
10. Air compressor casualty.
11. Loss of forward or after engine room (P-2).
12. Fire in the propulsion motor or generator (P-2).
13. Fire in the propulsion control cubicles or cable (P-2).
14. Engine slows down (Diesel).
15. Engine stops suddenly (Diesel).
16. Low lube oil pressure (Diesel).
17. Governor failure (Diesel).
18. High fresh water cooling temperature (Diesel).

C. Arouse interest by pointing out that most casualties to engine room machinery will shut down the plant and will affect other systems such as lighting, heat, ventilation and sanitation. Prevention of casualties is the most effective form of casualty control. By preventing casualties, the possibility of a loss of propulsion or of other engineering systems is greatly reduced.

IV. PRESENTATION.

A. Initial Action. In the event of a casualty, the following initial action must be taken immediately:

1. Notify the bridge via telephone and/or engine room telegraph if the maneuvering capabilities of the ship are impaired, or if a change of speed is necessary to correct or minimize the casualty.

2. Notify the chief engineer.

3. Control the casualty to prevent further damage.

4. Restore the normal operating effectiveness of the ship as soon as possible by using isolation or by-passing methods, or by utilizing available standby units.

B. Casualties and Remedies. Types of engine room machinery casualties and their remedial procedures follow:

1. Loss of or low lubricating oil pressure. This condition may lead to a serious bearing or reduction gear casualty.

a. Symptoms. Any of the following conditions will indicate loss or reduction of lubricating oil pressure, and must be investigated immediately:

(1) Pressure falls off on the lube oil pressure gage.

(2) Oil is not passing the bull's eye of the overflow from the gravity tank.

(3) Ringing of the low lube oil pressure alarm.

(4) Closing of the ahead throttle by the action of the lube oil pressure governor.

b. Causes. Some of the causes of loss of lube oil pressure are:

(1) Main lube oil pump failure and standby lube oil pump fails to start.

(2) Restriction in lube oil piping, strainers or pump.

(3) Low or empty lube oil sump or gravity tank.

(4) Lube oil too hot for the pump to maintain the required discharge pressure.

(5) Large lube oil leak.

(6) The purifier dumping oil to bilge.

c. Remedy. An uninterrupted supply of the lube oil must be maintained at all times while the main unit is operating. If the lube oil pressure falls off or is lost, the following action should be taken:

(1) Stop the unit as soon as possible.

(2) Check out the causes of the casualty and correct them.

(3) Ensure the flow of oil to all bearings, gears, etc., before returning the unit to service.

(4) After the unit is back in service, check periodically for hot bearings.

2. Loss of vacuum on the main unit. A loss of vacuum is accompanied by a loss of or greatly reduced power output of the main propulsion unit.

a. Symptons. Indications of a loss of vacuum are:

(1) Reduced or no reading on the vacuum gage.

(2) Main unit slows.

(3) A temperature rise in LP exhaust of main unit.

b. Causes. Some of the causes of loss of vacuum are:

(1) Loss of gland seal.

(2) Defect in the air ejector.

(3) Insufficient cooling water through the condensers.

(4) Insufficient circulating water through the air ejector.

(5) Air leaks from:

(a) Make-up feed system.

(b) Piping systems.

(c) Loop seal.

(d) Drain tank float valve.

c. Remedy. It is essential that a high vacuum be maintained to ensure the continued efficient operation of the plant. The following procedure should be followed when a loss of vacuum is discovered:

(1) Slow the main engine.

(2) Determine the reason for the loss of vacuum by checking:

(a) The gland seal.

(b) Cooling water through condenser.

(c) Circulating water through air ejector.

(d) For possible air leaks.

(e) The loop seal.

(3) Change to standby air ejector.

(4) When the vacuum has been restored, the main engine may be brought up to speed.

3. Jammed main engine throttle. The inability of the main throttle valve to function properly presents a casualty involving a loss of maneuverability of the ship, and could lead to collision or grounding. Remedial procedures are as follows:

a. If the throttle sticks open, use the main steam line stop valve for throttling.

b. In an emergency, use the astern throttle to stop the shaft.

c. If the astern throttle valve sticks, use the astern guarding valve for the astern throttle.

d. Check out the cause of the sticking valve and make repairs as soon as possible.

4. Leak in the main condenser. If a leak develops in the main condenser, salt water will leak into the condensate, and will be returned to the boilers. High salinity of the boiler water may cause serious scaling of the tubes and other heating surfaces. This may lead to priming or reduced steaming ability, with a loss or reduction of main propulsion power.

a. Causes. Leaks in the main condenser may be due to:

(1) Overheating of the condenser.

(2) Split or cracked tubes.

(3) Tubes leaking at tube sheet due to packing failure.

(4) Tubes in need of re-expanding.

(5) Electrolysis or erosive action of cooling water, causing pin holes in tubes.

b. Remedy. When high salinity is indicated by the salinity indicator, or by boiler water tests, determine that the condenser is leaking by testing condensate sample. If the condenser is leaking, the following procedures should be followed:

(1) If it is believed that the leak is small and arrival in port will be within hours:

(a) Pump sawdust through the cooling water side of the condenser.

(b) Keep the boilers fresh by blowing down as indicated by tests.

(2) If the leak is large and cannot be controlled by using sawdust:

(a) Secure the main engine.

(b) Shift all condensates to the auxiliary condenser.

(c) Secure main injection, overboard and vent valves when condenser is cool.

(d) Fill the fresh water side with warm distilled water.

(e) Remove inspection plates or condenser heads and inspect for leaks.

(f) Plug all leaks with approved type plugs, or reroll tubes leaking at the tube sheet.

(3) Return the plant to normal operation.

5. Main turbine vibration. Vibration of the main turbine will cause a reduction or loss of propulsion power, and may lead to serious secondary casualties if allowed to continue.

a. Causes. Vibration of the main turbine may be due to any of the following:

(1) Carryover of water with steam from the boilers.

(2) Damaged turbine blading.

(3) Distortion of the turbine due to uneven expansion.

(4) Damaged propeller or shafting.

b. Remedy. Turbine vibration must not be allowed to continue. The following action is necessary:

(1) Reduce the turbine speed.

(2) If the vibration is due to carryover, lower the water level in the boilers to a safe operating level.

(3) If due to damaged turbine blading, propellers or shaft, operate the unit at a speed where vibration is minimized as much as possible.

(4) If due to distortion, operate at slow speed until an even temperature is attained throughout the turbine.

6. Propeller or shaft damage. A casualty of this nature may cause serious secondary casualties to adjacent sections of shafting, bearings, reduction gears and engine, with accompanying reduction or complete loss of main propulsion power.

a. Symptons. Indications of this casualty are:

(1) Vibration of the shaft.

(2) Abnormal noises in the engine and reduction gears.

(3) Possible heating of the line shaft bearings.

(4) Possible heating of the stern tube bearing.

b. Remedy. The following procedures may be followed when this casualty exists:

(1) Reduce engine speed to minimize vibrations.

(2) Check through shaft alley to determine the cause of vibrations.

(3) If the casualty is in shafting or bearings in the shaft alley, make temporary repairs if possible.

(4) If repairs cannot be made, operate the engine at speeds which will minimize vibration as much as possible.

(5) Continue a check of bearings and shafting to prevent the spread of the casualty to unaffected parts.

7. Hot bearings. Abnormal temperature of bearings indicates a bearing casualty and may lead to a reduction or loss of propulsion power.

a. Symptoms. Check all abnormal temperatures or hot oil smells.

b. Causes. Overheating of bearings may be caused by the following:

(1) Failure of the lube oil system.

(2) Foreign matter in the lube oil system.

(3) Excessive wear or misalignment of the bearings.

c. Remedy for reduction gear bearings. Remedial procedures for casualties to the turbine, Diesel and reduction gear bearings are as follows:

(1) Reduce engine speed.

(2) Check quantity of lube oil to bearings, and clear any restrictions.

(3) Start purifier on lube oil system.

(4) Operate at reduced speeds which avoid abnormal temperatures.

(5) When operating conditions permit, inspect bearings for wear or misalignment.

d. Remedy for line shaft bearings. Remedial procedures for casualties to the line shaft bearings are:

(1) Reduce the engine speed.

(2) Check the lube oil level, wick feeds, and the oil rings.

e. Caution. Do not put cold water on the hot bearings.

8. Deaerating feed tank casualty. The ability of the D.A. tank to properly deaerate feed water and deliver it to the feed pump suction is of great importance in maintaining the plant's efficient operation. Any interruption in this process will cause loss of or reduced steaming capabilities of the ship.

a. Loss of heat. Remedial procedures to cope with the loss of heat in the deaerating heater are:

(1) Bleed live steam into the exhaust system to provide sufficient steam to keep D.A. temperature up.

(2) Check the exhaust steam regulator valve for proper operation.

b. Loss of water. Remedial procedures to cope with the loss of water in the deaerating heater are:

(1) Shift feed pump suction to the distilled water tank, and secure suction from D.A. tank.

(2) Check the following possible causes for loss of water in the D.A. heater:

(a) Condensate pump failure - mechanical or electrical.

(b) Adjustment of makeup feed or dump valve.

(c) Adjustment of condensate recirculating valve.

(d) Condensate spray nozzles in deaerator.

(e) Rupture in piping to or from deaerator, or in the tank itself.

9. Oil in the condensate system.

a. Causes. The condensate system may become contaminated with oil by any of the following:

(1) Leak in the bunker heating coils.

(2) Fuel oil heater leak.

(3) Leak in the cargo heating coils.

(4) Lube oil purifier heating coil leak.

(5) Sump tank heater coils.

(6) Gravity tank heater coils.

(7) Settling tank heater coils.

b. Remedy. A close watch should be maintained on the contaminated drain tank for indications of oil in the system.

(1) If oil is observed, isolate the drain tank and dump the drains into the bilge.

(2) Isolate the source of contamination and clean the drain tank before returning condensate to the tank.

(3) If oil is observed in the boiler gage glasses, secure the boilers one at a time and use surface blow until the glass shows clear.

(4) If oil shows in the deaerator, cut out and clean the heater.

10. Air compressor casualty. If the main air compressor fails, a standby compressor is usually set to cut in automatically and take the load.

a. If the standby compressor fails to cut-in, it may be started by hand; then the regulator is adjusted to cut in and out at the proper pressure.

b. Check the following parts of the main air compressor:

(1) The prime mover.

(2) Operation of the pressure controller and unloader.

(3) Intake filters, if dirty, clean with washing soda solution.

(4) Check for leaks in the piping, coolers and relief valves.

(5) Check "V" belt drive tension and set up on it if necessary.

11. Loss of forward or after engine room (P-2 type). A one generator, or two-motor operation may be necessary due to mechanical or electrical failure of the turbine or generator in one of the engine rooms. Remedial action should be as follows:

a. Maintain propulsion and steerage with unaffected unit unitl shift to one generator, two-motor operation is put into effect.

b. Set up motor transfer and disconnect switches for a one generator, two-motor operation as described by the manufacturer's instruction manual (available aboard ship for each particular unit).

c. Make temporary repairs within the ship's personnel capabilities.

12. Fire in the propulsion motor or generator (P-2 type). In addition to the possibility of fire spreading to the engine room, fire in a propulsion motor or generator causes an interruption in normal plant operation with the accompanying loss of maneuverability. Remedial action should be as follows:

a. Stop the unit and de-energize the motor or generator.

b. Secure the ventilation to the unit and trip the installed $CO^2$ fire extinguishing system on the motor. Use the portable $CO^2$ on the generator (unless a system is installed on the generator).

c. When the generator is affected, put in the jacking gear as soon as possible to prevent warping of the unit.

d. Maintain propulsion and steerage using the unaffected unit.

e. Make temporary repairs within the ship's personnel capabilities.

13. Fire in the propulsion control cubicles or cables (P-2 type). Short circuits, loose connections, accumulation of dirt and oil or moisture on or around electrical wiring of control hookups can cause a fire. Fire in the controller circuit could spread to other parts of the engine room, causing loss of the propulsion unit and reduced maneuverability if immediate action is not taken. The following remedial actions should be taken:

a. Stop the unit and de-energize the control circuits.

b. Extinguish the fire with $CO^2$.

c. Make necessary repairs to the controller circuit; operate at reduced load until assured the control circuit is functioning properly and the insulation tests are in accordance with the manufacturer's recommendations.

d. Maintain propulsion and steerage with the unaffected unit.

14. Engine slows down (Diesel). Power output and maneuverability of ship is reduced. Remedial action should include reducing the speed of the unit and checking:

a. The governor and controls.

b. Fuel oil system, strainers, filters, etc.

c. Fuel pump operation.

d. Exhaust system for obstructions.

15. Engine stops suddenly (Diesel). If twin screw, the power output and the maneuverability of ship is reduced. Remedial action should be as follows:

a. Check out the fuel system for obstructions or determine if air bound.

b. Check out the governor and controls.

c. Jack over the unit to see if the bearings are seized or frozen.

16. Low lube oil pressure (Diesel). This condition will cause overheating of the unit and burned out or seized bearings, shafting or pistons, etc., and may lead to the eventual loss of the unit.

a. Remedial action should include securing the unit immediately and checking the following:

(1) Lube oil level in the sump.

(2) Lube oil strainers and filters.

(3) Lube oil pump operation.

(4) For broken lube oil lines.

b. Caution. Do not start the engine again until the cause of low lube oil pressure is determined and repairs made.

17. Governor failure (Diesel). If the governor fails, the engine may either race or stop suddenly, causing excessive engine RPM or loss of power. The following remedial action should be taken.

a. If the engine starts to overspeed, secure the engine by the emergency stop control.

b. Check the governor oil level.

c. Check the setting of the needle valve.

d. Check the pilot valve and actuating linkage.

e. Flush out the governor and refill it with the proper oil.

f. Check the speed drop settings and correct as necessary in accordance with the manufacturer's instructions.

18. High fresh water cooling temperature (Diesel). Fresh water cooling of cylinder heads, cylinder jackets, exhaust valves, exhaust manifolds, etc., is an essential requirement in Diesel engine operation. Interruption of the cooling system may result in a serious casualty to the engine, producing reduced or complete loss of power output of the unit. Remedial action should be as follows:

a. Reduce the engine speed.

b. Check the fresh water level and pump operation.

c. Check the temperature regulator, valves and bypass regulator.

d. Vent air from the system and check for air leaks.

e. Check the system for obstructions in the suction and discharge sides.

f. Check the cylinders for cracks or gasket leaks between the fresh water side and compression side.

* NOTE: See effective revision of COMSTS INSTRUCTION 3540.5 covering operation of salt water and fresh water cooling systems for main and auxiliary engines in C1-ME2-13a class ships.

V. SUMMARY.

A. Personnel failures cause casualties through:

1. Improper maintenance.

2. Inattention to standard operating practices and procedures.

B. Action of engineering watch personnel during casualties includes:

1. Notifying the bridge of all casualties requiring speed changes or affecting the maneuvering capabilities of the ship.

2. Notifying the chief engineer.

3. Controlling the casualty.

4. Restoring the ship to normal operation as soon as possible.

C. Review briefly the key points of the following engine room machinery casualties:

1. Loss of or low lubricating oil pressure.

2. Loss of vacuum on the main unit.

3. Main engine throttle jammed.

4. Leak in the main condenser.

5. Main turbine vibration.

6. Propeller shaft damage.

7. Hot bearings.

8. Deaerating feed tank casualty.

9. Oil in the condensate system.

10. Air compressor casualty.

11. Loss of forward or after engine room (P-2 type).

12. Fire in the propulsion motor or generator (P-2 type).

13. Fire in the propulsion control cubicles, or cables (P-2 type).

14. Engine slows down (Diesel).

15. Engine stops suddenly (Diesel).

16. Low lube oil pressure (Diesel).

17. Governor failure (Diesel).

18. High fresh water cooling temperature (Diesel).

D. Stress the importance of prompt action and proper procedures in containing or controlling a casualty and of knowing beforehand how to cope with any casualty that may occur.

E. Emphasize that casualty <u>prevention</u> is the most effective form of casualty control.

VI. <u>TEST AND APPLICATION</u>.

A. <u>Test</u>. Use the following, and additional, questions as an oral quiz:

1. Q. What is the most effective form of casualty control?

   A. The <u>prevention</u> of casualties.

2. Q. What two failures contribute most to engineering casualties?

   A. Personnel failures and material failures.

3. Q. What action must be taken by the engineering watch personnel when a casualty occurs?

   A. (1) If the maneuvering capabilities of the ship are impaired, or speed changes are required when correcting or minimizing the casualty, the bridge must be notified immediately via the telephone and/or the engine order telegraph.
   (2) Notify the chief engineer.
   (3) Control the casualty to prevent secondary effects resulting from the casualty.
   (4) Restore the ship to normal operating effectiveness as soon as possible, by isolating methods, bypassing and/or using available standby units.

4. Q. What conditions will indicate a loss or a reduction of lubricating oil pressure to the main engine and reduction gears?

   A. (1) Pressure falls off on lube oil gage.
   (2) Oil not passing bull's eye of overflow from gravity tank.
   (3) Ringing of the low lube oil pressure alarm.
   (4) Closing of the ahead throttle by action of the lube oil pressure governor.

5. Q. A temperature rise in the LP exhaust of the main unit would indicate what condition?

   A. A loss of vacuum on the main unit.

6. Q. If the main engine throttle stuck in an open position, how would you shut down the main engine?

   A. By use of the main steam line stop valve.

7. Q. When high salinity is indicated by the salinity indicator, or by boiler water tests, how do you determine if the condenser is leaking?

   A. By testing condenser condensate sample.

8. Q. What must be done immediately when main turbine vibration is encountered?

   A. Reduce engine speed to minimize vibrations.

9. Q. What is the cause of abnormal termperatures of turbine, Diesel engine and reduction gear bearings?

   A. (1) Failure of the lube oil system.
   (2) Foreign matter in lube oil system.
   (3) Excessive wear of misalignment of bearings.

10. Q. What effect would a leak in bunker heating coils have on the condensate system?

    A. The condensate system would become contaminated with oil.

11. Q. Where would an oil leak to the condensate system show up first?

    A. At the contaminated drain tank.

12. Q. What is a one generator two-motor operation in a P-2 type ship?

    A. Where two motors are operated from one generator due to mechanical or electrical failure of the turbine or generator in one of the engine rooms.

13. Q. How would you combat a fire in a main propulsion motor in a P-2 type ship?

    A. Segure the ventilation to the unit and trip the installed $CO^2$ fire extinguishing system leading to the motor.

14. Q. What are the principal causes of fire in the propulsion control cubicles on P-2 type ships?

    A. Short circuits or loose connections, accumulation of dirt, oil or moisture on or around electrical wiring of control hookups.

15. Q. On a Diesel engine, what would be the results of low lube oil pressure?

    A. Overheating of the unit, burned out or seized bearings, shafting, pistons, and possible the eventual loss of the unit.