UNITED STATES
EXPERIMENTAL MODEL BASIN

NAVY YARD, WASHINGTON, D.C.

MODEL EXPERIMENTS TO DETERMINE THE RELATIVE EFFECT OF PROPELLER STRUTS AND BOSSINGS ON THE STEERING OF A TWIN SCREW SHIP

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U. S. EXPERIMENTAL MODEL BASIN
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The tests described in this report were undertaken at the U.S. Experimental Model Basin to establish the influence of propeller bossings as compared to propeller struts on the turning of a twin screw ship, and also to investigate the influence of cutting away the stern deadwood. For these experiments the 1:60 scale model of the U.S. Battleship "New Mexico," which had been previously used for rudder tests described in U.S.E.M.B. Report No. 106, was fitted for self-propulsion with two propellers of four inches diameter and four inches pitch. The displacement of the model for all the tests was 324 lb. and the initial speed was 2.84 knots, which corresponds to a ship speed of 22 knots. Only one rudder form, a conventional balanced rudder, was investigated. The area of this rudder was made twice the normal area in order to obtain a full turning circle within the limits imposed by the width of the model basin. This artificiality, of course, destroys the absolute value of the tests but should not impair their relative value.

The following five hull conditions were investigated, each at rudder angles of 35°, 40°, 45°, and 50°.

1) The original hull fitted with struts as shown in Fig. 1.

2) The original hull fitted with bossings, as shown in Fig. 1.

3) The original hull fitted with bossings and fins attached to and extending below the bossings, as shown in Fig. 1.

4) The model fitted with struts and with the stern deadwood partly removed, as shown in Fig. 2.

5) The model fitted with struts and with the stern deadwood completely removed, as shown in Fig. 2 and in the photograph Fig. 3.

METHOD of TESTING

The model with the rudder held on the center line was allowed to advance in a straight path to one side of the basin for a distance sufficient to reach steady speed. At a given instant the model was released and simultaneously an electric motor was started which turned the rudder through a worm gear arrangement to the desired angle, at which angle the gear became locked. The time required to lay the rudder was approximately one second. The path of the model with the rudder "hard over" was recorded photographically by means of a camera placed near the center of the turning circle some twenty-six feet above the model. A solid disc with a hole cut through it near the periphery revolved under the lens of the camera exposing the model once every half second. Small electric lights fixed near the bow and stern of the model left clearly defined marks on the photographic plate, thus fixing the position of the model every half second.

Typical records are shown in Figs. 4 and 5. Generally three plates were taken for each condition in order to enable fairing out small experimental errors inherent in the method.

EVALUATION of the TEST DATA

The coordinates of the bow and stern lights referred to rectangular axes, drawn through the position of the bow light at the instant of laying the rudder, were read from the plates and tabulated. The change of heading and the mean speed between recorded positions were then calculated and plotted against elapsed time and average curves were drawn through the spots. From these faired curves the turning circles for the bow light were recalculated and plotted in Figs. 6, 7, 8, and 9. The path of this point was chosen in preference to that of the center of gravity of the model because it was located practically on the line which has no velocity component normal to the fore and aft center line of the model, as appears in Figs. 4 and 5.

CONCLUSIONS

In spite of the limited scope of the tests, several conclusions may be drawn from them. First, as might be expected, the tactical diameter decreases in approximately a direct ratio as the rudder angle is increased from 35° to 45° and at a somewhat smaller rate for still larger angles. Secondly, for any given rudder angle the radius of curvature of the turning circle and the linear speed decrease until the model has turned approximately through 180° and thereafter remain constant, i.e. the path becomes a true circle.

The effect of the deadwood on the turning is quite marked. The curves show that the more the stern deadwood is removed, the more quickly the model enters the turning circle. This is what one would expect, considering that the model pivots about a point forward of the center of length and consequently the lateral resistance of the stern deadwood has a large lever arm. For the same reason the model fitted with struts enters the turning circle more quickly than when fitted with bossings. A complete reversal, however, takes place in the subsequent part of the turning circle, with the net result that the tactical diameter for the model with bossings is smaller than for the model with struts.

The following plausible explanation for this phenomenon is suggested: When the model has entered the turning circle the rudder becomes less and less effective until steady conditions have been reached, because the effective rudder angle becomes less and less. Now, it is reasonable to suppose that the bossings guide a considerable mass of solid water toward the rudder along the center line of the model, so that due to their presence the decrease in effective rudder angle is considerably minimized, with consequent greater rudder effort.

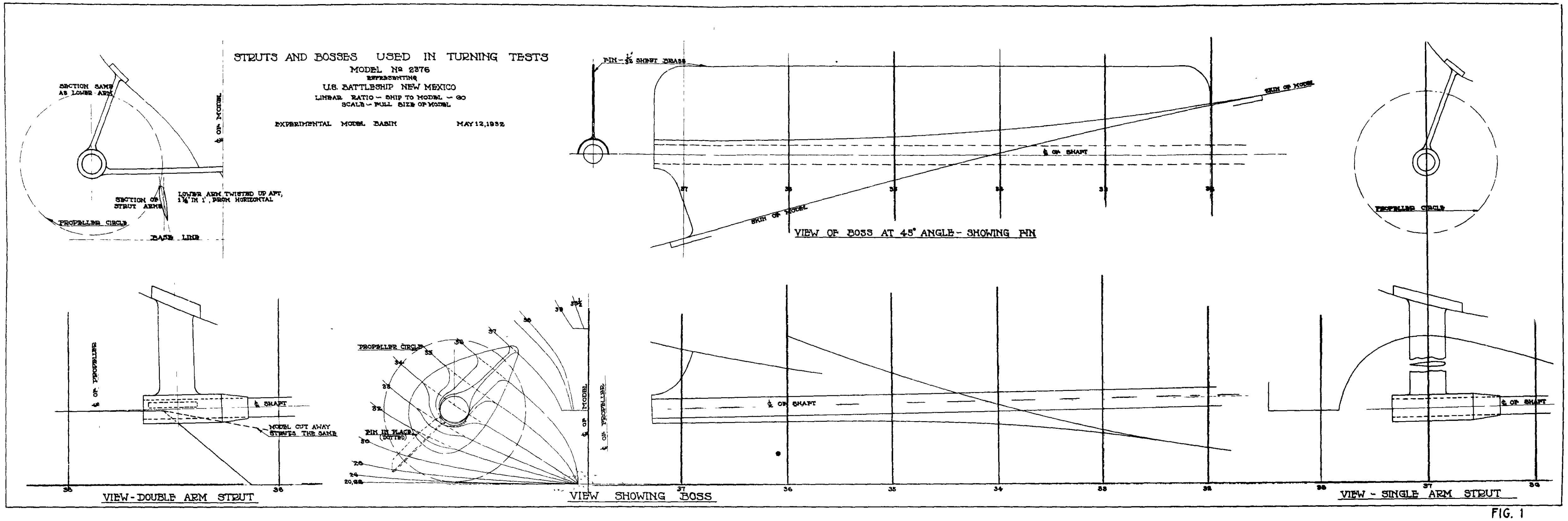
STRUTS AND BOSSES USED IN TURNING TESTS
MODEL Nº 2376
REPRESENTING
U.S. BATTLESHIP NEW MEXICO
LINEAR RATIO — SHIP TO MODEL — 60
SCALE — FULL SIZE OF MODEL
EXPERIMENTAL MODEL BASIN
MAY 12, 1932
SECTION SAME AS LOWER ARM
SECTION OF STRUT ARMS
LOWER ARM TWISTED UP AFT, 1¼" IN 1', FROM HORIZONTAL
PROPELLER CIRCLE
BASE LINE
℄ OF MODEL
PIN — ⅛" SHEET BRASS
SKIN OF MODEL
℄ OF SHAFT
VIEW OF BOSS AT 45° ANGLE — SHOWING PIN
℄ OF PROPELLER
MODEL CUT AWAY STRUTS THE SAME
PIN IN PLACE (DOTTED)
VIEW - DOUBLE ARM STRUT
VIEW SHOWING BOSS
VIEW - SINGLE ARM STRUT

FIG. 1

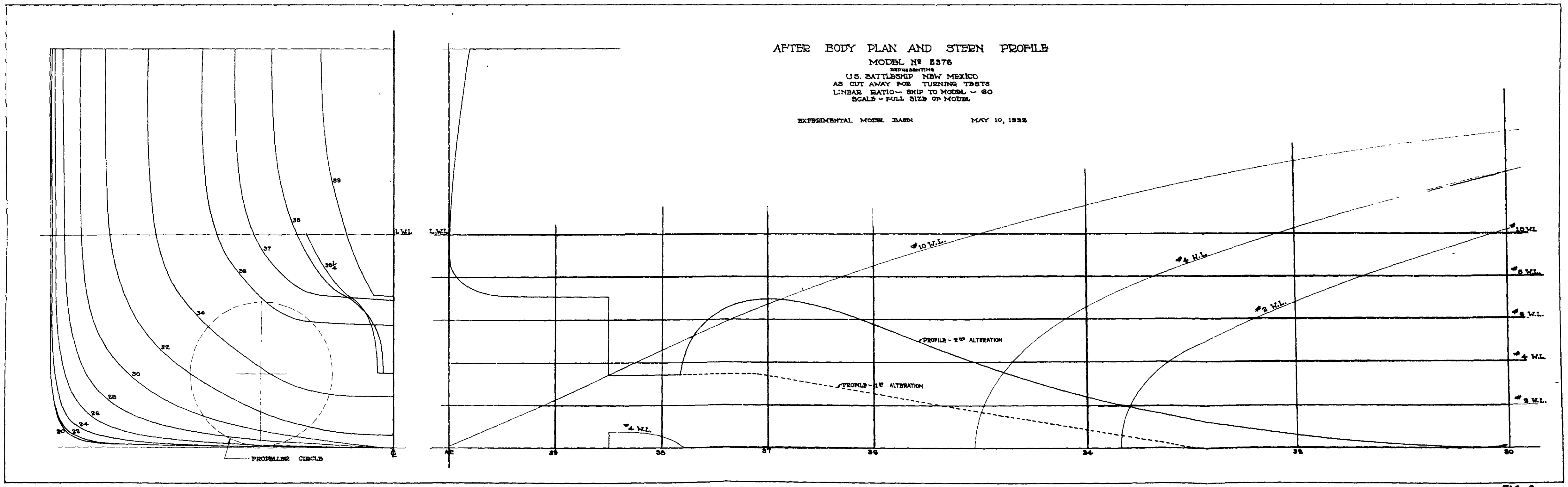
AFTER BODY PLAN AND STERN PROFILE
MODEL Nº 2376
REPRESENTING
U.S. BATTLESHIP NEW MEXICO
AS CUT AWAY FOR TURNING TESTS
LINEAR RATIO — SHIP TO MODEL — 60
SCALE — FULL SIZE OF MODEL
EXPERIMENTAL MODEL BASIN
MAY 10, 1932
L.W.L.
PROPELLER CIRCLE
PROFILE — 2ND ALTERATION
PROFILE — 1ST ALTERATION

FIG. 2

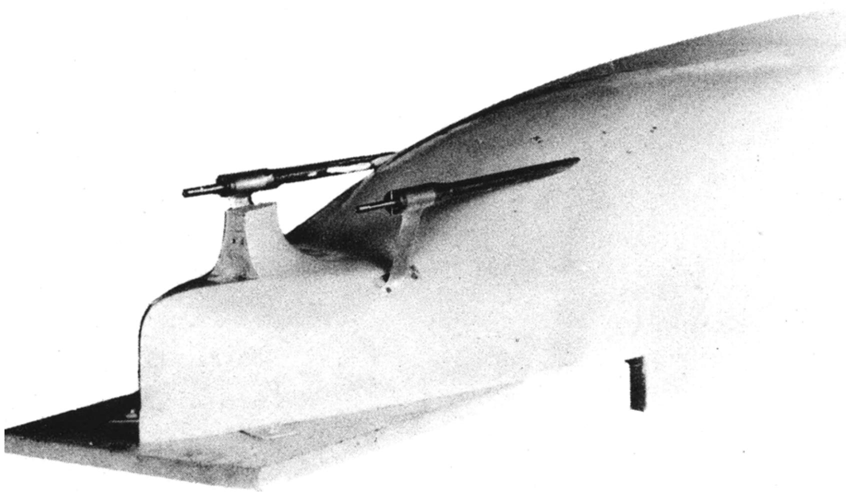

FIG 3

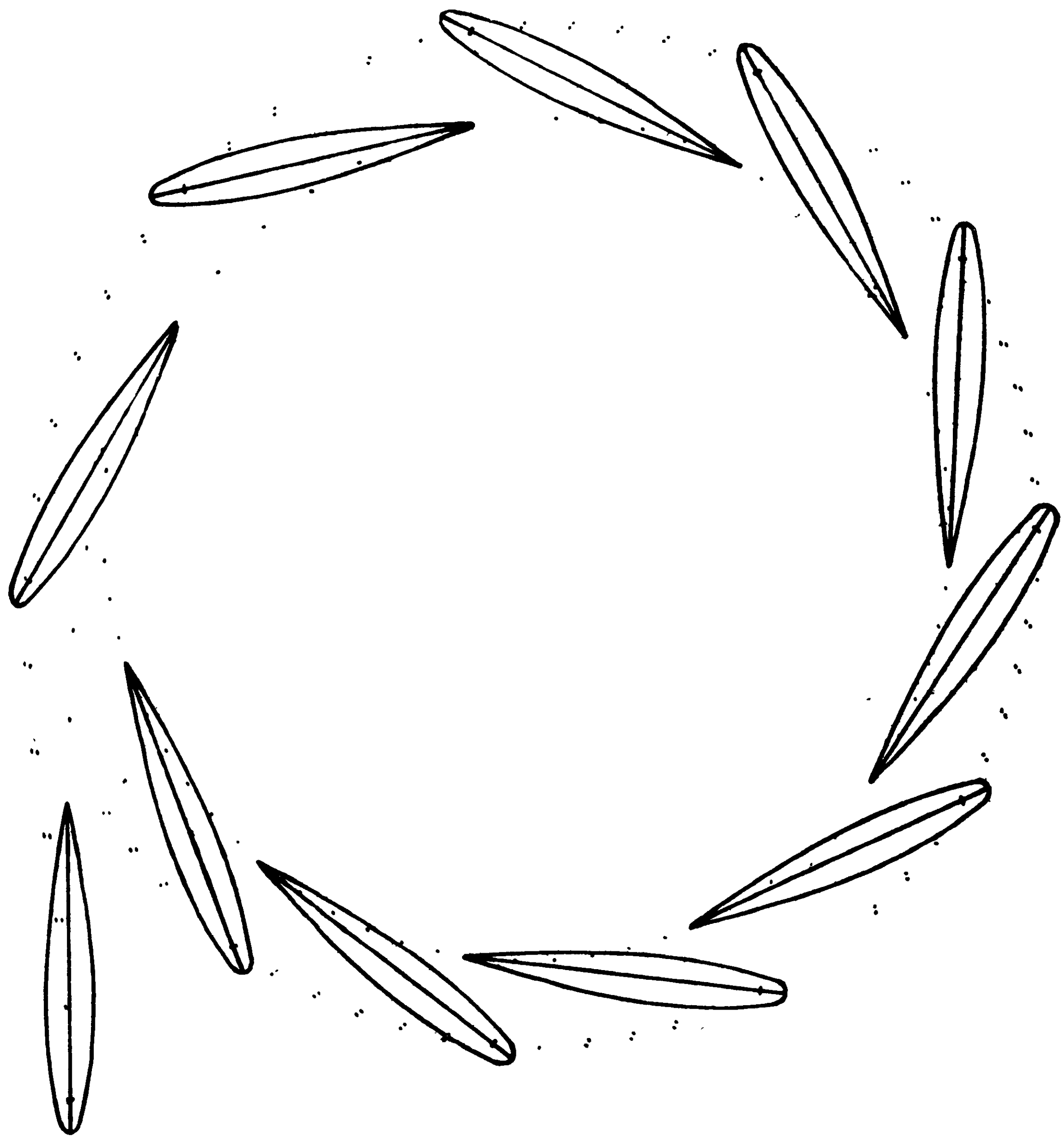

FIG. 4

ORIGINAL HULL WITH STRUTS

RUDDER ANGLE

50°

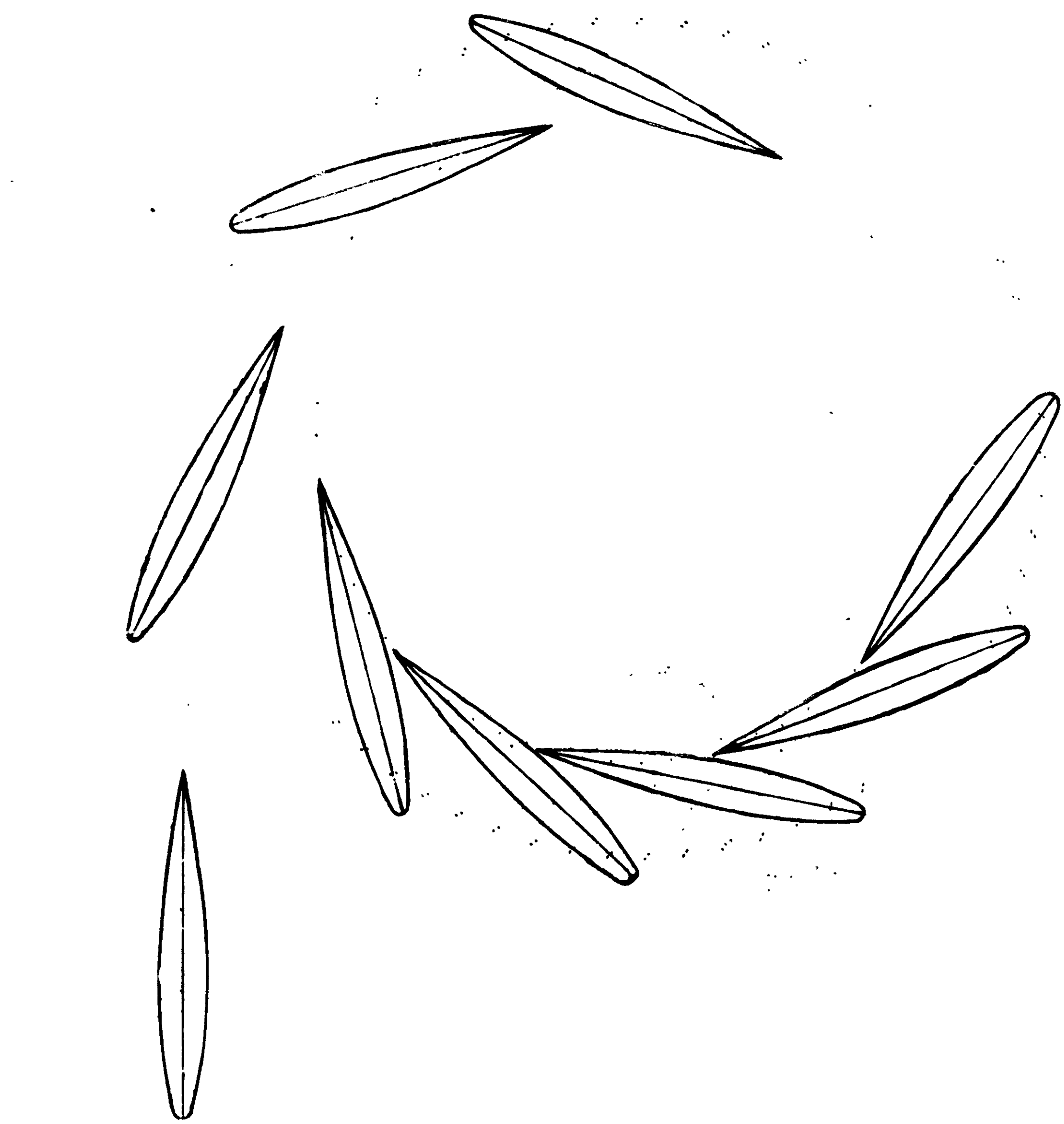

FIG. 5

ORIGINAL HULL WITH BOSSING

RUDDER ANGLE

50°

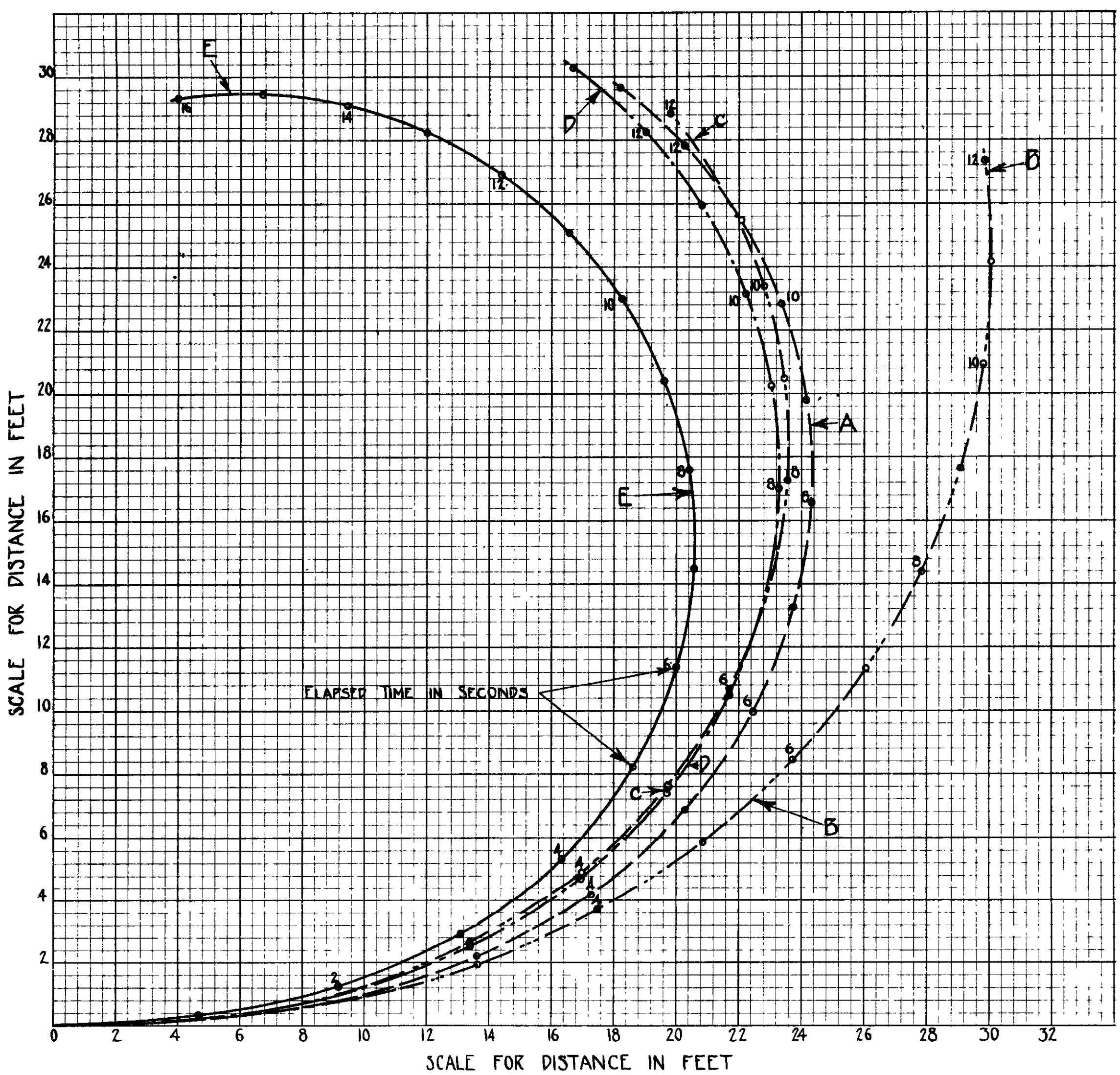

FIG. 6, TURNING CIRCLES, MODEL 2376 WITH RUDDER ANGLE = 35°
ORIGIN OF COORDINATES = INSTANT OF LAYING RUDDER.
TIME TO LAY RUDDER = 1 SECOND, APPROXIMATELY.

LEGEND

A ——— ——— ——— BOSSINGS ------------ ORIGINAL HULL
B --- ——— ——— --- BOSSINGS WITH FINS ----- ORIGINAL HULL
C -- ——— -- ——— STRUTS ------------- ORIGINAL HULL
D - ——— - ——— - ——— STRUTS ------ DEADWOOD PARTLY REMOVED
E ———————— STRUTS ---- DEADWOOD COMPLETELY REMOVED

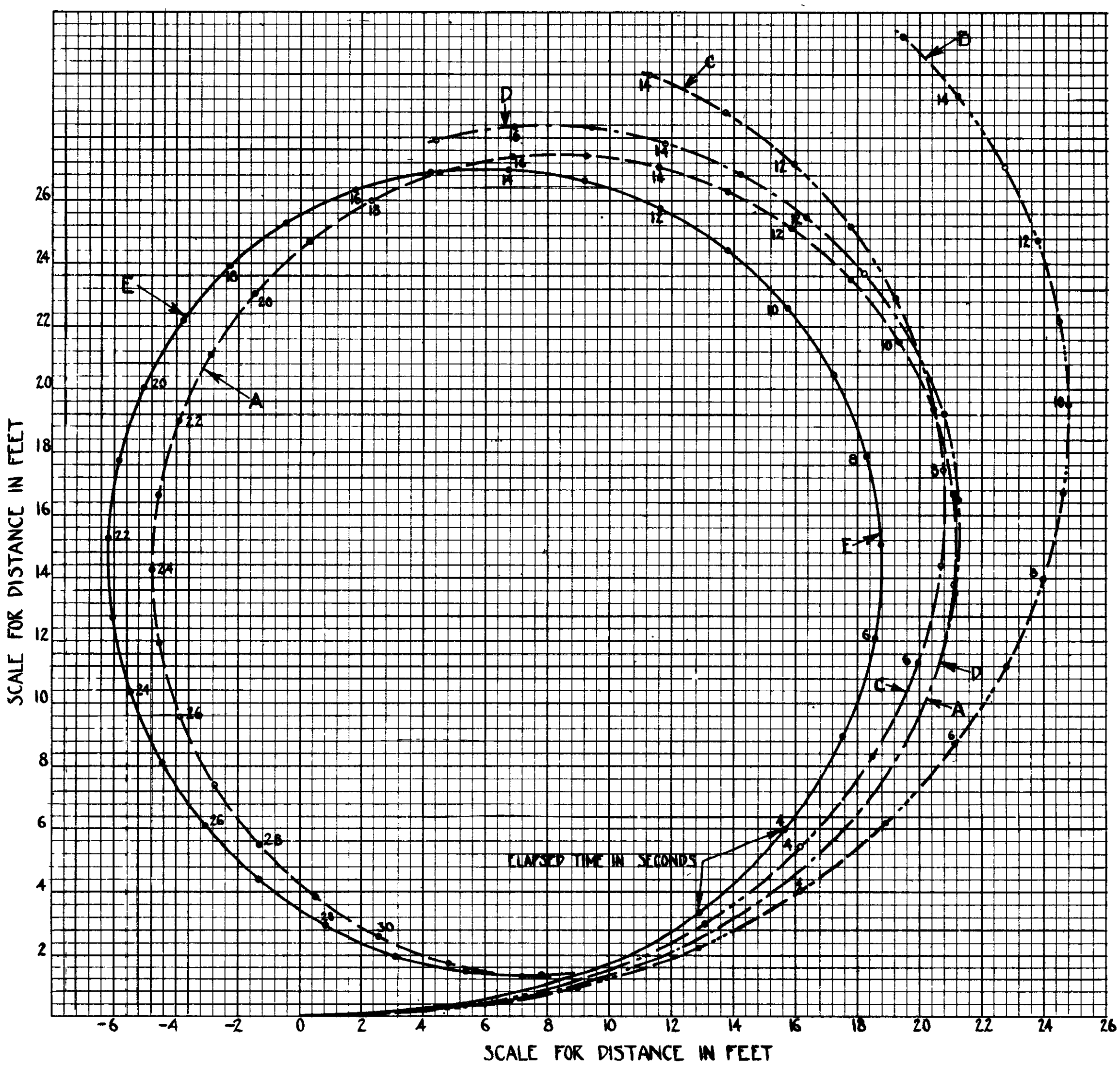

FIG. 7, TURNING CIRCLES, MODEL 2376 WITH RUDDER ANGLE = 40°
ORIGIN OF COORDINATES = INSTANT OF LAYING RUDDER.
TIME TO LAY RUDDER = 1 SECOND, APPROXIMATELY.

LEGEND

A —— —— —— —— ——BOSSINGS ------------ ORIGINAL HULL
B --- —— —— —— --- BOSSINGS WITH FINS -----ORIGINAL HULL
C -- —— —— -- ——STRUTS - - - - - - - - - - - -ORIGINAL HULL
D - ——- ——- - ——STRUTS - - - - - DEADWOOD PARTLY REMOVED
E ————————STRUTS - - - DEADWOOD COMPLETELY REMOVED

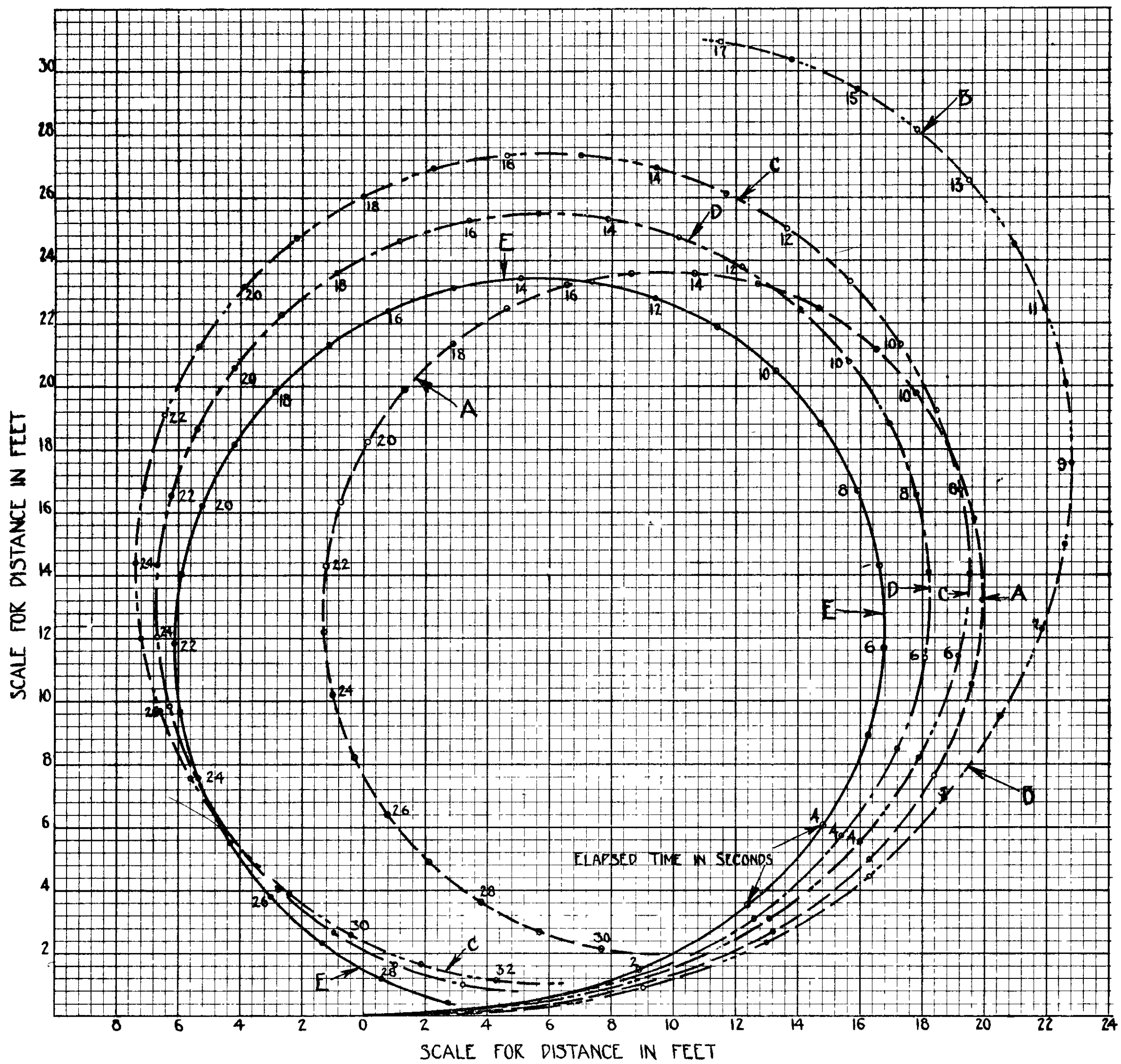

FIG. 8, TURNING CIRCLES, MODEL 2376 WITH RUDDER ANGLE = 45°
ORIGIN OF COORDINATES = INSTANT OF LAYING RUDDER.
TIME TO LAY RUDDER = 1 SECOND, APPROXIMATELY.

LEGEND

A ——— ——— ——— ———BOSSINGS -------------ORIGINAL HULL
B --- ——— ——— ——— --- ———BOSSINGS WITH FINS------ORIGINAL HULL
C -- ——— ———-·——— ———STRUTS -------------ORIGINAL HULL
D · ——— · ——— · ———-STRUTS -- ·---- DEADWOOD PARTLY REMOVED
E ————————————STRUTS----DEADWOOD COMPLETELY REMOVED

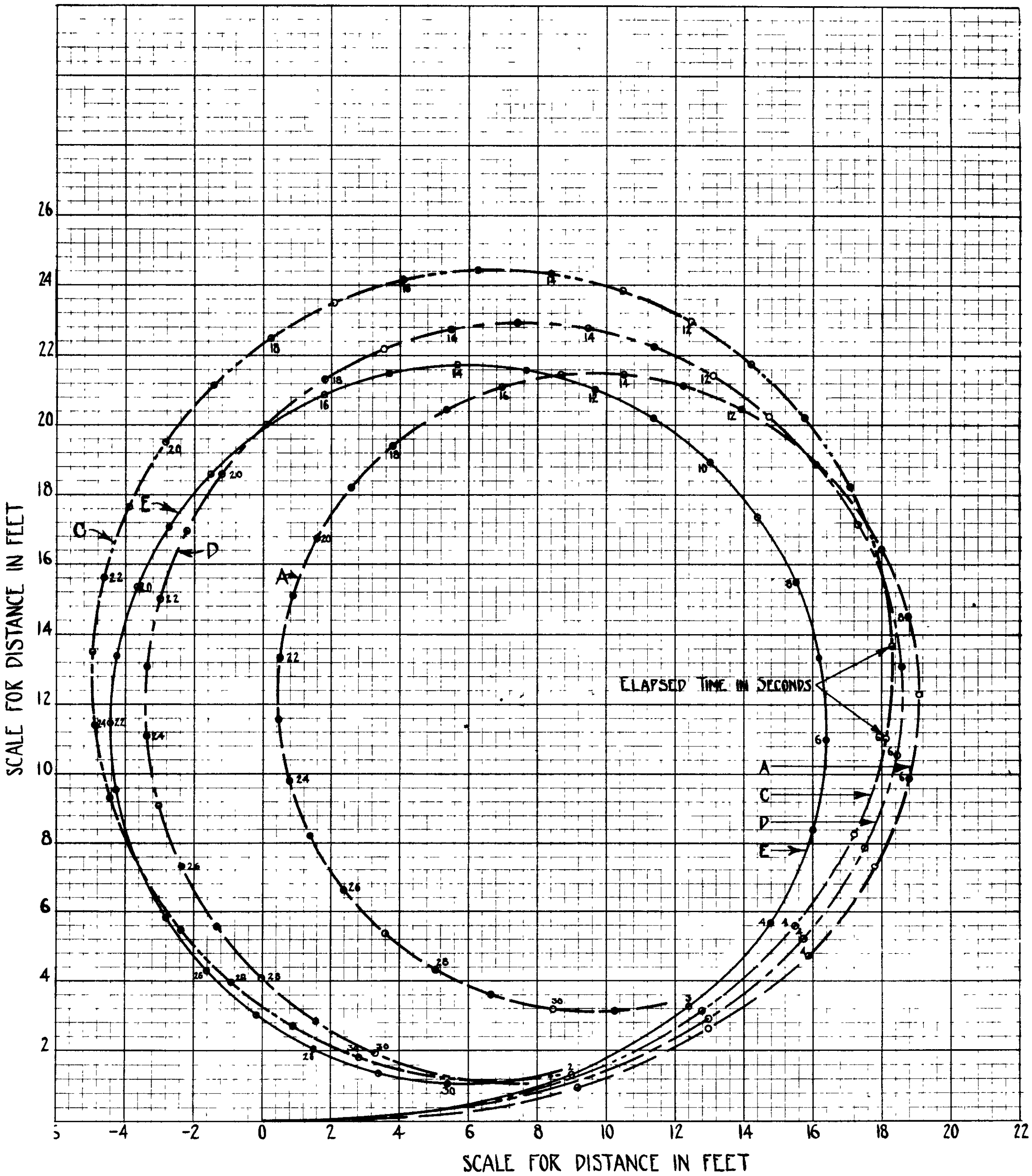

FIG. 9, TURNING CIRCLES, MODEL 2376 WITH RUDDER ANGLE = 50°
ORIGIN OF COORDINATES = INSTANT OF LAYING RUDDER.
TIME TO LAY RUDDER = 1 SECOND, APPROXIMATELY.

LEGEND

A ——— BOSSINGS ------------- ORIGINAL HULL
C ——— STRUTS ------------- ORIGINAL HULL
D ——— STRUTS ------ DEADWOOD PARTLY REMOVED
E ——— STRUTS --- DEADWOOD COMPLETELY REMOVED