RUDDER TESTS
WITH 10,000 TON CRUISER MODEL

U.S. EXPERIMENTAL MODEL BASIN
Navy Yard, Washington, D.C.

February 1929 Report 214

RUDDER TESTS
WITH 10,000 TON CRUISER MODEL

The tests described in this report were carried out in the U. S. Experimental Model Basin, Washington, D.C. at the request of the Bureau of Construction and Repair, U.S. Navy.

The purpose of these tests was to determine the relative superiority of various shapes of rudders.

Five rudders in all were tested at two model speeds, viz., 4.08 knots and 4.87 knots, corresponding to ship speeds of 22.0 knots and 26.3 knots, respectively.

The designs for three rudders were furnished by the Bureau of Construction and Repair. The remaining two rudders were modifications of the preceding ones, the changes having been suggested by the model basin. For purposes of identification the rudders were numbered 1 - 5 and the curves in the appended plates were marked correspondingly.

RUDDER 1 was the usual type balanced rudder partly supported by a fixed skeg as per Bureau of Construction and Repair plan 142669.

RUDDER 2 was a spade rudder, entirely supported inside of the hull. The outline and sections of the rudder were according to Construction and Repair drawing 09687, dated July 12, 1928.

RUDDER 3 was a modification of Rudder 2. The outline was kept the same. The sections were fined down toward the leading edge and toward the bottom. In addition the bottom edge was cut away so as to slope upward about 4 1/2 degrees from the leading edge toward the following

edge and a thin metal plate was attached to the bottom of the rudder. The width of this plate was approximately three times the width of the sections of the rudder at the bottom.

RUDDER 4 was a spade rudder having an outline and sections as per Construction and Repair drawing 09687 dated November 19, 1928.

RUDDER 5 was a modfication of Rudder 4. The outline was kept the same. The sections were filled out from the thickest part of the section toward the leading edge as well as toward the following edge.

Model 2697 of the 10,000 ton Light Cruisers 26, 27, and 28 was used for the tests. The model had a displacement of 1028 lbs. and was self-propelled by model propellers 703 - 706. The tests were carried out as follows:

The model was guided from the towing carriage while it was brought up to constant speed by its own propeller power. At a given signal the model was turned loose and an instant later the rudder was laid 36 degrees to port by means of a special apparatus. The time required to lay the rudder was approximately one and a half seconds. Further progress of the model was recorded by photographic means from overhead

DATA OBTAINED AND REDUCTION OF DATA

The photographic plate was exposed at time intervals of 1/2 seconds, hence the speed of the model in its path as well as the path itself was given. Unfortunately the conditions of the tests were such that time intervals

were recorded rather than total elapsed time beginning with the instant the rudder was laid. The method of reducing the data remedied this drawback, however, some uncertainty still persists due to the necessity of extrapolating.

The original data as they were read from the photographic plates are plotted on Sheets 1 and 2. The slope of these curves, representing the rate of change of heading of the model, allows some deductions to be made as to the relative effectiveness of the five rudders.

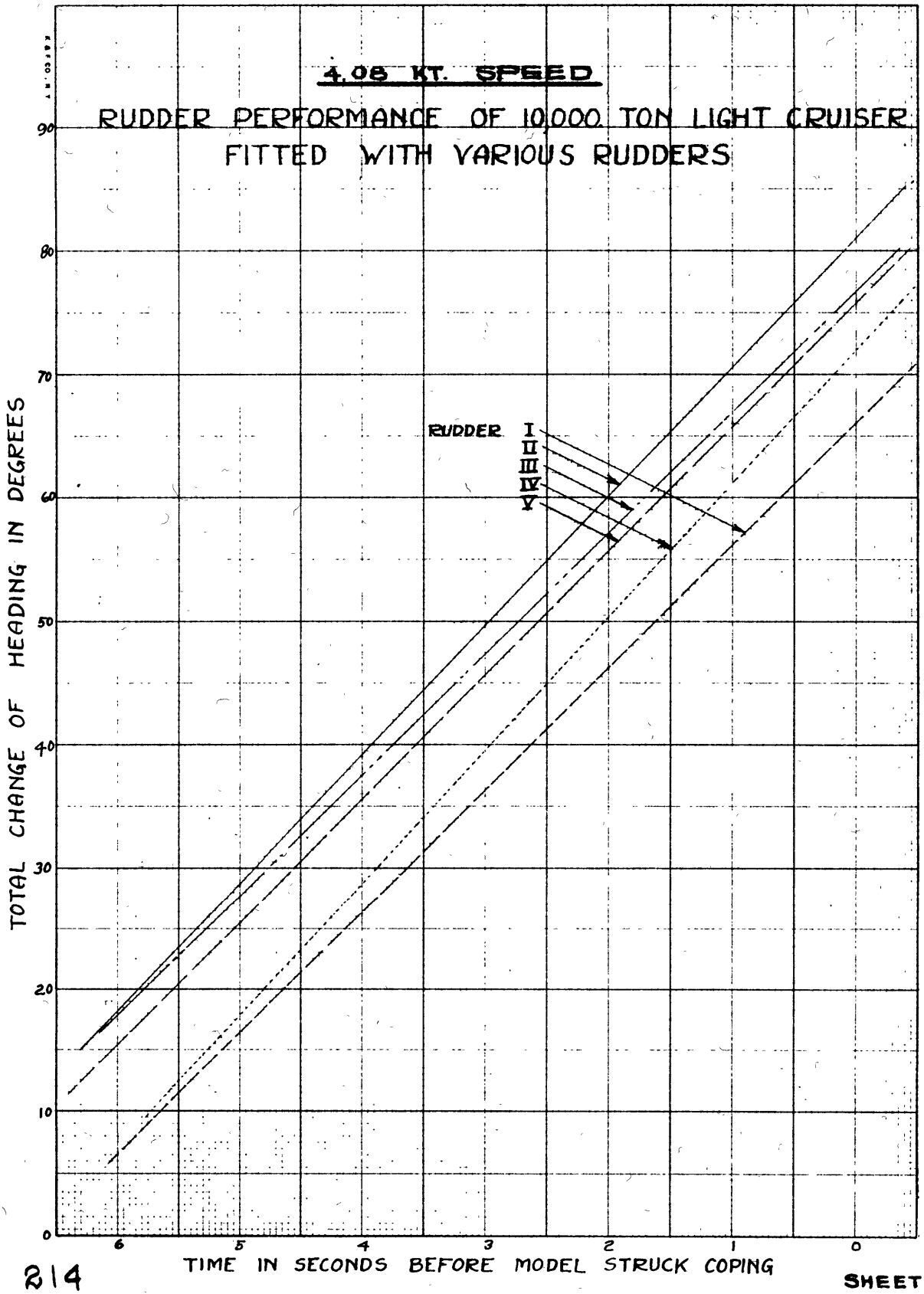
These same curves of total change of heading are plotted on Sheets 3 and 4 transferred to a common scale of total elapsed time, zero time being the instant the rudder was hard over. On these sheets are also shown the curves of model speed and the curves of radius of curvature of the least path. The latter curves were calculated from the former two.

On Sheets 5 and 6 are shown the actual turning paths of the model. The part of the curves between time "3 seconds" and time "8 seconds" were directly obtained from the photographic plates, while the part below three seconds was extrapolated making use of the speed and change-of-heading curves given on Sheets 3 and 4.

INTERPRETATION OF RESULTS

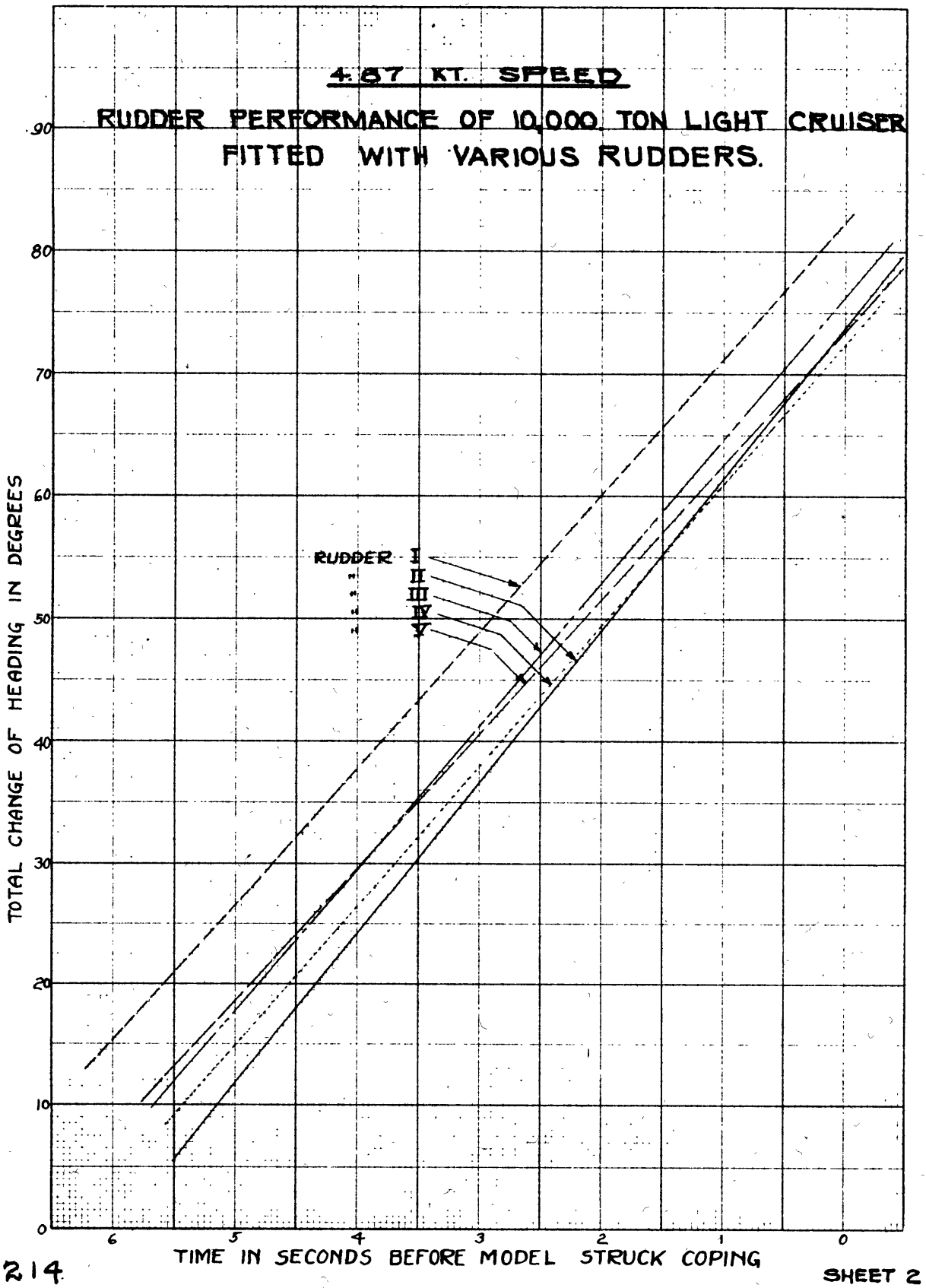
Inasmuch as the limited width of the Basin allowed a twenty foot model to turn through only a quarter of a circle and keeping in mind the limitations of the test mentioned above, some caution is necessary in drawing broad conclusions. However, it seems safe to say that the

spade rudders are superior to the type of balanced rudder in use now. Comparing the spade rudders among themselves it seems that a section with a blunt nose is superior to a section with a fine nose, but it is doubtful if the ship will agree with the model in this respect. Whether the shoe at the bottom of the rudder is an advantage or not does not appear clearly.


4.08 KT. SPEED
RUDDER PERFORMANCE OF 10,000 TON LIGHT CRUISER
FITTED WITH VARIOUS RUDDERS
RUDDER I
II
III
IV
V
TOTAL CHANGE OF HEADING IN DEGREES
0
10
20
30
40
50
60
70
80
90
6
5
4
3
2
1
0
TIME IN SECONDS BEFORE MODEL STRUCK COPING

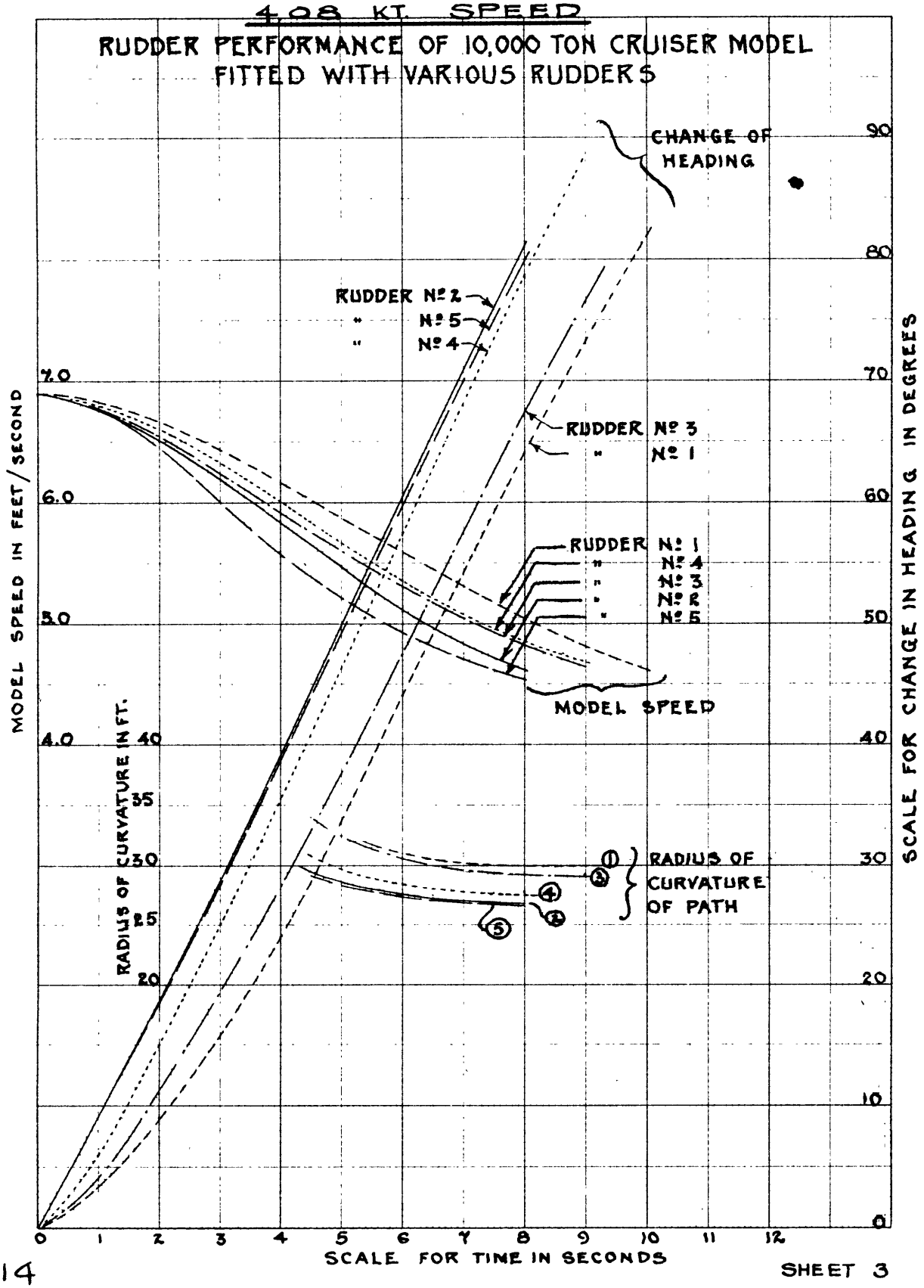
214

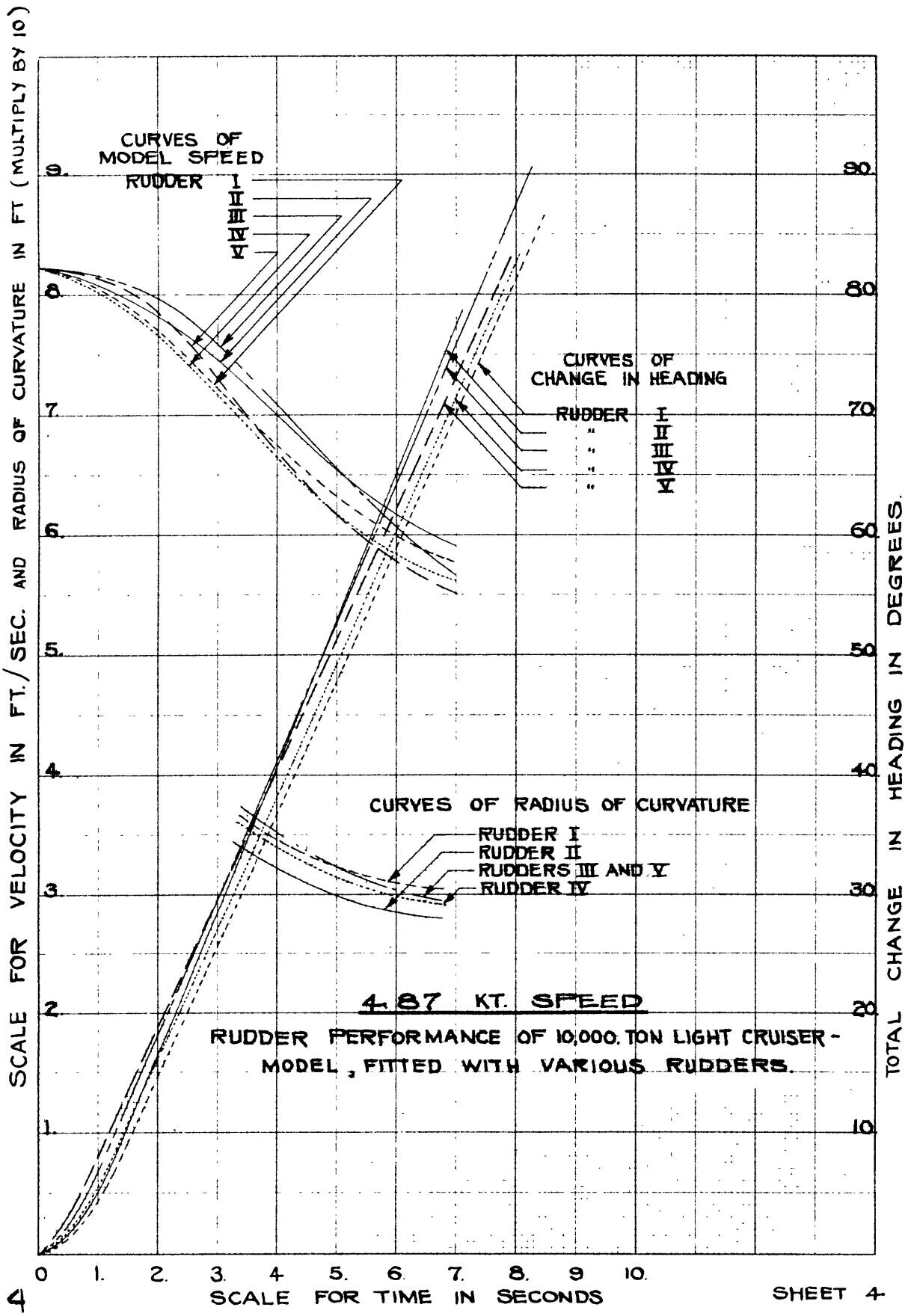
SHEET 1


4.67 KT. SPEED
RUDDER PERFORMANCE OF 10,000 TON LIGHT CRUISER FITTED WITH VARIOUS RUDDERS.
TOTAL CHANGE OF HEADING IN DEGREES
TIME IN SECONDS BEFORE MODEL STRUCK COPING
RUDDER I
II
III
IV
V
0
10
20
30
40
50
60
70
80
90
6
5
4
3
2
1
0

4.08 KT. SPEED

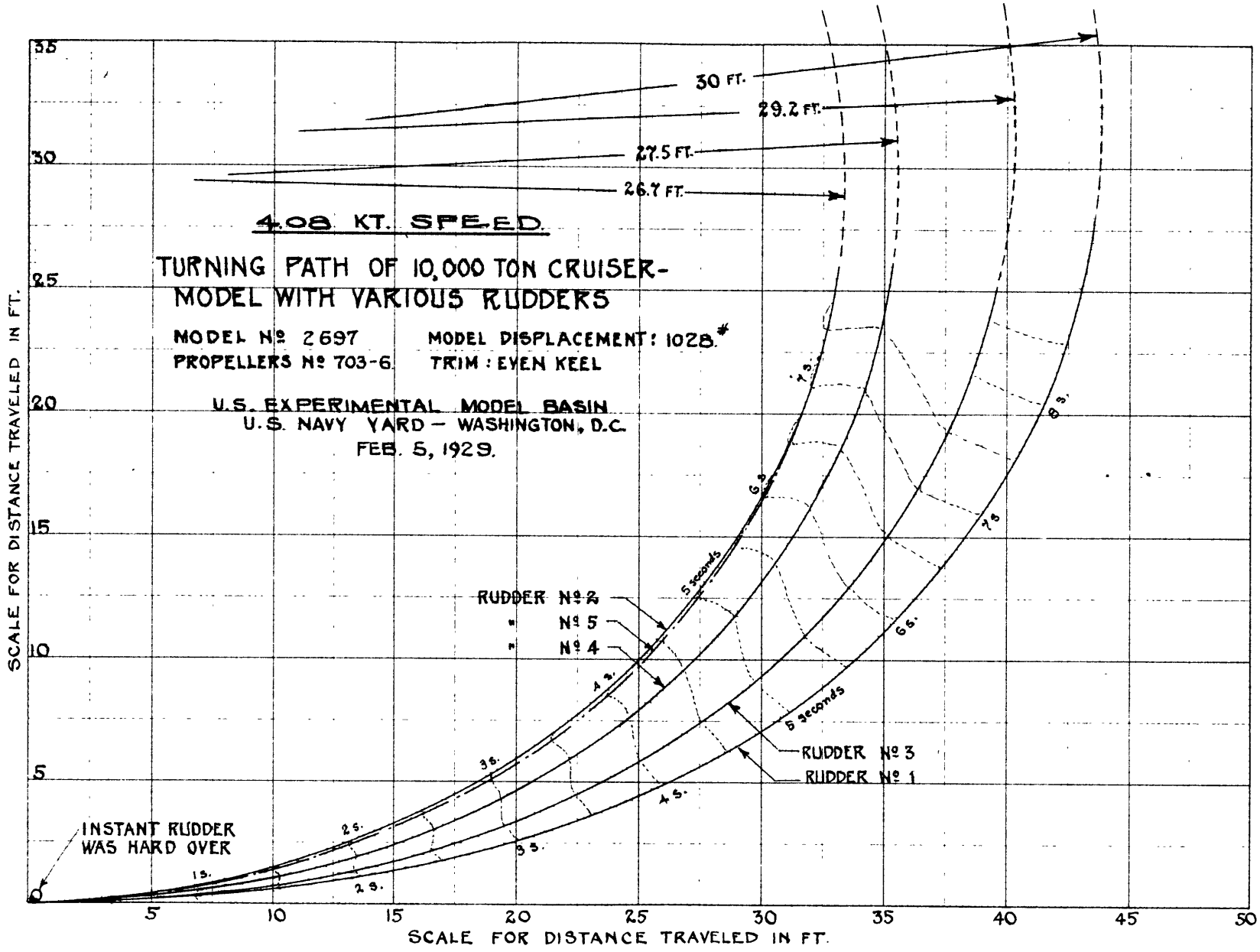
RUDDER PERFORMANCE OF 10,000 TON CRUISER MODEL FITTED WITH VARIOUS RUDDERS



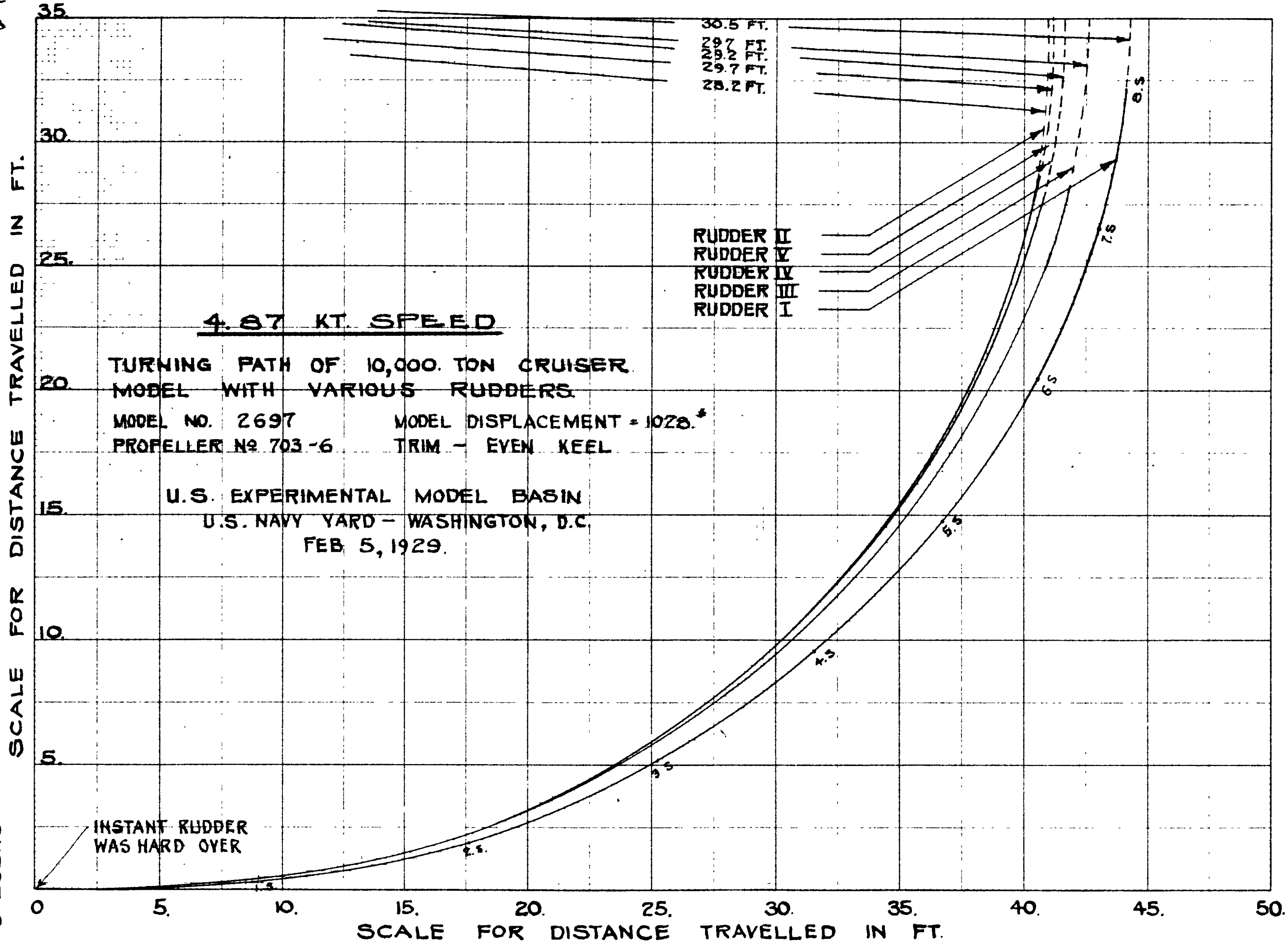

CURVES OF MODEL SPEED
RUDDER I
II
III
IV
V
CURVES OF CHANGE IN HEADING
RUDDER I
II
III
IV
V
CURVES OF RADIUS OF CURVATURE
RUDDER I
RUDDER II
RUDDERS III AND V
RUDDER IV
4.87 KT. SPEED
RUDDER PERFORMANCE OF 10,000. TON LIGHT CRUISER - MODEL, FITTED WITH VARIOUS RUDDERS.
SCALE FOR VELOCITY IN FT./SEC. AND RADIUS OF CURVATURE IN FT (MULTIPLY BY 10)
TOTAL CHANGE IN HEADING IN DEGREES
SCALE FOR TIME IN SECONDS
0 1. 2. 3. 4. 5. 6. 7. 8. 9 10.
9. 8. 7. 6. 5. 4. 3. 2. 1.
90 80 70 60 50 40 30 20 10

214

SHEET 4


30 FT.
29.2 FT.
27.5 FT.
26.7 FT.
4.08 KT. SPEED.
TURNING PATH OF 10,000 TON CRUISER-
MODEL WITH VARIOUS RUDDERS
MODEL Nº 2697
PROPELLERS Nº 703-6.
MODEL DISPLACEMENT: 1028.#
TRIM: EVEN KEEL
U.S. EXPERIMENTAL MODEL BASIN
U.S. NAVY YARD – WASHINGTON, D.C.
FEB. 5, 1929.
RUDDER Nº 2
" Nº 5
" Nº 4
5 seconds
5 seconds
RUDDER Nº 3
RUDDER Nº 1
INSTANT RUDDER
WAS HARD OVER
SCALE FOR DISTANCE TRAVELED IN FT.
SCALE FOR DISTANCE TRAVELED IN FT.

214


4.87 KT. SPEED
TURNING PATH OF 10,000. TON CRUISER MODEL WITH VARIOUS RUDDERS.
MODEL NO. 2697
MODEL DISPLACEMENT = 1028.#
PROPELLER № 703-6
TRIM - EVEN KEEL
U.S. EXPERIMENTAL MODEL BASIN
U.S. NAVY YARD - WASHINGTON, D.C.
FEB. 5, 1929.
30.5 FT.
29.7 FT.
28.2 FT.
29.7 FT.
28.2 FT.
RUDDER II
RUDDER V
RUDDER IV
RUDDER III
RUDDER I
INSTANT RUDDER WAS HARD OVER
SCALE FOR DISTANCE TRAVELLED IN FT.
SCALE FOR DISTANCE TRAVELLED IN FT.
0
5.
10.
15.
20.
25.
30.
35.
40.
45.
50.
2.S.
3 S
4.S
5.S
6 S
7.S
8.S

SHEET 6