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Ship Hydromechanics Department
Research and Development Report

First of Class Trials on USS Iowa (BB 61) Class – Past and Present

by

Richard J. Stenson

Presented at the Spring Meeting/STAR Symposium of the
Society of Naval Architects and Marine Engineers
New Orleans, Louisiana, 12-15 April 1989

DTRC-89/027 First of Class Trials on USS Iowa (BB 61) Class – Past and Present

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The U. S. Navy has for many years conducted First of Class Trials on each new class of ship built for the Fleet. During World War II, such trials were accomplished on the USS NEW JERSEY (BB 62) representing the new IOWA Class battleships which were then entering the fleet. These trials were conducted by the David Taylor Model Basin at Rockland, Maine in October 1943.

Over 40 years later, under the Battleship Reactivation and Modernization Program, the David Taylor Research Center (DTRC) was tasked by the Naval Sea Systems Command (NAVSEA) to conduct a new set of First of Class Trials for the IOWA Class. These new trials were deemed necessary due to the many changes to these ships which have occurred over the years and more recently during the Reactivation Program. The new trials were conducted on the lead ship, USS IOWA (BB 61) in August 1985 at the Hatteras East Coast

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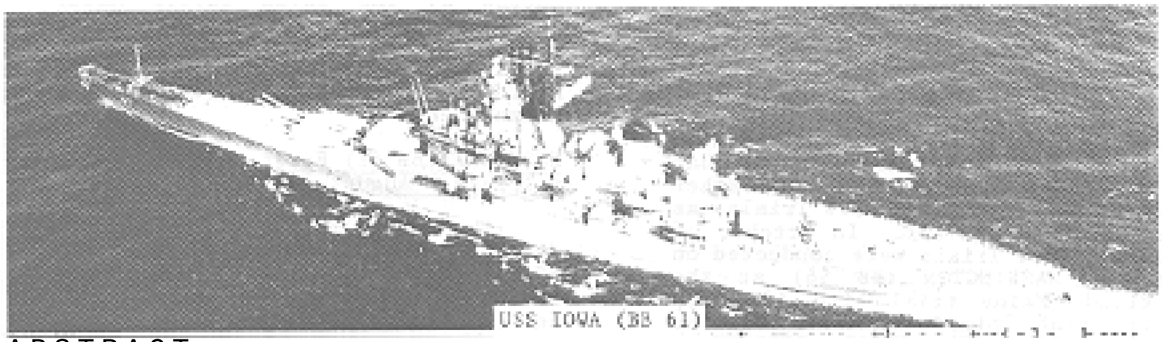
First of Class Trials on USS IOWA (BB 61) Class—Past and Present

Richard J. Stenson, Member, David Taylor Research Center, Bethesda, MD



ABSTRACT

The U.S. Navy has for many years conducted First of Class Trials on each new class of ship built for the Fleet. During World War II, such trials were accomplished on the USS NEW JERSEY (BB 62) representing the new IOWA Class battleships which were then entering the fleet. These trials were conducted by the David Taylor Model Basin at Rockland, Maine in October 1943.

Over 40 years later, under the Battleship Reactivation and Modernization Program, the David Taylor Research Center (DTRC) was tasked by the Naval Sea Systems Command (NAVSEA) to conduct a new set of First of Class Trials for the IOWA Class. These new trials were deemed necessary due to the many changes to these ships which have occurred over the years and more recently during the Reactivation Program. The new trials were conducted on the lead ship, USS IOWA (BB 61) in August 1985 at the Hatteras East Coast Tracking Offshore Range (HECTOR) operated by DTRC.

Trials techniques, methods of data collection, and data analysis have also changed considerably over the ensuing 42 years since delivery of these ships. These new techniques and procedures will be discussed, contrasted, and compared.

INTRODUCTION

Background

First of Class Trials have been conducted by the U.S. Navy on one ship of each class for close to 50 years. These trials typically consisted of Standardization Trials (speed/power measurements) , Tactical Trials (maneuvering and turning characteristics), and Fuel Economy Trials. In expanded to include Vibration Trials and Seakeeping Trials, As early as 1918, Standardization Trials were conducted on the battleship USS NEW MEXICO (BB 40) and the data was compared with the results
Propelled Model Tests conducted at the U. S. Navy Experimental Model Basin (EMB) at the Washington Navy Yard (l). Other battleship Standardization Trials were conducted on the USS MARYLAND (BB 46) in 1921, and on the USS PENNSYLVANIA (BB 38) in 1921, with both sets of trials being compared with model tests conducted at the EMB.

The first recorded attempt at conducting Tactical Trials was on the USS FARRAGUT (DD 348) Class, in July 1934 (2). During the design of the FARRAGUT Class, the Portsmouth Navy Yard submitted several suggestions relative to rudder design. Mode 1 tests were conducted with two different rudders, but because of the size of the model, and the limitations in space at the EMB, the results of the tests were inconclusive. It was decided to test the rudder full scale, and FARRAGUT was made available for these tests. In order to determine the effect of the rudder on propulsion it was considered essential to conduct Standardization Trials with both rudder designs. These trials were scheduled for the measured mile course at Rockland, Maine and it was only logical to conduct the turning test at this same location. An extensive series of turning tests were conducted with both rudder designs, and the evolution of a photographic method of conducting Tactical Trials at the Rockland, Maine trials course is discussed at great length in the report. The FARRAGUT was thus probably the first U.S. Navy ship to complete both Standardization and Tactical Trials during the same underway trial period and within the same general location.

As reported in (3), the possibiities of accurate determination of tactical data impressed the Chief of Naval Operations and led to an inquiry into the feasibility of the Experimental Model Basin obtaining these data on one ship of each new class. Early in 1938 a tentative schedule was worked out to provide for running these trials. It was decided that they should be separate trials rather than a part of the Builders Trials, as also reported in (3). In October of 1941 Tactical Trials were conducted on the USS WASHINGTON (BB 56) at the Rockland, Maine trial site (4). Up until that time under directives issued by the Office of Naval Operations and the Bureau of Ships, the now David Taylor Model Basin had conducted full scale Tactical Trials on an aircraft carrier USS YORKTOWN (CV 10), a light cruiser USS PHILADELPHIA (CL 41), a destroyer tender USS DIXIE (AD 14), a tanker USS CIMERRON (AO 22), and four destroyers: USS SOMERS, USS BLUE (DD 380), USS SIMS (DD 409), and USS GLEAVES (DD 423). The procedures for conducting these trials, which had evolved between 1934 and 1941, are well documented in reference 3, and will be discussed in greater detail later in this paper.

The year 1943 was a busy time for the David Taylor Model Basin trials group. Tactical Trials were conducted on the USS IRA JEFFREY (DE 63),(5), and Standardization Trials were conducted on the USS BILOXI (CL 80), (6), the USS BOSTON (CA 69), (7), and the USS BARTON (DD 722), (8). In October of 1943 First of Class trials including Fuel Economy, Tactical Trials, and Standardization Trials were conducted on the USS NEW JERSEY (BB 62) representing the IOWA Class battleships. Some 42 years later in August of 1985, First of Class Trials were again conducted, this time on IOWA herself, representing the four recently reactivated and modernized battleships currently in the fleet.

USS NEW JERSEY (BB 62) First of Class Trials - October 1943

The First of Class Trials conducted on USS NEW JERSEY in 1943 consisted of a Fuel Economy Trial conducted while in free route on 12, 13, and 23 October 1943, a Tactical Trial conducted at the Rockland, Maine tactical trial course on 26, 27, and 28 October 1943, and a Standardization Trial conducted on the Rockland, Maine measured mile course on 24 and 26 October 1943.

These trials were requested by the then Bureau of Ships, and were under the overall direction of the Navy Department's "Board of Inspection and Survey". The Standardization and Tactical Trials were conducted by the David Taylor Model Basin, while the Fuel Economy Trials were conducted by the Philadelphia Naval Shipyard with support from the David Taylor Model Basin for powering measurements.

USS IOWA (BB 61) First of Class Trials - August 1985

The First of Class Trials conducted on USS IOWA in 1985 consisted of Fuel Economy Trials conducted in free route on 2 and 3 August 1985, and on the Hatteras East Coast Tracking Offshore Range (HECTOR) on 4 and 5 August 1985, a Tactical Trial conducted at HECTOR on 3 August 1985, a Standardization Trial conducted at HECTOR on 3 August 1985, and some maneuvering trials (spirals and zigzag maneuvers) conducted in free route. These trials were requested by the Naval Sea Systems Command by a Naval Message, portions of which are reproduced here:

R301955Z JAN 85
FROM: COMNAVSEASYSCOM WASHINGTON DC
TO:COMNAVSURFLANT NORFOLK VA
SUBJ: USS IOWA (BB61) PERFORMANCE TRIALS
A. DTNSRDC BETHESDA MD, USS IOWA (BB 61) PERFORMANCE TRIALS AGENDA DTD NOV 1984
1. REF A IS THE PROPOSED AGENDA FOR THE USS IOWA (BB 61) PERFORMANCE TRIALS. PERFORMANCE TRIALS ARE USUALLY CONDUCTED ON THE FIRST SHIP OF A NEW CLASS TO DETERMINE THE VARIOUS CHARACTERISTICS FOR THE CLASS (I.E., SPEED, POWER, RPM, TORQUE, FUEL CONSUMPTION, CONTROL AND STABILITY, ETC.). DATA FROM THESE TRIALS WILL BE USED TO ESTABLISH FULL POWER REQUIREMENTS, PROVIDE FLEET WITH SHIP OPERATIONAL CHARACTERISTICS, AND VERIFY DESIGN PROCEDURES FOR THE BB 61 CLASS. THESE TRIALS ARE ALSO CONDUCTED FOR MAJOR CONVERSION SHIPS OR SHIPS IN PREVIOUS SERVICE WHEN NEW DESIGN EQUIPMENT-INSTALLATION AFFECTS THE PROPULSION AND MANEUVERING CAPABILITIES OF THE SHIP.
2. THE BB61 CLASS BATTLESHIPS HAVE NOT UNDERGONE STANDARDIZATION AND TACTICAL TRIALS SINCE OCT 1943. AS A RESULT OF ADVANCEMENTS IN INSTRUMENTATION TECHNOLOGY AND SHIP DESIGN CHANGES DURING MODERNIZATION, IT IS PLANNED THAT USS IOWA UNDERGO SELECTED PERFORMANCE TRIALS SHORTLY AFTER POST SHAKEDOWN AVAILABILITY (PSA).
3. TOTAL SHIP TIME FOR SUBJ TRIALS IS

APPROX 4 DAYS (2 DAYS ON HECTOR RANGE). REQUEST SCHEDULING OF USS IOWA FOR SUBJ TRIALS SOMETIME AFTER PSA (AUG-SEP 1985).

The trials were to be conducted under the overall direction of the David Taylor Research Center (DTRC) with the Fuel Economy Trials being under the direction of the Naval Ship Systems Engineering Station, delphia (NAVSSES, Philly), with support from DTRC for the powering measurements.

SHIP CHARACTERISTICS AND TRIAL CONDITIONS

USS NEW JERSEY (BE 62)

The USS NEW JERSEY was built by the Philadelphia Naval Shipyard and commissioned on 23 May 1943. The ship and propeller characteristics for the IOWA Class are shown in Table 1, while trial conditions for NEW JERSEY as tested in 1943 and IOWA as tested in 1985 are shown in Table 11. Figure 1 shows the NEW JERSEY as configured in the 1940's. As shown in Table II, the NEW JERSEY had only recently been undecked, and the Standardization Trials were conducted 21 and 23 days after undocking. The displacements for Standardization Trials conducted on the two different days were 57,102 t (56,200 cons) and 57,813 t (56,900 tons) with trims of 0.94 m (3.1 ft) by the stern and 0.45 m (1.5 ft) by the stern, respectively. The NEW JERSEY was equipped with four propellers, the inner two being 5-bladed, 5.18 m (17.0 ft) in diameter, with a pitch of 5.60 m (18.375 ft), while the outers were 4-bladed, 5.56 m (18.25 ft) in diameter, with a pitch of 5,80 m (19.04 ft). Although there is no discussion of the type of paint on the NEW JERSEY in any of the references, the hull was most probably painted with either the hot plastic or cold plastic types of paints which were in general use during that time period. The cruiser USS BOSTON (CV 69) which was standardized at the Rockland, Maine trial course on 22 October 1943, two days before NEW JERSEY, was painted with a type 142-c Hot Sprayed Plastic, as reported in (7), while the light cruiser USS BILOXI (CL 80) standardization in November of that year, was painted with type (65-SN) cold sprayed plastic as reported in (6).

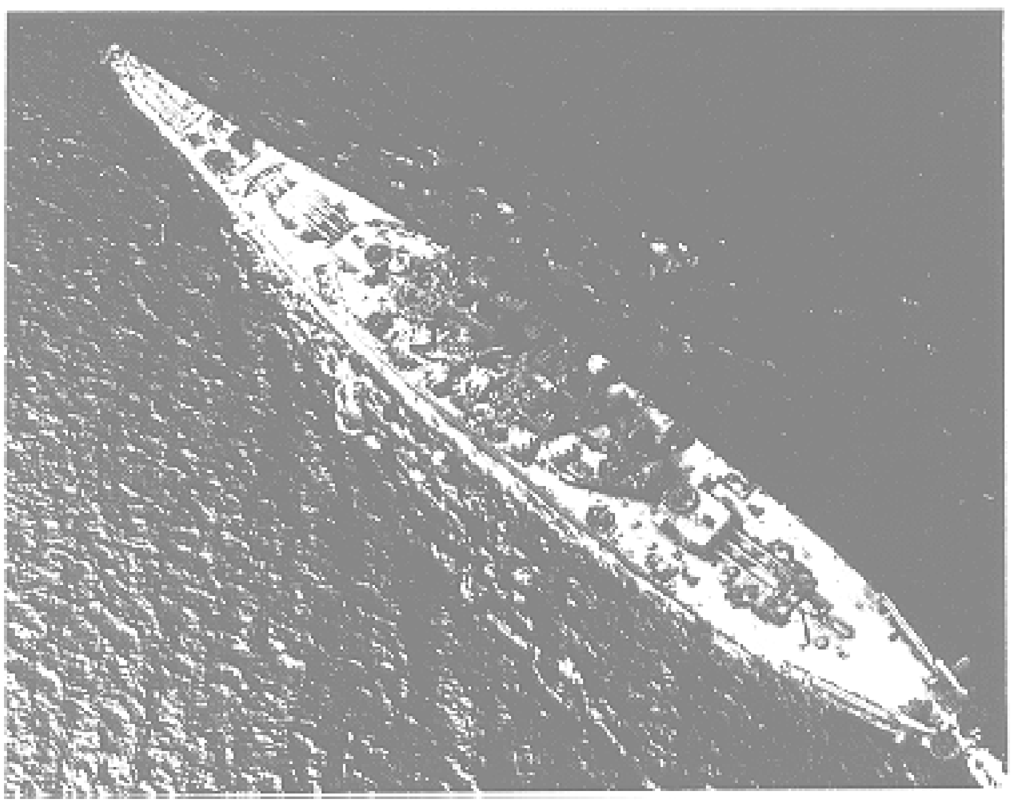


Fig. 1. USS NEW JERSEY (BB 62)

USS IOWA (BB 61)

The USS IOWA (BB 61) was built by the New York Naval Shipyard, and commissioned in February 1943. In September of 1982 IOWA was towed from the Philadelphia Naval Shipyard where she had been laid up, to the Avondale Shipyard in Westwego, Louisiana to commence her reactivation/modernization. After completion of the drydock portion of the reactivation, she was transferred to the Litton/Ingalls Yard, Pascagoula, Mississippi for completion of her reactivation/modernization. Effective 30 June 1984 the newly reactivated IOWA was homeported in Norfolk, Virginia. Figure 2 shows the configuration of IOWA as tested in August 1985. As previously mentioned, trial conditions for IOWA are shown in Table II.

Table I. USS IOWA (BB 61) Class ship and propeller characteristics.

SHIP CHARACTERISTICS		
Full Load		
Displacement, tons (t)	58,000	(58,930)
Length Overall (LOA), ft (m)	887.25	(270.4)
Length Between		
Perpendiculars (LBP), ft (m)	860	(262.1)
Beam, Molded, ft (m)	108.0	(32.9)
Number of Rudders	2	
Projected Rudder Area		
(per rudder), ft² (m²)	335	(31)

PROPELLER CHARACTERISTICS	
Number of Propellers	4
Number of Blades	5 Inboard, 4 Outboard
Propeller Diameter, ft (m)	
Shaft 1 - Starboard Outboard	18.25 (5.56)
Shaft 2 - Starboard Inboard	17.00 (5.18)
Shaft 3 - Port Inboard	17.00 (5.18)
Shaft 4 - Port Outboard	18.25 (5.56)
Propeller Pitch, ft (m)	
Shaft 1 - Starboard Outboard at 0.7 radius	19.04 (5.80)
Shaft 2 - Starboard Inboard at 0.794 radius	18.38 (5.60)
Shaft 3 - Port Inboard at 0.794 radius	18.38 (5.60)
Shaft 4 - Port Outboard at 0.7 radius	19.04 (5.80)

	USS IOWA (BB 61)	USS NEW JERSEY (BB 62)
Propeller Serial Number	1985	1943
Shaft 1 - Starboard Outboard	21382	Unknown
Shaft 2 - Starboard Inboard	5241	Unknown
Shaft 3 - Port Inboard	5242	Unknown
Shaft 4 - Port Outboard	18567	Unknown
Propeller Rotation	Outboard	Outboard

IOWA was drydocked between 26 April and 24 May 1985 at the Norfolk Naval Yard, Portsmouth, Virginia. During this time the ship's rudder and bottom were spot sandblasted and touched up with a vinyl resin type paint system. As reported in (9), the ship's hull was in very good condition at the time of the undocking. The Standardization Trial was conducted 71 days after undocking at a displacement of 56,858 t (55,960 tons).

Table II. Trial conditions USS NEW JERSEY (BB 62) 1943, and USS IOWA (BB 61) 1985.

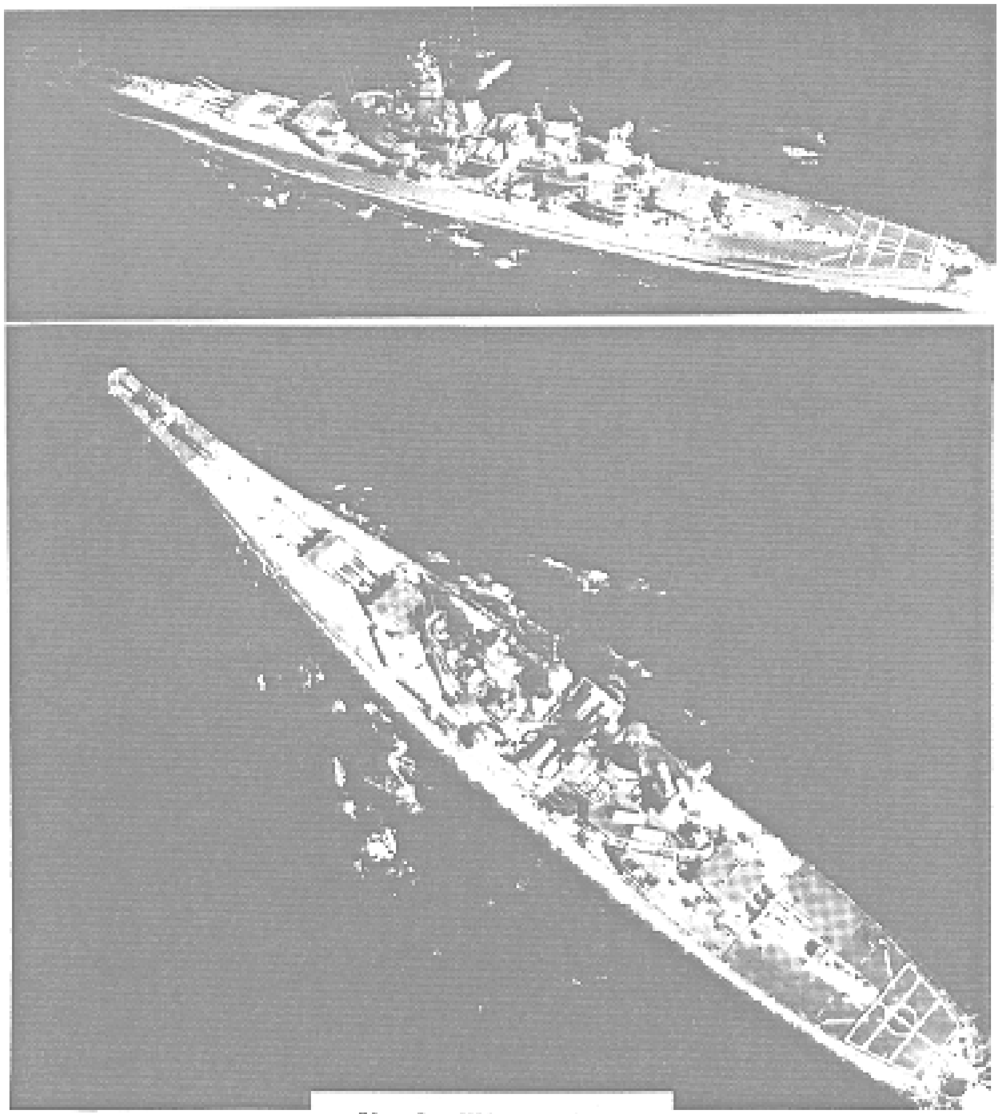
	USS NEW JERSEY (BB 62)	USS IOWA (BB 61)
Dates of Trial		
Standardization	24 and 26 Oct 1943	3 Aug 1985
Tactical	27 Oct 1943	4 Aug 1985
Fuel Economy	12-13 Oct 1943 and 23 Oct 1943	2-3 Aug 1985
Displacement,tons(t)		
Standardization	56,200 (57,102), 56,900 (57,813)	55,960 (56,858)
Tactical	56,900 (57,813)	55,890 (56,779)
Seawater Temperature,°F(°C)		
Standardization	64° (18°)	81° (27°)
Seawater Specific Gravity		
Standardization	1.0254	1.0245
Days Out of Drydock		
Standardization	21, 23	71

IOWA was equipped for these trials with the same propeller configuration as that on NEW JERSEY in 1943. A photograph of the IOWA in drydock just prior to the trials is shown in Fig. 3.

TRIAL SITES AND TRIAL PROCEDURES

USS NEW JERSEY (BB 62)

Measured Mile Course, Rockland, Maine. The measured mile course at Rockland, Maine was used for the Standardization Trials on USS NEW JERSEY and is depicted in Fig. 4. This trial course was described by Admiral David W. Taylor (10) as approximating fairly closely to the ideal requirements for a measured mile. As can be seen, the course consists of two sets of range beacons separated by 1,853 m (6,080 ft) or 1 nmi. The course is configured in a North/South orientation so that the ship conducting trials will steer either a heading of 000°True or 180° True. The course is in sheltered waters and has a water depth ranging from 76.2 m to 152.4 m (250 ft to 500 ft). In addition to the range beacons, the course is defined by six range buoys, one at each end of the measured mile, one a mile from each end, and one three miles from each end. The buoys are for steering purposes only. The ends of the mile course are fixed by the range



beacons. When the front and rear beacons at either end of the course are in line visually to an observer onboard ship, he is at one end of the course which is perpendicular to the range lines.

Standardization Trials Procedure. A Standardization Trial typically consists of a series of speeds with three acceptable consecutive runs at each speed over the measured mile course. A ship traveling on the designated compass course (000" or 180°) will travel 1 nmi over the ground between the range beacons for each run. Since there is some current, the speed through the water is not equal to the speed over the ground. By averaging (mean of means) the speed of three runs , the true speed through the water can be computed.

A typical trial party in the 1940's was headed by a David Taylor Model Basin Project Manager, who was in charge of civilian personnel operating the trials instrumentation and analyzing the data. His liaison onboard was the Officer in Charge of Ship's Observers. The ship's observers consisted of a Forward Deck Observer, Assistant Forward Deck Observer, Midship Deck Observer and After Deck Observer whose duties were to sight the range beacons at either end of the trial course and determine elapsed time. Phone talkers and messengers would communicate and transmit data to the trial computing room from the many locations onboard ship. The civilian trial party consisted of torsionmeter operators, data takers stationed at various locations in the Engine Room spaces, and data calculators in the trial computing room. The total trial party could easily number 20 to 30 people for a ship like NEW JERSEY .

Fig. 3. USS IOWA (BB 61) in drydock,

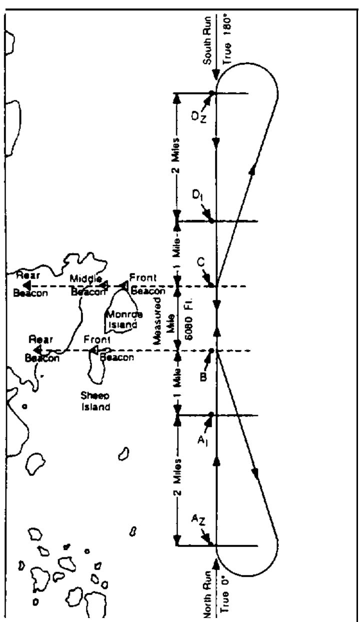


Fig. 4. Measured Mile Course, Rockland, Maine.

Before starting the trial, the observers were notified to man their stations. The messengers would distribute data books to the various stations as required. As each station was manned, the phone talker would report in to the trial computing room that his station was fully manned. When all stations were manned, the trial was ready to begin.

During the approach to the trial course, in advance of each run, the ship would be steadied out on the approach heading, using the minimum rudder necessary to maintain heading. The main throttles were adjusted to give the desired r/rein, and word was passed giving the run number and direction. Approximately 30 s before crossing the first set of range beacons, a two-bell standby signal was transmitted to all stations by the Assistant Forward Deck Observer. As the first range was crossed, the Forward Observer would start his stopwatch and a single bell of execution was given to signify that the run had begun, and to alert data takers to record data. Typically ten samples of data would be manually recorded in the data books from the various instruments located throughout the ship. As each successive observer lined up the range beacons, he would start his stopwatch. As the second set of range beacons was lined up by the Forward Deck Observer, he would stop his watch and a second one-bell signal was given to signify the end of the run. As the Midship and Aft Observers lined up the range beacons, they would stop their watches which would complete the data taking. As soon as the run was completed the recorders would send their data by messenger to the computing room. The ship would proceed at the same heading for a long enough distance to assure a good approach for the next run before making a turn.

This procedure was followed for each run of a three-pass speed spot, and for numerous speeds. The procedure involved the coordination of many people throughout the ship, and required good visibility of the range beacons in order for a run to be successful. Thus the trials were conducted in daylight hours only, and often as in the case of the NEW JERSEY, required two days of testing in order to develop a complete Standardization curve.

Tactical Trials Course, Rockland, Maine. The Tactical Trial Course at Rockland, Maine used for the Tactical Trials on USS NEW JERSEY is shown in Fig. 5. According to (3) Tactical Trials were held at Rockland, Maine, during the months of April through October that weather conditions and length of daylight would be favorable. For the first trials of the year, shore station equipment was loaded onboard ship and transported to Rockland, where it would remain for the trial season. The shore station equipment and personnel were landed by small boat. The equipment was set up at two sites: Station 1 located at the Rockland Breakwater Light, and Station 2 at owls Head Light, both shown in Fig. 5. Each shore station party consisted of four observers, Basin representative in charge, and three Petty Officers from the ship. The ratings of the Petty Officers were usually a Radioman, a Signalman, and an experienced Gunpointer. A typical shore station party is shown in Fig. **6**.

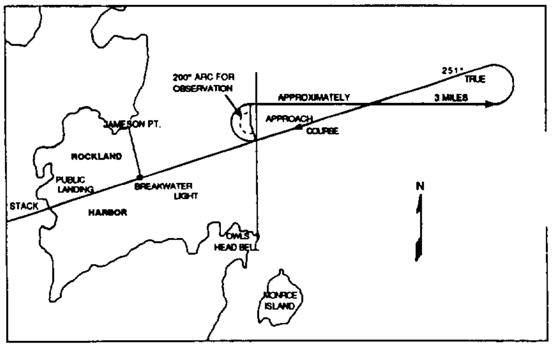


Fig. 5. Tactical Trial Course, Rockland, Maine.

Fig. 6. Shore station party, Rockland, Maine.

Tactical Trial Procedure. In the 1940's the Tactical Trials generally consisted of a series of turns of about 200° at various approach speeds and rudder angles and acceleration and deceleration runs at various conditions. There is, however, no record of any acceleration and deceleration runs being conducted on NEW JERSEY at Rockland. The typical conduct of a tactical turn is depicted in Fig. 5. The ship steadies up on the approach course of 251° True, steering on a range formed by the Rockland Breakwater Light, and a tall stack about 8 km (5 mi) inland as shown in the figure. The ship indicates that it is on the approach course by two-blocking “Baker”. The shore stations are informed by radio of the run number. One minute before the EXECUTE signal is given, the shore stations are told to stand by.

About 30 s before Owls Head bears 180° True, the words “Three Bells” are transmitted to the shore station by radio, while simultaneously a three-bell signal is given aboard ship. Fifteen seconds later the words “Two Bells” are transmitted and a two-bell signal is given. When Owls Head Light bears 180° True, the EXECUTE signal is given. On this signal the rudder is thrown over to the desired angle and MARX is given on the radio and a one-bell signal is given. At suitable intervals thereafter, single-bell signals are given together with a numerical count on the radio. In addition to these audible signals, the ship’s two 61 cm (24-in.) searchlights are manned during the trials. One light is aimed at each shore station at all times during the run and a flash of light is made for each bell signal. A standby is thus available to the shore station in case the radios fail. During a run the ship’s position and relative bearing was recorded photographically from each of the two shore stations at each signal transmitted. Simultaneous readings of ship’s rudder angle, angle of heel, and ship’s heading were recorded onboard.

Upon completion of a run the “end of run” signal is given on the radio simultaneously with a five-bell signal on the signal system. The ship then hauls down ‘Baker” and heads out to sea for another approach. As with the Standardization Trials , the procedure required close coordination of personnel not only onboard ship, but on shore as well, Data was recorded manually and photographically. Trials were limited to daylight hours with good visibility. Shore station personnel were required to sight on the ship’s main mast by telescope continuously throughout the run, and data was hopefully recorded simultaneously at approximately 10-s intervals. A signal man was available to communicate with the ship by semaphore in case radio communications were lost.

Fuel Economy Trials Procedure. The Fuel Economy Trial on NEW JERSEY were conducted in free route. The data was collected during two separate time periods: 12 to 13 October 1943 and again on 23 October 1943. During the first trial period, runs at 15 kn, 20 kn and Full Power were accomplished. During the second trial period, runs at 25 kn and 30 kn were accomplished. The duration of each run was approximately 2 hr of steady steaming for each condition with all observations being recorded at approximately 15-min intervals. Fuel oil to the boilers was measured in all spaces . Shaft r/min and torque were recorded and shaft horsepower was calculated for all four shafts during portions of each trial run. Fuel oil samples were obtained during each trial and were submitted to the Naval Boiler Turbine Laboratory (NBTL) for analysis.

USS IOWA (BB 61)

Hatteras East Coast Tracking. Offshore Range (Hector). The Hatteras East Coast Tracking Offshore Range (HECTOR) is depicted in Fig. 7. HECTOR is located 50 nmi northeast of Cape Hatteras, North Carolina. The center of the range is located at 35°52.5′ latitude North, and 74°51.0′ longitude West. The range site makes use of two of four offshore towers which are used by the Navy for pilot training. A photograph of one of the towers is shown in Fig. 8. The unmanned towers are 17.5 nmi apart, and at the edge of the continental shelf, thus permitting trials to be conducted in water depths ranging from 28 to 600 fathoms. Permanently mounted pulse radar tracking instrumentation is powered by a combination of solar panels and lead calcium batteries. As shown in Fig. 7, the tracking range is configured in the shape of a rectangular box 2 nmi wide by 4 nmi long, with the long axis oriented on a heading of 018° True. The center of the box is approximately 10 nmi perpendicular to a line drawn between the two towers. The 2 nmi by 4 nmi box represents the optimum area for determining ships′ position by radar tracking. Tracking can occur well outside the box, however the intent is to collect all trial data within this area. Both Standardization and Tactical Trials, and other trials requiring accurate positional information can be conducted on HECTOR.

Standardization Trials Procedure. The Standardization Trials procedure is relatively unchanged since the 1940′s and still consists of running a series of speeds with three acceptable consecutive runs at each speed to eliminate current effects. The Gulf Stream running along the East Coast of the United States veers eastward just south of HECTOR. Currents on the range have been typically 0.5 kn or less for trials conducted to date. The ship steers the designated compass course, in this case 018° or

However, instead of covering a distance of 1 nmi between range beacons, it transverses the optimum tracking area for 3 min. The distance traveled for each run thus varies with speed. The major differences in the conduct of the Standardization Trial is in the automation and speed of the data collection and in the real time display of critical

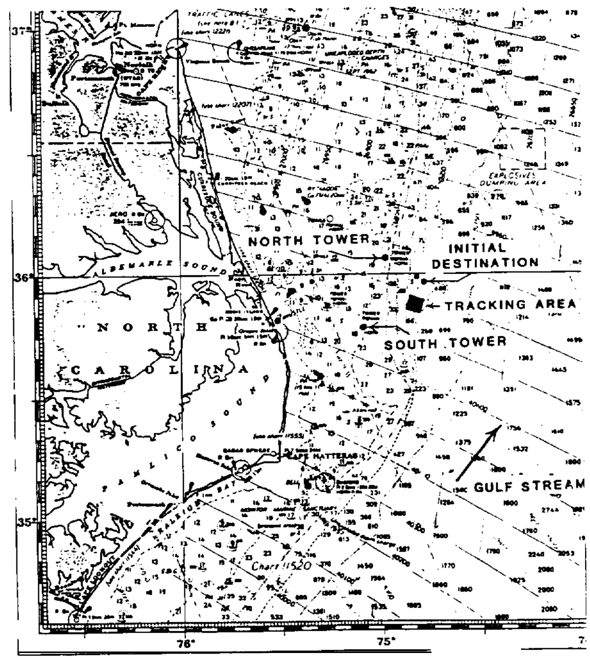


Fig. 7. Hatteras East Coast Offshore Range (HECTOR).

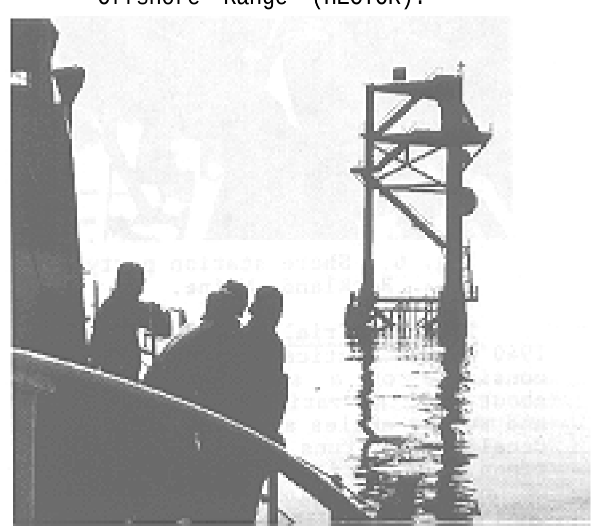


Fig. 8. HECTOR Range tower.

test parameters. A Cathode Ray Tube (CRT) screen, located on the bridge, displays the HECTOR box, and a continuous 1 s update of the ship's position on the range. This enables the ship's navigator to position the ship in relation to the box for the start of a run. Another CRT screen on the bridge is used to display shaft r/min, shaft torque, and EM Log speed, so that all of these parameters can be steadied out prior to commencing a run. The ship is not constrained to starting and stopping a run when range beacons line up, nor are there as many repeat runs because an EXECUTE is missed. As long as the ship is within the optimum tracking area, a run may be commenced. The radar tracking range also offers the capability of 24-hr a day operation, and operation in periods of low visibility. Rain squalls and dense fog, however, can detract from range tracking. The Standardization Trials on IOWA conducted at HECTOR were completed in 8 hr.

Tactical Trials Procedure. The Tactical Trial procedure for the IOWA trials consisted of conducting a series of 540° turns at three different approach speeds using various right and left rudder angles. The ship was steadied up on an approach course of 018° or 198°. A COMEX command was given and 1 min of approach data was collected. An EXECUTE command was given and the rudder was moved smartly to the predetermined position and held until the ship had changed heading 540°, at which time a FINEX command was given ending the run. The 540° turn enables the positional data to be corrected for drift due to wind and current. The assumption is made that the ship steadies out to a constant rate of change of heading after approximately 120° heading change from the approach course. Positional information between 120° and 180° is compared to positional information between 480° and 540°. Changes in position between these two portions of the turns are attributed to drift due to wind and current. Drift vectors are determined and applied to each and every positional data point collected during the turn, thus correcting the tactical turn to a condition of zero wind and current. A drift corrected plot of the turn and its associated tactical data, advance, transfer, and tactical diameter, are available for review shortly after completing a turn. The Tactical Trials on IOWA were completed in 5 hr, commencing at 2000 and finishing at 0100.

Fuel Economy Trials Procedures. The Fuel Economy Trials on IOWA were conducted both in free route while in transit to HECTOR, and on the range. The runs conducted in free route consisted of a full power buildup at six distinct r/min's with all four shafts propelling the ship. The runs conducted on the range were either locked shaft or trailed shaft runs. The trials procedure was essentially similar to those employed in the 1940's with the exception of the range tracking and the instrumentation used to collect powering data. The fuel economy runs in free route were typically 1 hr in length with data collected at 15-min intervals for each distinct condition. The locked and trailed shaft runs on HECTOR were typically two 10-min runs in opposite directions at each condition with the ship being tracked throughout for accurate speed determination.

INSTRUMENTATION

USS NEW JERSEY (BB 62)

A block diagram showing the types and location of the instrumentation most probably used during the trials on the NEW JERSEY is depicted in Fig. 9. As can be observed in the figure, the majority of the equipment required manual operation with the data being recorded with pencil and paper. As discussed earlier, this involved numerous personnel located at various widely-scattered locations about the ship. This necessitated an elaborate bell and light system to alert data takers and equipment operators when a run was to start or finish. Figure 10 is a photograph showing an actual trial room of a multi-shaft ship in the 1940's.

Standardization Trials Instrumentation. The Standardization Trials instrumentation consisted of equipment necessary to accurately measure the ship's speed and powering characteristics. As previously discussed, the ship speed was determined by observers visually sighting range beacons on shore, and determining by stop watch the time required to travel 1 nmi. Another important function of the observers was to electrically start and stop a device called a chronograph as the ship entered and exited the measured mile. A photograph of a chronograph is shown in Fig. 11. The operation of the chronograph is described in great detail in (11). Simply put, the chronograph was electrically connected to each observer station, a wind anemometer, and to two different types of counters on each propeller shaft. As the device was started and stopped, it recorded the total number of revolutions of the anemometer and each propeller shaft as well as the time of the three observers. Knowing the total revolutions, the anemometer and propeller shaft r/rein's could then be determined by dividing by the average time of the three observers. Knowing the anemometer r/rein, the relative wind speed in knots could then be determined from the anemometer calibration curve.

The determination of propeller shaft torques was most probably accomplished with the use of Ford type torsionmeter husk assemblies which

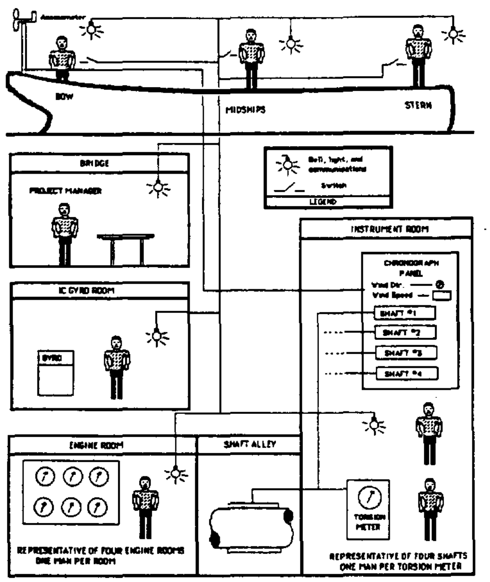


Fig. 9. Instrumentation block diagram, USS NEW JERSEY (BB 62),

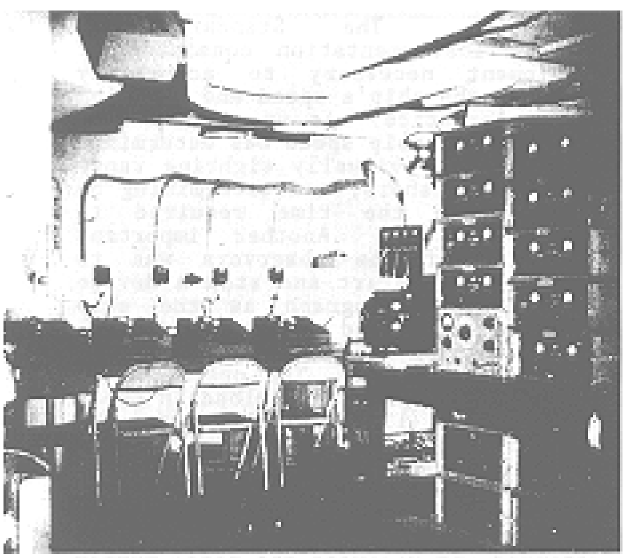


Fig. 10. Typical instrument trial room, 1943.

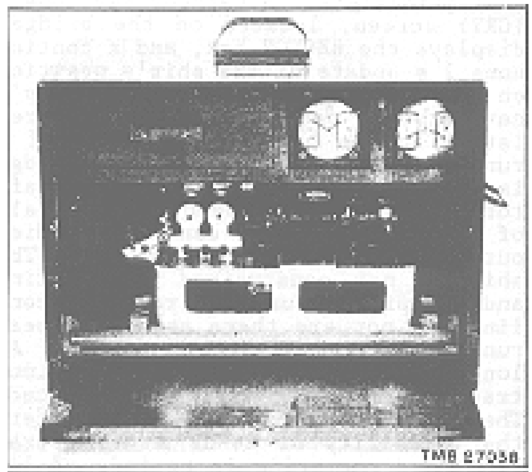


Fig. 11. Chronograph.

were in general use about the time of the NEW JERSEY trials. Although not the Ford type, a somewhat similar torsionmeter husk and magnetic micrometer system is shown in Fig. 12. As can be seen in the figure, these units were very large, weighing as much as 45 kg (1,000 lb), and it required considerable effort to mount them on the propeller shafts in the shaft alley. Also shown in the figure is the slip ring assembly whereby the electronic signal was recorded off the rotating shaft. The test tube technology components of the torque recording device, the magnetic micrometer, are also depicted in the figure. Details of the principles of operation of the magnetic micrometer and the torsionmeter shaft system are presented in (12) and (13) respectively. Each of the torsionmeters required a dedicated operator to q anually record torque signals periodically throughout each run. When a run was completed, these signals would be averaged and then multiplied by the corresponding shaft r/min and the proper constants to arrive at shaft horsepower for the run.

Tactical Trial Instumentation. In addition to the shipboard channels already discussed, the Tactical Trials required the recording of ship's heading, rudder angle, and roll angle. Also, shore station equipment was required to optically track the ship's position. Figure 13 shows a shore station tripod assembly in use during the 1940's. Again the majority of the data was manually recorded and as previously mentioned each shore station team consisted of four observers. Analysis of turning circle data thus required the merging of shore based positional information with onboard ship heading and rudder angle data. Naturally this could not be accomplished during the trial, but was only possible after the trial, back in the office.

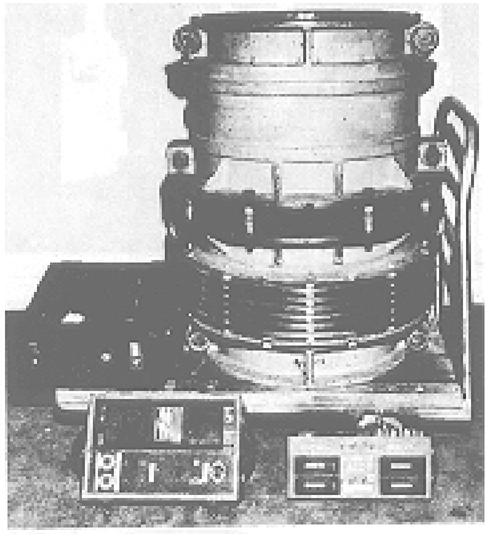


Fig. 12. Torsionmeter husk and magnetic micrometer.

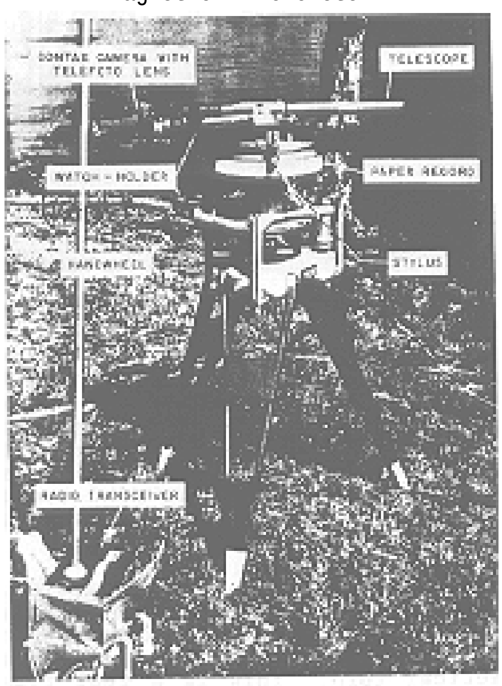


Fig. 13. Shore station tripod.

Fuel Economy Trial Instrumentation. The Fuel Economy Trial instrumentation consisted of all of the equipment required for the Standardization Trial to measure shaft horsepower, plus the necessary fuel oil meters to determine fuel consumption. Displacement type fuel oil meters were utilized in each engine room and the data for each run was manually recorded. The fuel consumption data was then merged with the powering data to determine specific fuel rates.

USS IOWA (BB 61)

Figure 14 shows a block diagram of the instrumentation used on the USS IOWA trials. As can be observed in the figure, the data was collected electronically by computer in a digital format. Signals obtained from throughout the ship were routed to the Flag Bridge where they were signal conditioned, processed, and converted to engineering units. Selected channels of engineering units were then further routed to the Navigation Bridge where they were displayed on CRT's to aid the Trial Director and ship'S force in the conduct of the trial. Figure 15 shows a display of standardization data on the bridge CRT.

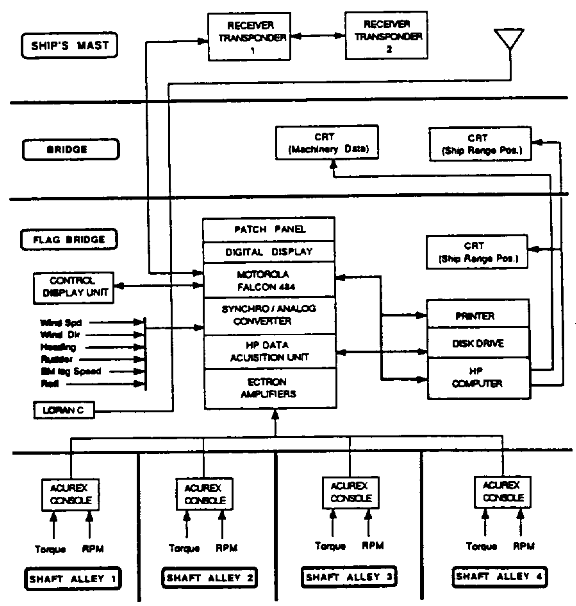


Fig. 14. Instrumentation block diagram, USS IOWA (BB-61).

Standardization Trials Instrumentation. As previously discussed, to determine accurate ship's speed, the IOWA trials were conducted at HECTOR . The tracking equipment used at HECTOR is the Motorola Falcon system. The equipment basically consists of a receiver/transmitter (R/T) , located on the ship's mast, two transponders, one on each of the two range towers, and a console located in the flag bridge. A transponder, R/T, and console is shown in

Fig. 16. The R/T is used to interrogate each of the transponders, and the time required to receive its response is used to determine the range from each tower and thus ship's position by the use of trigonometric relationships. The console system is used to then process the range information to display ship's position and speed on the CRT's located on the Navigation Bridge. The accuracy of ship s position is ±3 m (±3.3 yd). The accuracy of the ship's speed is a function of run time and is determined from repetitive positional updates. For runs conducted on IOWA the accuracy was typically 0.05 kn. Propeller shaft torque for the IOWA trials was measured by the use of an Acurex type torsionmeter depicted in Fig. 17. As can be seen, this unit is considerably smaller and lighter than the husk type units used in the 1940's. In addition, by using telemetry, there is no contact with the rotating components of the torsionmeter as with the slip rings on the old units. The system consists of two clamping rings which are used to mount a hermetically-sealed sensor bar. within the sensor bar is a strain gauge bridge assembly which is used to sense the displacement of the shaft due to twist over the known length between the clamping rings. Knowing the accurate dimensions of the shafting, outside diameter, and inside diameter, and the modulus of rigidity of the shafting material, the torque can be calculated, The accuracy of the torque measurement is ±1.5%. Propeller shaft r/min was determined for the IOWA trials by the use of an infrared sensor. Sixty strips of reflective tape were mounted on each shaft and the infrared sensor was used to "see" the strips and determine r/rein. The use of 60 strips enables the r/min to be displayed continuously and enables the determination of dynamic r/min changes.

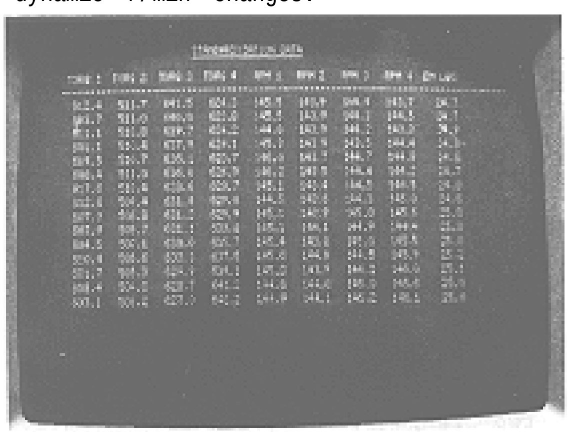


Fig. 15. CRT display, standardization data.

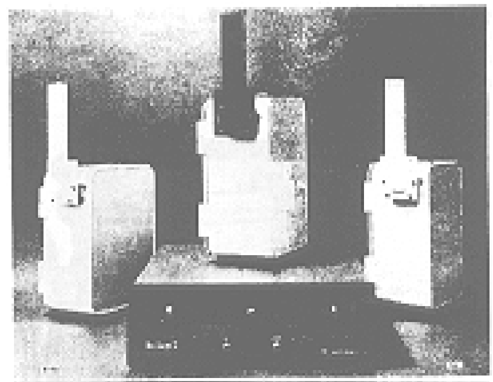


Fig. 16. Motorola Falcon tracking equipment.

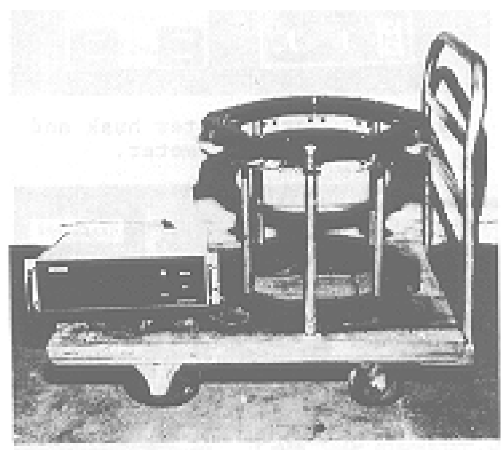


Fig. 17. Acurex torsionmeter.

Relative wind speed and direction were determined during the IOWA trial by the use of a calibrated anemometer. The anemometer was located at the bow of the ship so that it would not be influenced by the ship's superstructure. Relative wind speed and direction was continually recorded by the computer.

Tactical Trials Instrumentation.

Tactical data on IOWA was basically determined by range tracking. Show? Fig. 18 is a CRT display of a tactical turn. This is a real time display of the uncorrected turn. Upon completion of the turn, drift corrections are applied as previously discussed, and a corrected tactical turn can be displayed on the CRT. Along with the CRT display, a hard copy is provided to the ship's force with the pertinent tactical characteristics: advance, transfer, and tactical diameter.

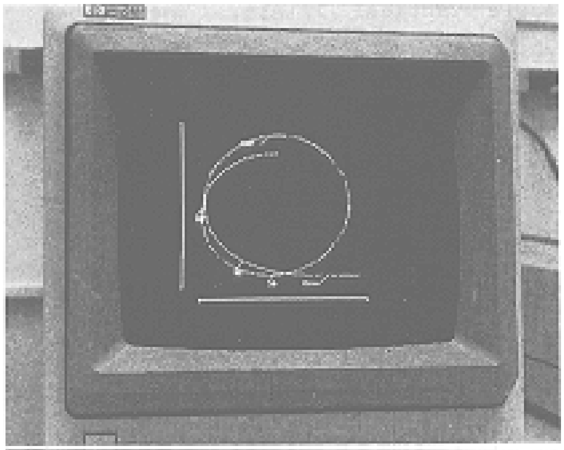


Fig. 18. CRT display, tactical turns.

In addition to the positional information, ship's heading, rudder angle, roll angle, and all of the powering information shown in the instrumentation block diagram is recorded throughout each run. This enables the determination of run time histories showing the dynamic responses of shaft torque, r/min, and ship's speed throughout the maneuvers. All of this information is available onboard ship at the completion of each run, rather than waiting to merge shore data with shipboard data, as in the 1940's.

Fuel Economy Instrumentation. With the exception of the instrumentation utilized to determine shaft horsepower, the Fuel Economy Trial instrumentation was not much different than in the 1940's. Fuel oil meters were still read manually at the start and stop of a particular run, and fuel consumption was determined. However, instead of only having discreet powering data available, this data was recorded continuously during a run by computer for predetermined blocks of time. Thus , time history plots of all four shaft torques and r/mins, and resulting shaft horsepower were available for determining specific fuel rates. The powering data could also be compared to the Standardization Trial data to determine accurate speeds and thus the cruising range of the ship.

PRESENTATION AND DISCUSSION OF RESULTS

USS NEW JERSEY (BB 62)

Standardization Trials. The results of the standardization trial On USS NEW JERSEY are shown in Fig. 19 and are tabulated in Table III. As can be observed the standardization curve consisted of five different speeds with the data collected at Rockland, Maine. The highest powering condition obtained on the range was at 29.3 kn, with an average shaft r/min of 183.2, a total shaft torque of 6,351,200 N-m (4,684,400 lb-ft), and a total shaft horsepower of 163,400 shp. This was considerably less than the design horsepower of 212,000 shp. Unfortunately the run by run individual shaft information for these trials is not available, so the cause of not being able to reach design full power is not known. AS best as can be determined by extrapolation of the existing data, the NEW JERSEY in 1943, at a displacement of 57,813 t (56,900 tons) was capable of a speed of slightly less than 31.0 kn at the design horsepower of 212,000 shp.

Table III. USS NEW JERSEY (BB 62) Standardization Trial data, 1943.
(Displacement 56,200 tons, 24 October)
(Displacement 56,900 tons, 26 October)

Speed (kn)	Average R/min	Total Torque (lb-ft)	Total Shaft Horsepower
15.50	89.2	989,170	16,800
20.05	117.0	1,705,800	38,000
24.90	147.2	2,783,000	78,000
27.92	168.9	3,930,400	126,400
29.30	183.2	4,684,400	163,400

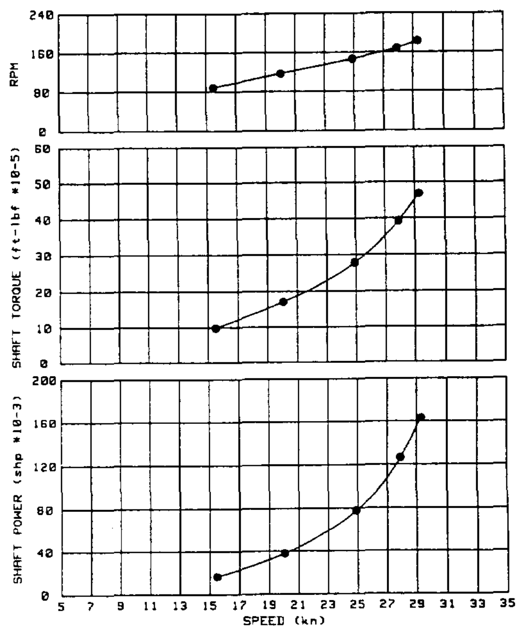


Fig. 19. Standardization Trials data, USS NEW JERSEY (BB 62).

Tactical Trials. The Tactical Trials results are shown in Figs. 20 through 21 and in Table IV. The data is nondimensionalized with the largest turning circle given a value of 1.000. Figure 20 shows the tactical plot of this 20 kn turn using 15° of right rudder. As can be observed, data is only available through approximately 180° change of heading. Positional information was also only recorded once every 15 s, and it is not apparent how corrections were made for drift due to wind and current, though the report states corrections were made. Figure 21 is a cross plot of nondimensionalized advance, transfer, and tactical diameter versus approach speed at a number of different rudder angles. Only the first three speeds on these curves were developed from the full scale Tactical Trials. The dashed symbols on the curves were developed from model tests.

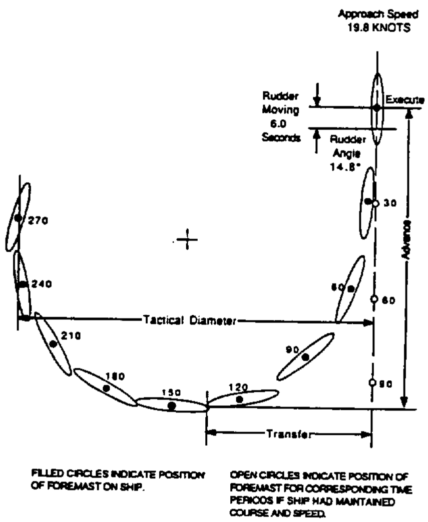


Fig. 20. Tactical plot, USS NEW JERSEY (BB 62)

Table IV. USS NEW JERSEY (BB 62) Trials data, 1943.

Approach Speed (kn)	Rudder Angle (deg)	Non-dimensionalized Turning Characteristics Advance	Transfer	Diameter
14.8	15.0R	0.921	0.885	0.952
15.5	20.6R	0.841	0.743	0.819
14.5	25.0R	0.785	0.690	0.708
14.6	34.3R	0.682	0.610	0.619
19.8	14.8R	1.000	1.000	1.000
21.1	20.8R	0.839	0.779	0.793
19.4	24.8R	0.757	0.708	0.747
19.5	34.5R	0.715	0.583	0.584
24.5	15.3R	0.963	0.873	0.947
24.3	24.8R	0.799	0.631	0.708
24.5	34.8R	0.763	0.588	0.605

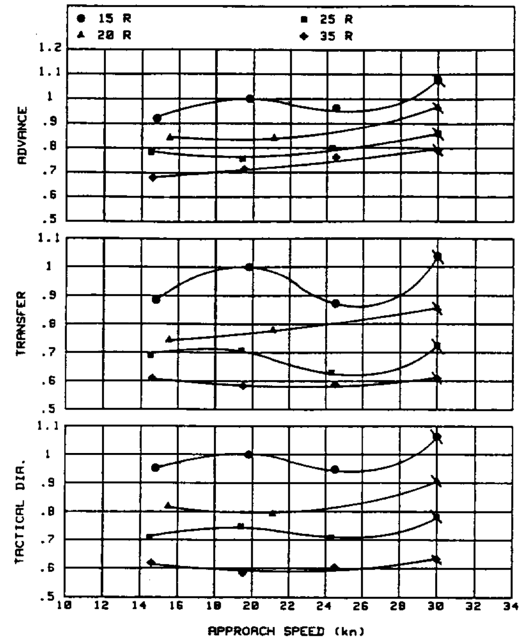


Fig. 21. Tactical Curves, USS NEW JERSEY (BB 62)

Fuel Economy Trials. Results of the Fuel Economy Trials conducted on the NEW JERSEY are presented in Fig. 22 and in Table V. This curve presents fuel consumption in gallons per hour versus shaft r/min.

Table V. USS NEW JERSEY (BB 62) Fuel Economy Trials data, 1943.

Speed (kn)	R/Min Avg.	SHP Total	Fuel Flow (gal/hr)	Fuel Flow* (lb/hr)	Specific Fuel Rate (lb/shp/hr)
15.3	87.9	16,470	1,900	15,500	0.941
20.0	116.7	38,340	3,000	24,400	0.636
25.1	148.5	81,900	6,200	50,600	0.618
29.7	186.1	170,960	13,000	105,000	0.614
31.0	203.0	221,030	17,700	142,900	0.647

*Weight of fuel used 8.09 lb/gal.

USS IOWA (BB 61)

Standardization Trials. The results of the Standardization Trials conducted on IOWA are shown in Fig. 23 and Table VI. The IOWA Standardization Trials consisted of seven spots conducted on HECTOR with the top powering condition achieved at 29.4 kn. The maximum total torque obtained was 5,580.500 N-m (4,116,000 lb-ft), at an average shaft r/min of 180.4, with a resulting total shaft horsepower of 141,500 shp. Full power was not achieved on the range due to a minor boiler casualty restricting the operations at HECTOR to seven boilers. Powering data was also recorded during the Fuel Economy Trials, however, and portions of this data is included in Fig. 23 and Table VI as the top spot. This fuel economy powering data indicates that IOWA was capable of 31.0 kn at an average r/min of 198.2, developing 6,681,500 N-m (4,928,000 ft-lb) of torque and 186,400 shp, while at a displacement of 56,858 t (55,960 tons). Extrapolating this data to full power indicates that IOWA could reach a speed of 32.25 kn.

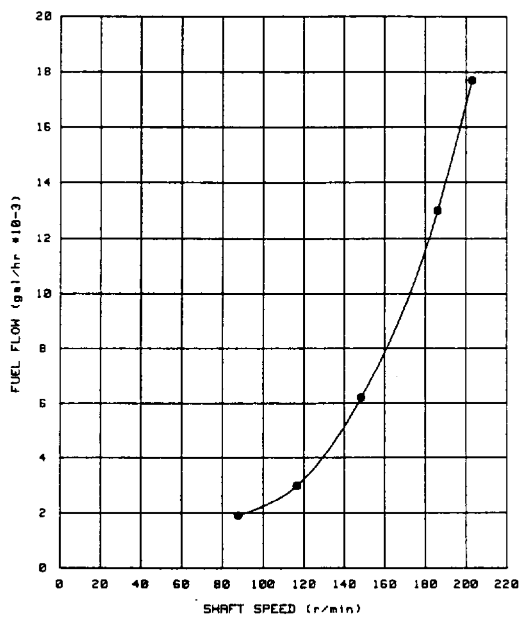


Fig. 22. Fuel Economy Curves, USS NEW JERSEY (BB 62).

<u>Tactical Trials</u>. The nondimensionalized Tactical Trial results for IOWA are presented in Figs. 24 and 25 and Table VII. As can be observed in Table VII, a total of nine right turns were conducted at nominal rudder angles of 15°, 25°, and 35°, and at nominal approach speeds of 15, 22 and 30 kn. In addition, three check turns were conducted at a nominal 35° left rudder, one each at 15, 22, and 30 kn to determine the difference between right and left rudder. Figure 24 shows a tactical plot of a typical turn on IOWA. Positional data is updated once per second, and the turn is carried out through 540° change in heading to permit drift vectors to be determined. As previously discussed, this enables the correction of the data for drift due to wind and current. Figure 25 is a cross plot of nondimensionalized advance, transfer, and tactical diameter versus approach speed for both left and right rudder. As can be observed, right rudder results in less advance than left rudder, approximately the same transfer, and a smaller tactical diameter.

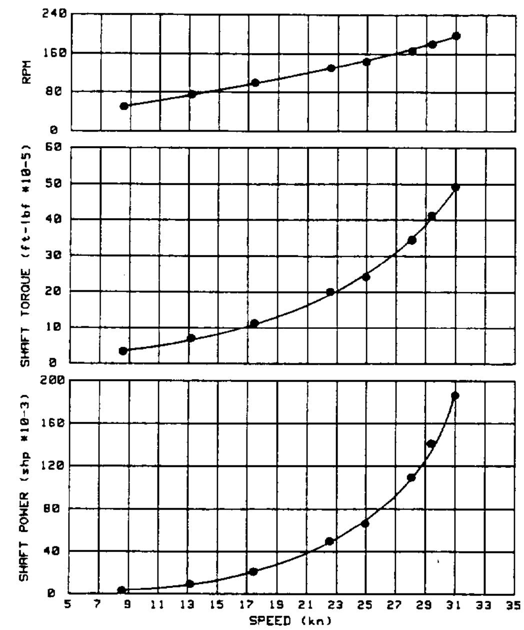


Fig. 23. Standardization Trials data, USS IOWA (BB 61).

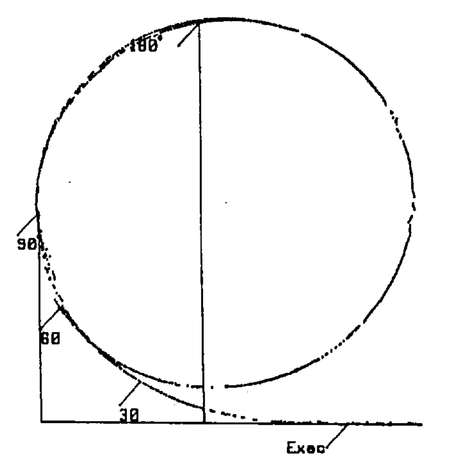


Fig. 24. Tactical plot, USS IOWA (BB 61).

Table VI. USS IOWA (BB 61) Standardization Trial data, 1985.
(Displacement 55,960 tons, 3 August)

Run	Range Speed	R/MIN					Shaft Torque (lb-ft)					Shaft Horsepower (shp)				
No.	(kn)	1	2	3	4	Avg.	1	2	3	4	Total	1	2	3	4	Total
1020S	9.29	52.9	49.9	50.1	50.4	50.8	86,000	80,000	76,000	80,000	322,000	900	800	700	800	3,200
1030N	7.84	50.4	48.9	49.5	50.0	49.7	90,000	84,000	92,000	88,000	354,000	900	800	900	800	3,400
Avg.	8.56					50.2					338,000					3,300
1040N	12.68	78.4	75.6	75.3	74.8	76.0	199,000	166,000	183,000	170,000	719,000	3,000	2,400	2,600	2,400	10,400
1050S	13.67	73.2	75.9	76.4	75.7	75.3	175,000	155,000	173,000	170,000	673,000	2,400	2,200	2,500	2,400	9,500
1060N	12.65	77.4	74.7	75.0	74.7	75.4	191,000	146,000	182,000	171,000	690,000	2,800	2,100	2,600	2,400	9,900
Avg.	13.17					75.5					698,000					9,800
1070N	17.29	99.3	95.8	99.0	100.0	98.5	277,000	220,000	303,000	300,000	1,100,000	5,200	4,000	5,700	5,700	20,600
1080S	17.67	100.7	100.5	99.0	100.1	100.1	275,000	265,000	287,000	297,000	1,124,000	5,300	5,000	5,400	5,700	21,500
1090N	17.18	101.0	100.7	99.6	99.5	100.2	298,000	267,000	307,000	297,000	1,170,000	5,700	5,100	5,800	5,600	22,200
Avg.	17.45					99.7					1,130,000					21,400
1110N	22.10	131.6	130.1	129.1	128.5	129.8	536,000	470,000	525,000	515,000	2,046,000	13,400	11,600	12,900	12,600	50,500
1120S	22.93	132.5	131.2	132.5	128.7	131.2	501,000	461,000	544,000	476,000	1,982,000	12,600	11,500	13,700	11,700	49,500
Avg.	22.52					130.5					2,014,000					50,000
1130S	25.47	147.6	144.5	145.1	143.6	145.2	646,000	544,000	635,000	618,000	2,443,000	18,200	15,000	17,500	16,900	67,600
1140N	24.65	144.2	143.4	143.5	143.0	143.5	616,000	544,000	643,000	632,000	2,435,000	16,900	14,900	17,600	17,200	66,600
1150S	25.07	145.0	144.1	144.7	144.3	144.5	606,000	509,000	634,000	631,000	2,380,000	16,700	14,000	17,500	17,300	65,500
Avg.	24.96					144.2					2,423,000					66,600
1160N	27.62	167.9	165.2	167.8	164.8	166.4	902,000	750,000	932,000	882,000	3,466,000	28,800	23,600	29,800	27,700	109,900
1170S	28.30	169.5	165.9	169.0	166.1	167.6	891,000	735,000	933,000	882,000	3,441,000	28,700	23,200	30,000	27,900	109,900
1180N	28.11	167.3	165.0	167.9	163.8	166.0	880,000	748,000	944,000	876,000	3,448,000	28,000	23,500	30,200	27,300	109,000
Avg.	28.08					166.9					3,449,000					109,700
1190S	29.71	180.5	179.5	182.7	180.9	180.8	977,000	929,000	1,156,000	1,047,000	4,109,000	33,600	31,800	40,200	36,100	141,600
1200N	29.08	179.3	179.2	182.3	180.8	180.4	992,000	934,000	1,168,000	1,064,000	4,158,000	33,900	31,900	40,500	36,600	142,900
1210S	29.78	180.3	180.4	178.2	182.0	180.2	977,000	939,000	1,059,000	1,066,000	4,041,000	33,500	32,300	35,900	37,000	138,700
Avg.	29.41					180.4					4,116,000					141,500
2120*	30.4	207.6	191.2	195.3	203.1	199.3	1,303,000	1,032,000	1,325,000	1,326,000	4,986,000	51,500	37,600	49,300	51,300	189,700
	30.3	205.3	191.1	194.9	202.1	198.4	1,267,000	1,030,000	1,325,000	1,306,000	4,928,000	49,600	37,500	49,200	50,300	186,600
	29.9	202.6	189.4	193.8	200.9	197.7	1,239,000	1,015,000	1,321,000	1,296,000	4,871,000	47,800	36,600	48,800	49,600	182,800
Avg.	30.2 (31.0)					198.2					4,928,000					186,400

*Full Power Fuel Economy Test Run. Speed data recorded from ship's EM Log. Average EM Log speed of 30.2 kn converts to 31 kn from range calibration of log.

Fuel Economy Trials. The Fuel Economy Trials results for IOWA are presented in Fig. 26 and Table VIII. The figure presents fuel flow in gallons per hour versus shaft r/min. Included in Table VIII is shaft horsepower information which enables the calculation of specific fuel rates in lb/shaft horsepower hour.

COMPARISON OF DATA

Standardization Trials. Figure 27 presents a comparison of the two Standardization Trials. The agreement between the two sets of r/min trial data is quite remarkable. The shaft horsepower data, however, is not in agreement. The IOWA requires less shaft horsepower than NEW JERSEY to achieve a given speed at the upper end of the speed range. This difference may be partially attributed to the new smooth paint systems in use today as contrasted with the hot plastic type of paint prevalent in the 1940's. In addition, IOWA was at a slightly lower displacement than NEW JERSEY, 56,858 t versus 57,458 t(55,960 tons versus 56,550 tons), although this is not considered significant. Other possible causes of these differences could be in the comparative accuracies of the torque measurements, and the constants used in the calculation of shaft torque (modulus of rigidity, outside diameter of shafting, and inside diameter of shafting). It was not possible to determine the values used in 1943. For the IOWA trials, the torsionmeters were installed on a solid section of shafting with a 23-in. outside diameter and a modulus of rigidity of 11.6 x 10^6 lb/in² was used.

Tactical Trials. A comparison of the Tactical Trial data for IOWA and NEW JERSEY is shown in Fig. 28. These comparisons are quite remarkable especially considering that the extremities of the 1943 data were developed from model tests. One apparent inconsistency is in the plots of advance and transfer where it can be seen that the IOWA's advance is consistently greater and its transfer consistently less than NEW JERSEY's although the tactical diameters are quite similar for the two ships. One possibility for this discrepancy may be the method of constructing the plot of the ship's path throughout the maneuver. Current methods plot the positional path of the R/T mounted on the ship's main mast, with the ship's heading being determined by the gyro. This position then includes the drift angle, the angle between the ship's heading and a tangent to the turning circle. A slightly different method used in the 1940's consisted of plotting a tangent to the ship's foremast at each point and not using the compass heading, thus excluding the drift angle. It appears that this method has a greater impact on the determination of advance and transfer than it does on tactical diameter. It is also not apparent whether the NEW JERSEY data had been adequately corrected for drift as is evident by the irregular shape of the NEW JERSEY curves as compared with those of the IOWA.

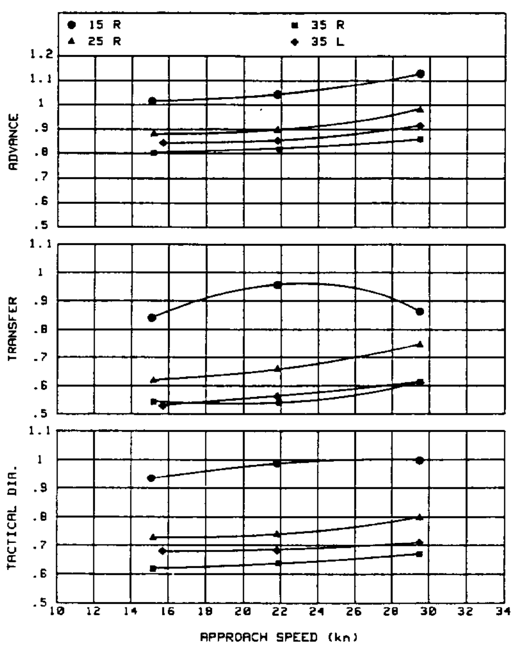


Fig. 25. Tactical curves, USS IOWA (BB 61).

Table VII. USS IOWA (BB 61) Tactical Trials data, 1985.

Approach Speed (kn)	Rudder Angle (deg)	Non-dimensionalized Turning Characteristics Advance	Transfer	Diameter
15.1	14.4R	1.016	0.840	0.934
15.2	24.8R	0.882	0.618	0.728
15.2	33.8R	0.804	0.544	0.617
15.7	34.1L	0.847	0.530	0.679
21.8	14.4R	1.043	0.956	0.989
21.8	24.5R	0.897	0.659	0.739
21.9	34.0R	0.819	0.542	0.637
21.8	33.3L	0.856	0.563	0.682
29.5	15.5R	1.129	0.863	0.997
29.5	24.7R	0.980	0.746	0.797
29.5	33.8R	0.862	0.613	0.669
29.5	33.0L	0.916	0.611	0.711

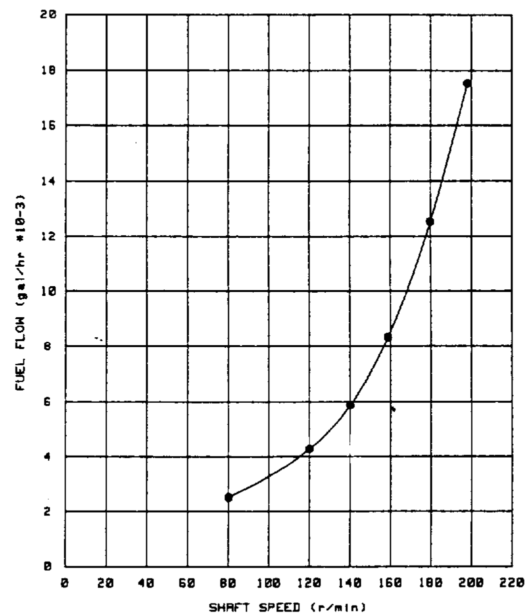


Fig. 26. Fuel Economy Curves, USS IOWA (BB 61).

Table VIII. USS IOWA (BB 61) Fuel Economy Trials data, 1985.

Speed (kn)	R/Min Avg.	SHP Total	Fuel Flow (gal/hr)	Fuel Flow* (lb/hr)	Specific Fuel Rate (lb/shp/hr)
14.9	80.1	13,290	2,509	17,754	1.336
20.9	120.1	38,730	4,281	30,288	0.762
24.0	140.2	61,010	5,864	41,510	0.680
26.8	158.9	90,290	8,342	59,102	0.655
29.2	179.9	138,190	12,527	88,681	0.642
31.0	198.1	186,260	17,535	124,210	0.667

*Weight of fuel used 7.08 lb/gal.

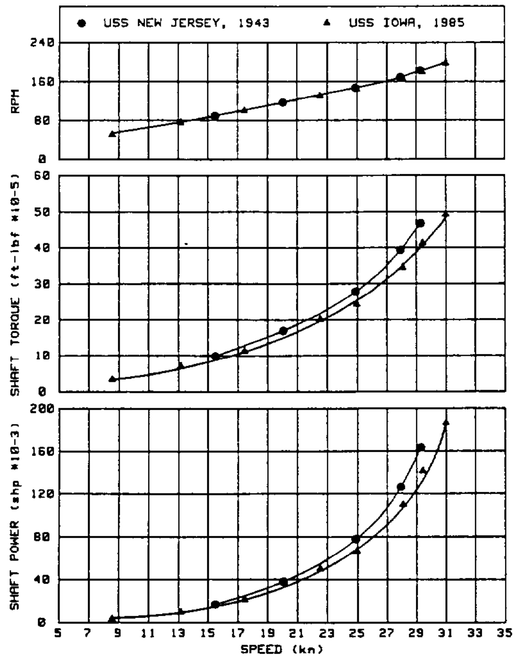


Fig. 27. Standardization Trials comparison.

Fuel Economy Trials. A comparison of the Fuel Economy Trial data is shown in Figs. 29 and 30. The fuel consumption and specific fuel rate as a function of r/min is higher for the IOWA. This may be attributable in part to the greater hotel load (air conditioning, electronics suites, etc.) as compared to the NEW JERSEY.

CONCLUSIONS

First of Class Trials conducted on the USS NEW JERSEY (BB 62) in 1943 have been contrasted with a similar set of trials conducted on the USS IOWA (BB 61) in 1985. Trial techniques have been shown to have evolved over the years as a result of advances in electronic instrumentation and computers, to become much more automated. Data collection and analysis have evolved to the point of real time displays of the various test parameters during the conduct of the trial, again as a result of advances in instrumentation and computers. The conduct of a trial today is a much less labor intensive effort on the part of the trials teams than it was in 1943.

The similarities in the problems affecting the two trials are striking. In 1943 a casualty prevented the determination of full power speed on the measured mile. In 1985 a similar problem beset the trial and full power could not be reached at HECTOR. In both cases, off-range data was used to help determine the corresponding speed at full power. Problems besetting trials in the 1940's still occur in the 1980's.

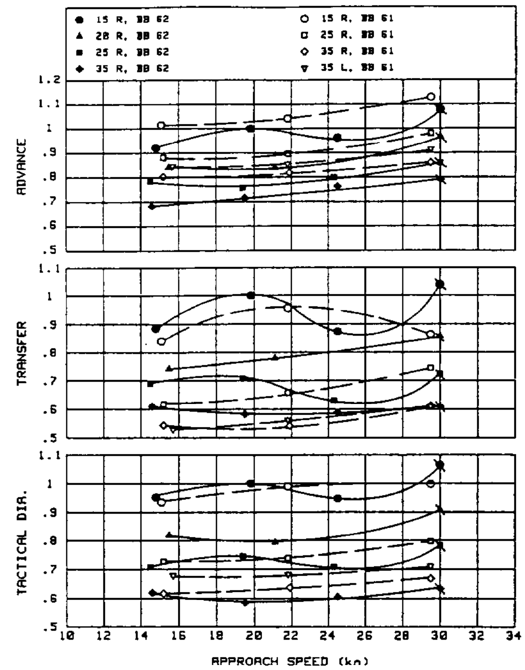


Fig. 28. Tactical Trials Comparison.

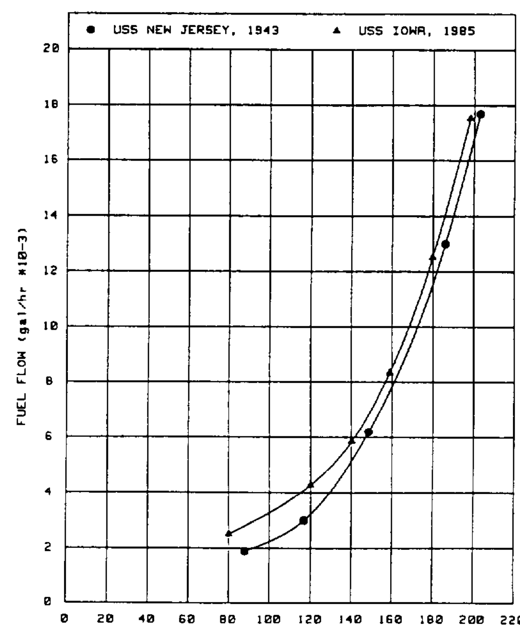


Fig. 29. Fuel Economy Trials comparison (fuel flow).

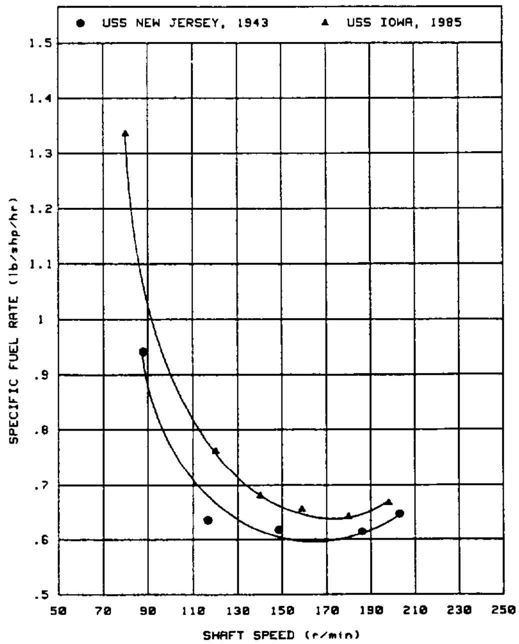


Fig. 30. Fuel Economy Trials comparison (specific fuel rates).

The similarity and repeatability of the trial data collected on two different ships over 40 years apart using different equipment, techniques, and personnel reflects highly on the accuracy of the data and the professionalism and care involved in both trials. The data collected during the 1940's supplemented by the 1985 trials data will be invaluable to the operators of the four battleships as they assume their roles as the focal points of the Surface Action Groups of the Fleet on into the Twenty-First Century.

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