

**REPORT OF BOARD ON  
COMPARATIVE TRIALS OF  
THE SCOUT CRUISERS  
BIRMINGHAM-SALEM-CHESTER**

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Report of Board on Comparative Trials of the Scout Cruisers Birmingham-Salem-Chester by  
Various

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**VARIOUS**

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**Birmingham-Salem-Chester**

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December 22, 1909



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## COMPARATIVE TRIALS OF SCOUT CRUISERS.

### BIRMINGHAM—SALEM—CHESTER.

NAVY DEPARTMENT,  
BUREAU OF STEAM ENGINEERING,  
Washington, D. C., December 22, 1909.

SIR: The Board appointed by the Navy Department, under orders dated October 21, 1908, to carry out comparative tests of the main and auxiliary machinery of the scout cruisers U. S. S. *Birmingham*, *Salem*, and *Chester*, having finished the work assigned to it, respectfully submits, as directed, the following report, embracing an analysis of the results obtained, together with a copy of the data recorded during the various tests made.

#### OBJECT AND DESCRIPTION OF TESTS.

The object of the tests was to ascertain and compare the steam economy of the three types of propelling machinery fitted in the vessels named, the hulls being practically of the same model, at various speeds while underway and under as nearly as possible identical conditions. To accomplish this, special water-measuring apparatus was built and installed in each ship for the tests, and so arranged that the weight of steam used by the propelling machinery, as well as the auxiliaries, could be, after condensation, separately and accurately ascertained. In order to make the comparison complete, six distinct series of tests were carried out, as follows:

- I. Tests of auxiliary machinery (vessel in port).
- II. Boiler evaporative tests (vessel in port).
- III. Standardization runs. Each vessel was standardized over the Rockland measured mile course just prior to undertaking the (IV) steam-consumption tests. As will appear later, this involved standardizing the *Salem* on two different occasions, as two series of steam-consumption tests were carried out. In these trials, moreover, and as well as all other (V and VI) sea runs, the aim was to load each vessel so that the displacement for each trial should be as nearly as could be calculated in the beginning, an average of 4,000 tons. All ships were dry-docked prior to standardization and coal-consumption trials, and the bottoms cleaned and painted.
- IV. Steam-consumption tests of main and auxiliary machinery (vessel under way).
- V. Coal-consumption tests of about 1,000, 750, and 2,000 knots at speeds, respectively, of 10, 15, and 20 knots per hour.
- VI. A full power run of twenty-four hours' duration. The *Birmingham* was unable to complete this trial on account of a defect which developed in the machinery. This vessel, after finishing twelve hours of the test, slowed down and returned to port.

It will be convenient to describe the different sets of tests in the order above mentioned, although they were not carried out in the sequence outlined.

As above stated, the scheme of comparison adopted was to ascertain by measurement of the exhaust steam the economy of not only the propelling machinery under varying conditions of sea speed, but in addition, of the various auxiliaries. It may be pointed out here that coal-consumption trials, even with the same quality of coal, weather, and condition of bottoms, do not furnish the means of accurate comparison, because of the personal element in firing, which can not be eliminated or satisfactorily allowed for. Moreover, the boiler plants on the *Birmingham* and *Salem* differ from that on the *Chester*, which introduces another inevitable complication in any attempt at comparison, by weight, of coal consumed.

While the water-measuring apparatus was so arranged that on the steam-consumption tests underway, the steam used by the main propelling machinery could be separately determined from the steam used by the auxiliaries in operation as a whole, it was considered desirable, nevertheless, to fix by actual test and under varying conditions the steam necessary for each individual auxiliary. These tests, which constitute Group I, were made on each vessel while at the Boston Navy-Yard, and the results recorded are more particularly described under "Tests of auxiliary machinery."

Group II covers evaporative boiler tests on the *Chester* and *Salem* with the vessels in port. It may be remarked that similar tests on the boiler plant of the *Birmingham* were considered unnecessary since this plant is identical in all important particulars with the *Salem's* installation. These consisted of a series of four tests on each vessel, using the two after boilers, which latter connect to and are the only boilers delivering gases of combustion to the after smoke-stack. On the *Salem* these consisted of forced draft tests with closed fireroom under air pressures equivalent, respectively, to one-half,  $1\frac{1}{2}$ ,  $2\frac{1}{2}$ , and 4 inches of water. A series of tests was made on the *Salem* at the various air pressures stated, but the board considered these unsatisfactory. A second series was run at a later date, therefore, under more favorable conditions and with satisfactory results. Only the results of the second series of tests, however, are tabulated in this report. The *Chester's* tests covered one at natural draft, with others at one-half,  $1\frac{1}{2}$ , and  $2\frac{1}{2}$  inches of water, respectively, the aim being to simulate conditions of steaming in service and to approximate to the same coal consumption per square foot of grate in the boilers of each vessel.

Standardization runs (Group III) were conducted under the supervision of the Board of Inspection and Survey, and results are plotted on plates 85 (*Birmingham*), 86 and 87 (*Salem*), and 88 (*Chester*).

Group IV comprises tests on all ships, measuring exhaust steam of condensation from the main and auxiliary machinery, with vessels at sea, and at various speeds, from about 10 knots up to the maximum. In these tests the exhaust steam entering the main condensers was, after condensation, measured in the main measuring tanks; furthermore, if found desirable, the amount entering each condenser could be separately determined, thus making it possible to compare the steam consumptions of the starboard and port main turbines or engines. Exhaust steam from all auxiliaries in operation,



including drains, discharge from traps, etc., was delivered to the auxiliary condenser and, after condensation, discharged to the auxiliary measuring tank. The total boiler output, therefore, in steam during any test, amounted to the sum of the weights of water collected in the main and auxiliary tanks. No attempt to measure or weigh the coal used on these trials was made. On the *Birmingham*, 10 steam-consumption tests, as above described, were run in all, and the data collated is given in Tables 33 to 42. Two series of tests were made on the *Salem*; the first set, which included 10 tests, furnished clue to damage of starboard main turbine blading, which eventually resulted in a complete overhaul at the contractors' works (Fore River Shipbuilding Company), and repair of the injured parts. The discovered defects are mentioned more at length later in this report. As, however, the repairs referred to were not undertaken until after completion of the (V) competitive coal-consumption trials, and the twenty-four hours' (VI) full-power run, the data obtained on these trials are given in full, in addition to the results on 14 other steam-consumption tests forming the second series, which latter were made when the machinery of the *Salem* had been placed in good condition. Steam-consumption trials on the *Chester*, embracing tests of the 4, 5, and 6 turbine combinations, at various speeds, and numbering 29 in all, were carried out. Of these, the results of the first 5 are at variance with results of later similar tests in the series. This may have been due to the fact that the 5 tests referred to were the first steam-consumption tests undertaken of the main and auxiliary machinery, as a whole, and it is probable that inaccuracies resulted from inexperience in operating the machinery in connection with measuring apparatus, the difficulties of which were greatly accentuated in the beginning by unsatisfactory working of the main lift pumps, which later were put in proper condition. The steam-consumption results of these 5 tests are regarded as unreliable, but have been tabulated in Tables 66 to 70 for other data.

Group V comprises data collated from sea runs of the three vessels in company, extending over periods of ninety-six, fifty, and ninety-eight hours, respectively, and at speeds of about 10, 15, and 20 knots. On these trials the same grade of coal, loaded at the naval coaling station, Bradford, R. I., was used on all ships, and the amount burned by each vessel was carefully determined. As it was desired that the mean displacement for each trial and for each ship should be as nearly as possible 4,000 tons, calculation was made prior to every coaling, of the amount necessary to be taken aboard, so that, making due allowance for the coal required to propel the ship to the open sea before each trial began, and, as well, that necessary for the trial itself, the displacement, when one-half of the trial was finished, would approximate to the figure stated. It is evident, then, that this involved starting each trial at a greater displacement than 4,000 tons, and ending with a displacement below that figure. All trials were begun off the harbor of Newport, R. I., and finished close to that port. Each ship maintained, at all times, very closely the revolutions indicated as necessary by the standardization curve for speeds of 10, 15, and 20 knots, respectively, and at no time were the vessels widely separated, being always in sight of one another, and, of course, subject to the same weather conditions. Particular attention was given to secure accurately the number of cubic feet of coal

consumed, but, in addition, such other data were taken as would enable the steam consumption of all machinery in use to be approximately and separately figured from results of steam-consumption tests previously made. Prior to these trials, water-measuring apparatus had been removed from all ships.

The full power trials (VI), extending over a period of twenty-four hours, were undertaken with the view of demonstrating the highest sustained sea speed, for the time mentioned, of these vessels. As in all other sea trials, the aim was to have each vessel at an average displacement for the trial of 4,000 tons, as nearly as could be figured. The coal for all ships was of the same grade and procured at the Bradford coaling station. As previously stated, the *Salem* and *Chester* finished this trial, but the *Birmingham* was obliged to discontinue, after twelve hours, on account of looseness of I. P. crosshead (starboard engine), which caused violent vibrations and liability to further damage in event of continuing the trial.

A brief description of the hull and machinery of these vessels is given below.

#### PRINCIPAL HULL DATA.

The hulls (pl. 1) of all vessels, except in minor particulars, are alike. Steel is used throughout, and the outside plating generally is on the raised and sunken strake system. The frames, spaced 36 inches apart, are generally of channel section, 6 by  $2\frac{1}{2}$  by  $2\frac{1}{2}$  by 13.3 pounds.

The outside plating, below the load water line, consists of 15-pound plating, reduced to 12-pound at the ends, and of 12-pound plating elsewhere. Flat keel plates, about 36 inches in width, are in two thicknesses; the inner of  $17\frac{1}{2}$  and the outer of 20 pound plate. The vertical keel, about 39 inches in depth, is of 15-pound plate. Garboard and sheer strakes are  $17\frac{1}{2}$  pounds, reduced to 15 pounds at the ends. Nickel-steel protection (80-pound plate) of variable width, extends fore and aft in wake of engine, boiler, and dynamo rooms.

The weight of hull, including nickel-steel protection, but without machinery, coal, stores, outfit, armament, and ammunition, etc., is approximately 2,015 tons. Principal dimensions are:

Length between perpendiculars, feet.....	420
Length over all, feet and inches.....	423-2
Length on L. W. L., feet.....	420
Breadth, molded, feet and inches.....	46-8
Breadth, extreme, feet and inches.....	47-0 $\frac{1}{2}$
Ratio of length to beam.....	8.97
Draft (official contract trial, 3,750 tons displacement), feet and inches....	16-9
4,000 tons displacement, feet and inches.....	17-4 $\frac{1}{2}$
4,710 tons displacement (about fully loaded), feet and inches.....	19-2 $\frac{1}{2}$
Displacement per inch at mean draft (16 feet 9 inches), tons.....	31.07
Area of midship section (3,750 tons displacement), square feet.....	566
Area of L. W. L. section (3,750 tons displacement), square feet.....	12,960
Wetted surface section (3,750 tons displacement), square feet.....	19,900
Coefficient (at 3,750 tons displacement):	
Block.....	.40
Midship.....	.72
L. W. L. plane.....	.66
Coal bunker capacity in tons (43 cubic feet per ton):	
<i>Birmingham</i> .....	1,395.3
<i>Salem</i> .....	1,388.3
<i>Chester</i> .....	1,407

## MACHINERY INSTALLATIONS.

Main propelling machinery, of 16,000 I. H. P., at maximum power, of the twin-screw, reciprocating type, for the three scout cruisers, was designed by the department. Proposals, however, for the construction of these vessels were invited under two classes, viz, first, for hull and machinery in accordance with department's plans and specifications; second, in general accordance with the department's plans and specifications, but on bidder's design of machinery, preference to be given, other things being equal, to a turbine installation.

After examination of the bids submitted, contracts were awarded on the department's design of hull, as follows: To the Fore River Ship and Engine Building Company, Quincy, Mass., two vessels—the *Birmingham* and *Salem*—at a contract price of \$1,556,000 each; the first named to have the department's design for propelling machinery, and the latter to be equipped with Curtis marine turbines. Contract for the remaining vessel, the *Chester*, was awarded to the Bath Iron Works, Bath, Me., at \$1,688,000; the propelling installation to be of the Parsons marine type.

Both contractors were required to guarantee, under penalty, and in addition to various other trials, a successful sea trial of four hours' duration at an average speed of not less than 24 knots on a displacement of not less than 3,750 tons.

A summary of the important data of the propelling machinery of the three vessels follows:

## BIRMINGHAM.

[Plate 2.]

The engines, which turn the propellers outboard, are of the vertical inverted 4-cylinder, direct-acting, triple-expansion type, with unjacketed cylinders, placed in two water-tight compartments, and operating twin screws. Each engine was designed for an indicated horsepower of 8,000 at 200 revolutions per minute, with a steam-chest pressure of 250 pounds per gage. Beginning forward, the order of the cylinders is, forward L. P., H. P., I. P., and after L. P. The forward L. P. and H. P. cranks are opposite, as are the I. P., and after L. P., the second pair being at right angles with the first. All main valves are of the piston type, worked by double-bar Stevenson links. There is one piston valve for the H. P. and two each for the I. P. and L. P. cylinders.

Engine framing is of forged steel, cylindrical columns, trussed by forged-steel stays. All crank, thrust, line, and propeller shafting is hollow, and shafts, piston, and connecting rods, and working parts generally, are of forged steel:

## CYLINDERS.

Number for each engine.....	4
H. P. diameter, inches.....	28½
I. P. diameter, inches.....	45
F. L. P. diameter, inches.....	62
A. L. P. diameter, inches.....	62
Diameter of piston rods, inches.....	6
Stroke of all pistons, inches.....	36