TURBINIA

TYNE AND WEAR
COUNTY COUNCIL
MUSEUMS

(Front cover)
Turbinia at speed
Inset - Hon. Sir C.A. Parsons, from the portrait by Sir W. Orpen R.A.

FORWARD

The experimental steam launch *Turbinia* designed by Sir Charles Parsons, is part of the Museum collections administered by the Tyne and Wear County Council through its Museums services. In 1975, plans were initiated by the County Council for the establishment of a new Museum of Science and Engineering to replace the former Museum housed in the Palace of the Arts, a temporary building dating from the 1929 North East Coast Exhibition. In 1981, the first phase of the new Museum was opened in Blandford House, Newcastle Upon Tyne, and a scheme to re-display the *Turbinia* is under active consideration by the County Council.

To mark the importance of the *Turbinia* in the history of engineering, the American Society of Mechanical Engineers, New York, has designated the *Turbinia* as an International landmark. This publication, written by Adrian Osler, Keeper of Shipping, Tyne and Wear County Museum Service, has been prepared to mark this important occasion. The County Museum Service is grateful to The American Society of Mechanical Engineers for making this publication possible through a generous grant.

John Thompson

Director of Museums and Art Galleries

October 1981

The American Society of Mechanical Engineers

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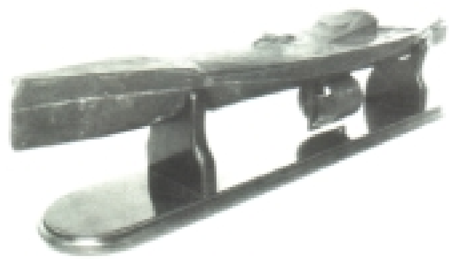
Charles Parsons - His Early Years
Charles Parsons, later the Hon. Sir C.A. Parsons, C.B., K.C.B., O.M., (1854 - 1931), ranks high amongst the many British engineers and inventors of the Victorian and Edwardian eras. He came from a distinguished scientific family and his father, the third Earl of Rosse, was a noted astronomer and one time President of the Royal Society.

After education by private tutor Charles Parsons furthered his studies at Trinity College (Dublin) and Cambridge University, at both of which he specialised in mathematics. His association with the North East of England commenced in 1877 when, in view of his ardent engineering interests, he entered Sir William Armstrong's famous Elswick Works on



Model launch, reputedly built by Parsons in the early 1880's showing a unique (compressed air-powered) combined underwater turbine/propeller unit. Though not directly related to the Turbinia project it shows his early interest in turbine propulsion for vessels.

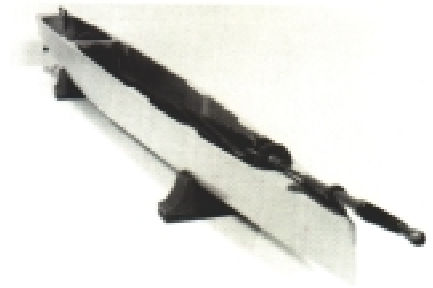
Tyneside as a premium apprentice. Following four years apprenticeship there he carried out a short period of research partnership with Kitson and Co. in Leeds and then joined Clarke, Chapman & Co. of Gateshead-on-Tyne as a junior partner.

Developing the Turbine
His interest in high speed steam

engines had already been aroused through the designing of epicycloidal engines at Elswick and Leeds and with Clarke, Chapman's electrical department he turned his attention to the often attempted development of a practical steam turbine. His first, and very comprehensive, patent for a compound reaction steam turbine was filed in 1884. This pioneer machine, which was of ‘parallel flow’ design, was a success and in the next few years important problems regarding lubrication, blade efficiency and control were solved, together with the application of the turbine to dynamos (turbo-generators) for generating electricity. Production of turbo-generators was then commenced both for land and shipboard use and, from the evidence available, it seems likely that it was during this period that Parsons first seriously considered the direct application of this type of turbine to marine propulsion.

However, in 1889 he left the firm of Clarke, Chapman & Co. and in doing so lost the patent rights to the ‘parallel flow’ turbine. A complex legal battle for their recovery followed, but for five years he was denied the opportunity to develop any form of ‘parallel flow’ machine so that the efforts of his own new company had to be concentrated on ‘radial flow’ turbines. After great development efforts these proved basically less efficient than the ‘parallel flow’ machines, but some of the results gained were later to prove of use in other fields. Despite the deficiencies of the ‘radial flow’ machines Parsons was, by late 1893, commencing design work for the purpose of actually applying turbine power to ship propulsion. In January 1894 he took the principle part in forming the Marine Steam Turbine Co. (Heaton) which was given the exclusive licence rights for major patents dealing with turbine propulsion for ships. It was also at this time that he recovered for reasonable costs his original patents for the ‘parallel flow’ design.

The stage was thus set for the entry of the *Turbinia,* for Parsons had already effectively “solved a problem which for a hundred years and more has exercised and baffled the ingenuity

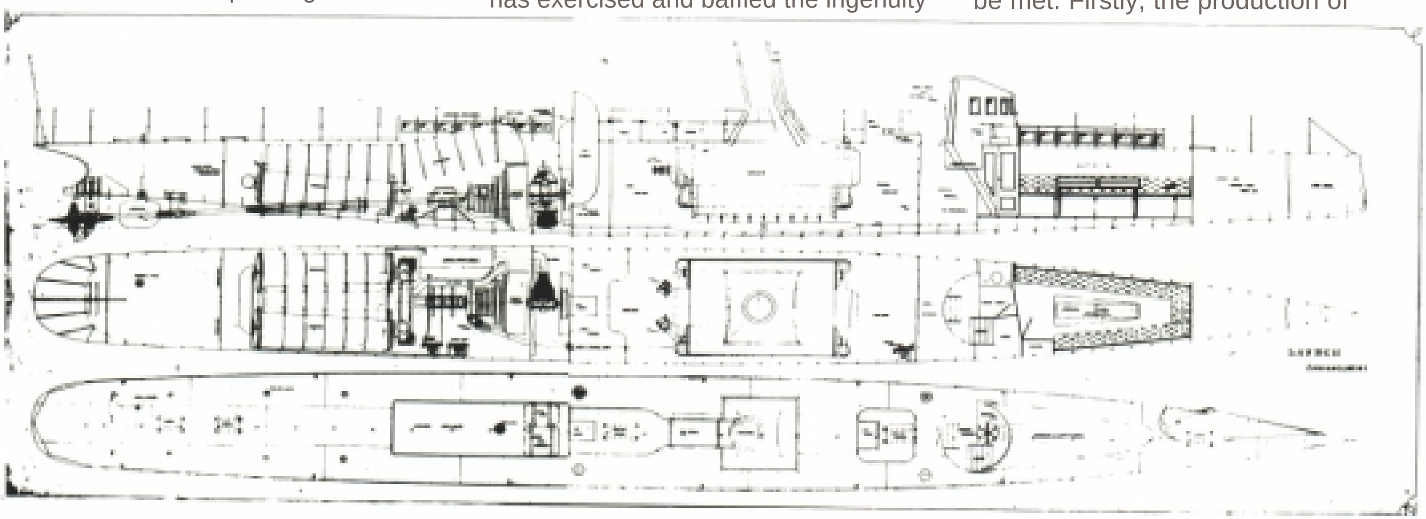


The larger of the two models used by Parsons to determine the hull resistance and power requirements for the Turbinia. Although model testing was still something of a novelty Parsons results were extemly accurate.

of inventors. Many persons have endeavoured to employ the velocity of steam for the purpose of causing rotary motion without the intervention of any reciprocating apparatus. But no one before Mr. Parsons ever suceeded in producing a steam turbine of practical utility”.

Turbinia is born

In order to apply the turbine successfully to marine propulsion two particular requirements still needed to be met. Firstly, the production of

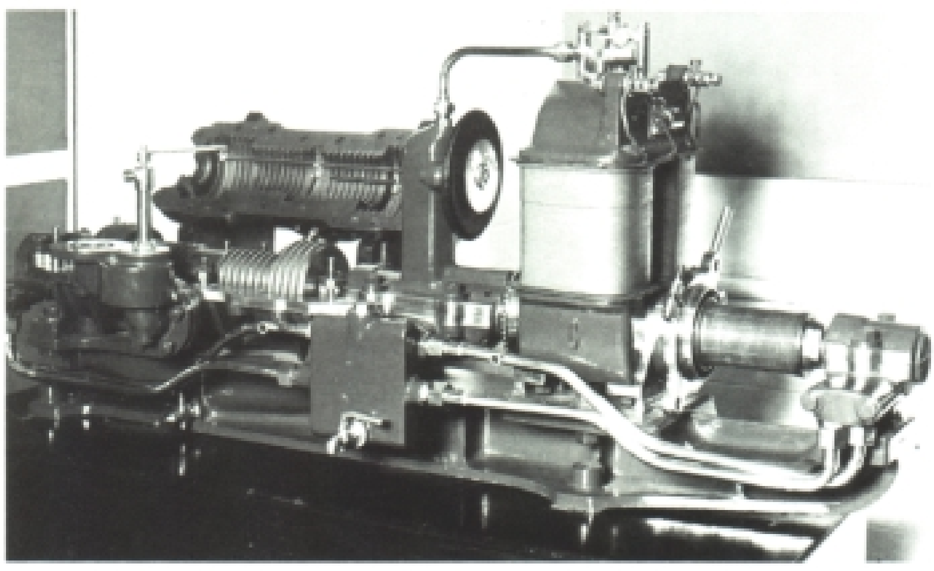


An original layout plan of 1894 for the Experimental Launch (Turbinia) showing quite clearly the radial turbine installation with single shaft and propeller. Engine controls were worked from the open deck, the later ‘locomotive cab’ style protection only being added just before the Spithead Review.

propellers suited to the extremely high speed of the turbine and, secondly, the use of a condensing system which would provide water re-circulation to the boilers and assist turbine efficiency. The second matter was already partly dealt with since Parsons had prepared a condensing design as early as 1888 and a condensing 'radial flow' land turbine was successfully tested in 1892; but the first requirement, the matching of propellers to turbine speed later proved a more serious problem than anticipated.

The aim of the Marine Steam Turbine Co. was to thoroughly test the application of Mr. Parson's well-known steam turbine to the propulsion of vessels "and to demonstrate the advantages of the turbine for this purpose". The decision was thus taken to construct an experimental high-speed craft of around 100 feet length to be powered by a 1,000 horsepower turbine. The resulting vessel became the *Turbinia* or, initially, simply the Experimental Launch. However, before the vessel could be constructed extensive model tests were required to determine the hull characteristics and power requirements. The necessary experiments were commenced by Parsons himself on ponds at Ryton (then his home) and Heaton (the turbine works). In accordance with contemporary high-speed practice the hull was to be of high length/beam ratio (approx. 1:10) with wedge-shaped bows lacking flare and rounded body sections to decrease wetted area drag. The original design calculations of late 1893 in fact included an extreme hull of 100 ft x 8 ft x 5 ft 7½ ins. to a draught of 3 ft, but the beam later chosen was 9 ft, probably to gain greater displacement. In the form eventually adopted there was a pronounced flattened run to reduce the tendency of the after end to squat at high speeds. The distinctive counter stern above this seems almost to have been produced on aesthetic grounds alone, Parsons later indicating that a 'built down' stern would have been as adequate in practice, if not better. A 2 foot long model, driven by twisted rubber cords, produced the first significant results and this was followed by a similar one of 6 feet length with a geared drive producing 8,000 r.p.m.; the torque (power applied) was ascertained by use of a miniature air dynamometer and hull resistance was determined by towing tests. Thus propeller efficiency, propeller slip and horsepower requirements were all calculated from apparently simple, but really very accurate, experimental methods which owed much to the pioneer work of W. Froude. Later Admiralty tests, and modern computer based simulations, have shown that Parsons model experiments gave extremely accurate results.

Although all design and draughting work was carried out by Parsons and his own staff the company did not have the facilities for constructing the hull. This was contracted out nearby to the firm of Brown and Hood of Wallsend who, although not shipbuilders, were experienced sheet metalworkers, an appropriate skill since the deck and hull plating were only one sixteenth and three sixteenths of an inch thick. By February 1894 the vessel was under construction and plans were in hand for fitting a compound 'radial flow' turbine, developing some 1,500 h.p. at 2,000 r.p.m., with direct drive to a single two-bladed propeller. Although the 'parallel flow' patents had by now been recovered experience with high power units of this type was limited, so the 'radial flow' turbine was installed. The vessel was apparently launched without publicity on 2nd August, 1894, less than a year after the preliminary designs were started, a remarkable achievement for a team headed by a man with no previous naval architecture experience.

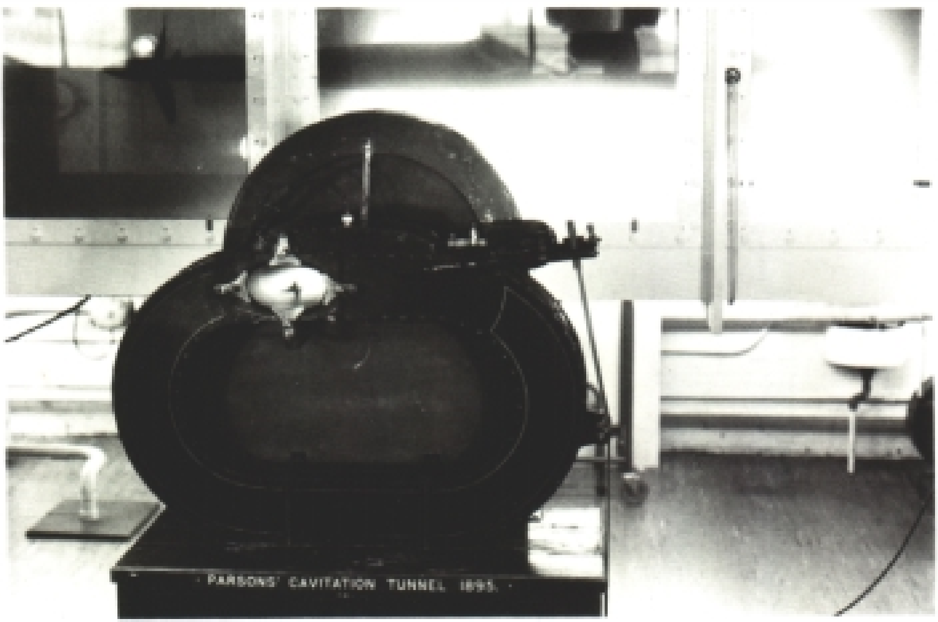


A small, 8 kilowatt, turbo-generator of the 'parallel flow' type built for Parsons own house (then Holeyn Hall, Wylam) in 1895; three much larger turbines of similar 'parallel flow' type were installed in the Turbinia when she was re-engined in 1895-96.

Propeller Problems

Trials of the *Turbinia* began on the 14th November 1894 but results were disappointing, propeller slip was nearly 50% and speeds were low. A four-bladed propeller was substituted and eventually seven different arrangements were tried but all with similar results. A cleverly designed shaft dynamometer was built to ascertain that the turbine's power was sufficient; this indicated 960 h.p., near enough the 1,000 h.p. theoretically required. Another nine sets of propellers were then tested, but all showed relatively low efficiency. The best performance was obtained with triple screws of 20 inch, 22 inch and 22 inch diameter, at one pitch ratios, but slip was still 37.5%, at 1,750 r.p.m., giving a speed of only 19¾ knots. Other men might have given up at this apparent failure to achieve high speeds, but Parsons persevered.

By early 1895 he suspected that the problem lay with the formation of "vacuous cavities" behind the fast moving propeller blades, and the practical implications of this cavitation effect were revealed publicly by Thornycroft and Barnaby in March of that year. As the turbine's speed could not be reduced the answer in the case of the *Turbinia* seemed to be in the use of multiple propellers with increased blade area. The decision was thus taken to replace the single shaft with three shafts and, since the patents were now recovered, to use the more efficient 'parallel flow' turbines with one compound stage (high, medium and low) to each shaft. At the same time extensive experiments were carried out on model propellers using the world's first propeller testing tanks which were devised by Parsons himself. With this equipment it was possible to photograph cavitation taking place and make quantitative measurements of its effects.



Parsons model propeller testing tank was the world's first, allowing him to photograph and study propeller problems well enough to ensure the Turbinia's eventual success. Although greatly increased in size and sophistication the modern (Newcastle University) propeller tank in the background is a direct descendant of Parsons original apparatus.

Success

By February 1896 the three 'parallel flow' turbines were installed, minor modifications to air pumps etc. were carried out and three propellers, 18 inches in diameter and of one pitch ratio, were fitted on each shaft (making nine in all). Several further sets of propellers were tried, the best results coming from a set of nine, each of 18 inch diameter and 24 inch pitch. Overall the division of the turbines, which applied one-third of the total power to each shaft, gave greatly increased propeller efficiency and

The triple shaft, nine propeller, layout seen on the reconstructed Turbinia is essentially that used in her high-speed trials of 1897 and at the Spithead Review. Many later direct-drive turbine installations in other vessels also used multi-propeller layouts.

speed. The results were outstanding, though not unexpected by Parsons, and by December an average speed of 29.6 knots had been reached over the measured mile whilst, with further improved propellers, 32.76 knots was achieved by April of the following year. Eventually, maximum speeds of over 34 knots were recorded. The *Turbinia* was thus the fastest vessel in the world.

Scientifically and practically the possibilities of the turbine for high-speed marine propulsion had now been conclusively demonstrated though, despite some early developments, progress was to slow down for a short time before its widespread adoption in naval and

One of the most dramatic photographs in marine engineering history, the Turbinia racing through an avenue of warships at Queen Victoria's Diamond Jubilee Naval Review, 1897. The Turbinia was then the fastest vessel in the world, touching some 34 knots on this particular run.

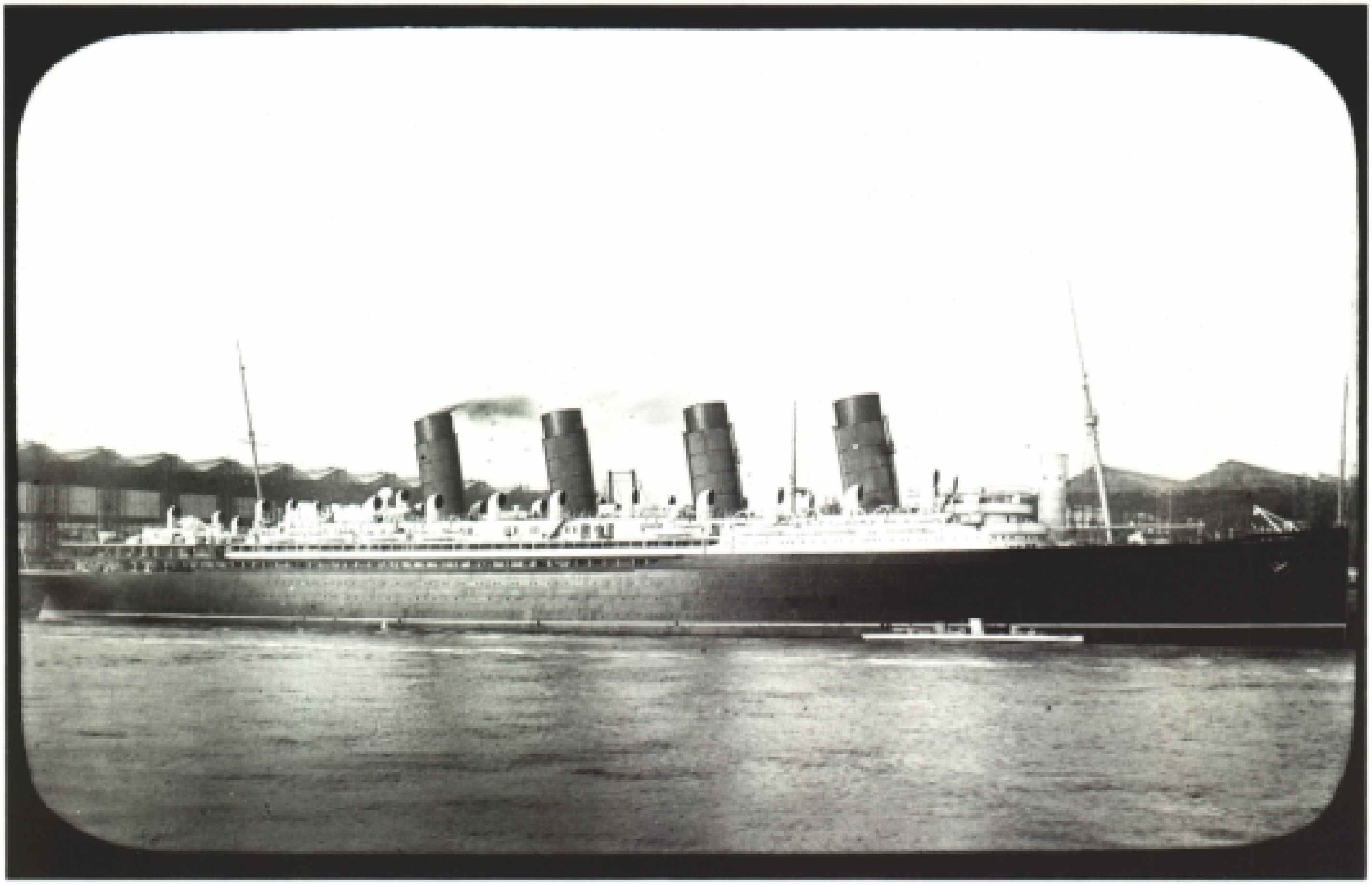
mercantile circles. But that is another story.

The *Turbinia's* Subsequent Career

In April 1897 the *Turbinia* was put through a comprehensive series of independent trials by Professor J.A. Ewing F.R.S. of Cambridge and, in maritime and scientific circles, these did much to validate Parsons work and present it appropriately. However, the greatest popular notice was caused by *Turbinia's* appearance at Queen Victoria's Diamond Jubilee Naval Review at Spithead in June of the same year. Here she appeared, despite common belief to the contrary, with the tacit approval of all concerned, though her daring handling at speed caused much comment and several anxious moments. All in all it was an exceptionally successful publicity exercise, much of the credit belonging to her Captain, Christopher J. Leyland, who was a director and leading campaigner for the Marine Steam Turbine Company.

Following the Spithead Review further trials of the *Turbinia,* often including engineer representatives of the Admiralty, were carried out; but Parsons attention increasingly centred on the two torpedo boat destroyers *(Viper and Cobra)* which were to be fitted with turbines. Also, experiments were in hand with a small reduction geared turbine fitted in a 22 foot launch. Indeed, since the future at sea eventually proved to lie with the geared, rather than the direct-driven, turbine this little launch can in retrospect be seen to rank in importance with *Turbinia* herself.

At this time a new company was formed, the Parsons Marine Steam Turbine Co. Limited, which was given sole licence for the building of marine steam turbines. A new factory was built at Wallsend and retained till its closure the title, "Turbinia Works". The *Turbinia* remained virtually unchanged, her purpose now largely being that of a high-speed demonstration vessel; a function which she performed for example on the Seine at the great Paris Exhibition of 1900. In fact the return passage from this particular exhibition proved to be one of the most hazardous parts of her career, since first she almost collided with a sailing ship and later was forced to run for shelter in heavy North Sea weather. In 1902 the last change was made in her basic form, single propellers of 28 inch diameter and pitch replacing the triple screws on each shaft. In 1907 she was steamed for what proved to be the last

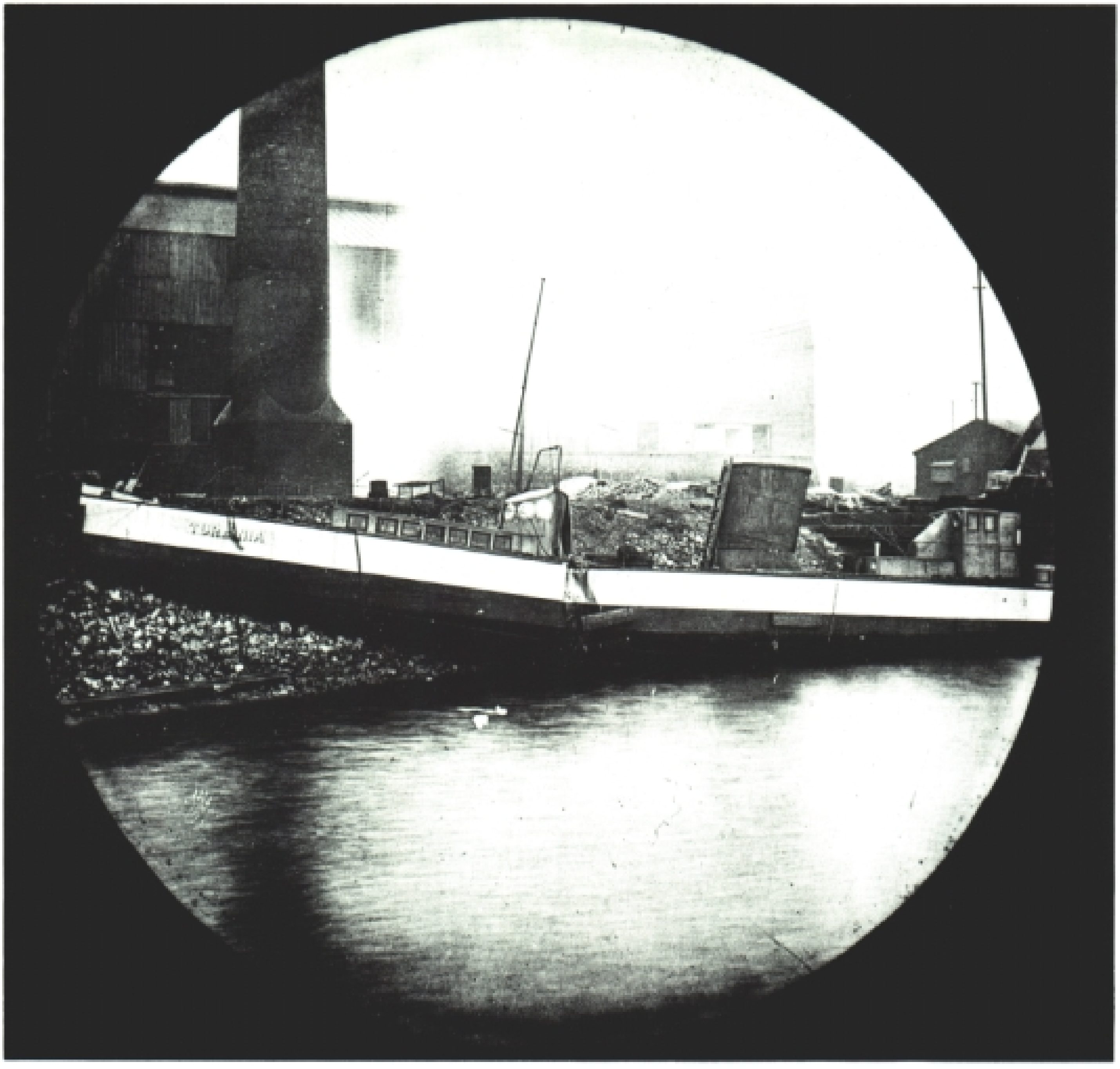


A remarkable photograph showing the Turbinia alongside the nearly completed Mauretania (1907). In less than a decade the marine turbine had turned from an experimental device into a proven power unit capable of propelling transatlantic liners and battle ships. Turbinia was 100 feet long with turbines of some 2,000h.p. and was the "worlds fastest vessel" for only a few months - Mauretania was 762 feet long with Parsons turbines of 74,000 h.p. and held the "Blue Riband" of the Atlantic for twenty two years.

time in order to accompany the liner R.M.S. *Mauretania* on her trial trip, but alas the air pump, always temperamental, broke down and the *Turbinia* could not proceed all the way. It seems a final irony that a piece of reciprocating steam machinery should rob the vessel, which had proved the efficiency of direct rotation by steam, of a final glory.

Turbinia in Retirement

Unfortunately, soon after this the *Turbinia* was accidentally cut almost in two aft of her wheelhouse following an across-river ship launch. The badly damaged hull was lifted onto the quayside but despite the attention of the owning company it gradually deteriorated and, in 1926, it was offered to the Science Museum (London) who, through space limitations, could only take the aftermost 45 feet including the turbines and propeller shafts. The forepart of the vessel remained at the works until 1944 when it was presented to Newcastle Corporation for exhibition in their Municipal Museum of Science and Engineering. Then, in 1959, owing to re-organisation of material the Science Museum (London) found they could no longer house the aftermost section, but following considerable effort, the North East Coast Institute of Engineers and Shipbuilders in



A sad vignette showing the Turbinia lying broken-backed on the shore after she was rammed by a ship launched from the south bank of the Tyne.

The Turbinia today. Following an initiative, primarily provided by the North East Coast Institute of Engineers and Shipbuilders, the Turbinia was reconstructed and re-housed in an annexe added to the Newcastle Municipal Museum of Science and Engineering.

association with Newcastle Corporation (who provided the site) housed the vessel in a purpose-built museum annexe at Exhibition Park, Newcastle upon Tyne. The two halves of the Turbinia were joined together with a resconstructed centre section and in 1961 the vessel was restored to appear in near original condition, though in fact recent research suggests that some minor alterations and improvements could still be made to bring her to her exact 'Spithead Review' appearance.

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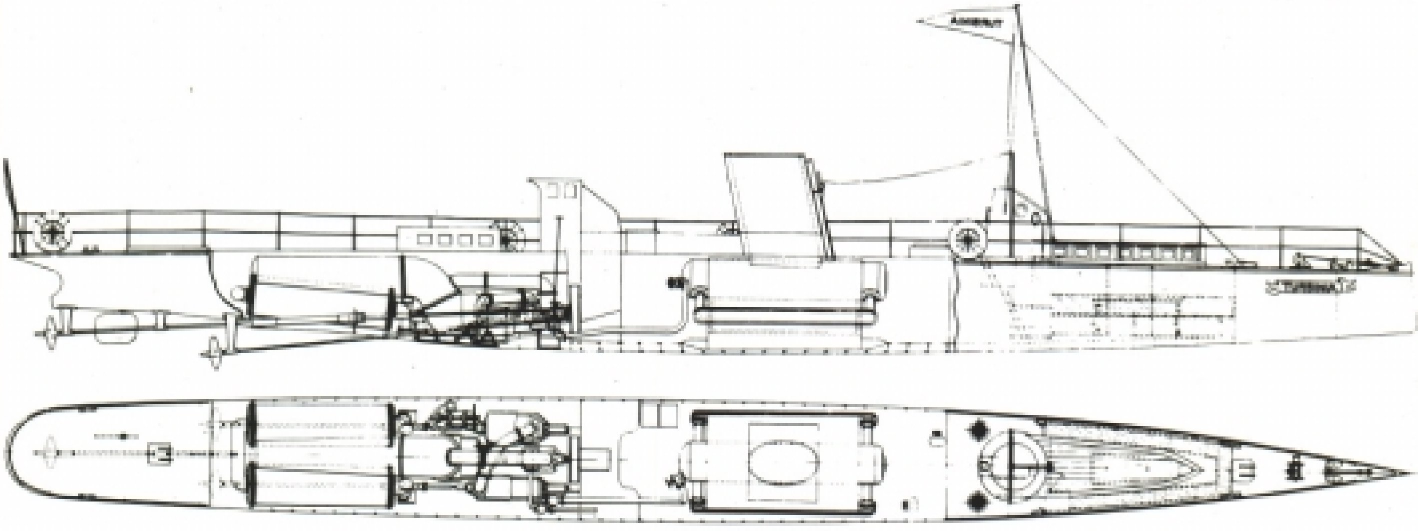
(Back cover)

A general arrangement plan of the early 1900's showing Turbinia's final layout and appearance with a single propeller on each of her three shafts



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