ASME International

A Historical Mechanical Engineering Landmark

Naval Surface
Warfare Center
Carderock Division

West Bethesda, Maryland

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The David Taylor Model Basin

HISTORIC MECHANICAL ENGINEERING LANDMARK

David Taylor Model Basin

1939

The David Taylor Model Basin is among the largest of its kind in the world, containing a shallow-water basin, a deep-water basin and a high-speed basin. Using its sophisticated combination of towing carriages, wavemakers, and measuring equipment, engineers are able to determine the seakeeping qualities and propulsion characteristics of ship and craft models up to 40 feet in length. Since it became operational, the facility has provided key support in the development of naval architecture for the Navy, Coast Guard, the Maritime Administration, and maritime industry.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS - 1998

"The purpose of the David W. Taylor Model Basin is to make accurate and reliable predictions of the performance of ships by research on models."

Introduction

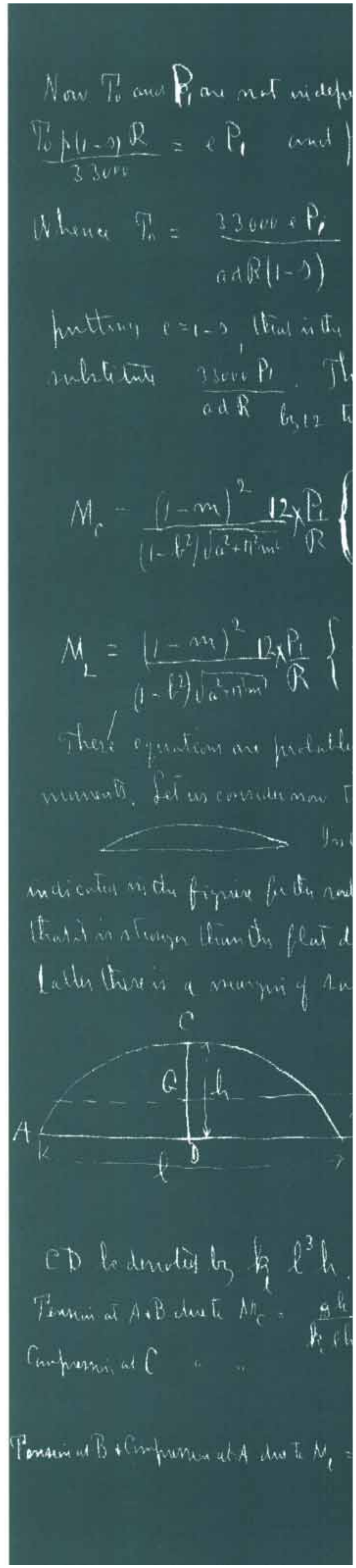
The David Taylor Model Basin (DTMB) was conceived, designed, and built by the United States Navy Department for building and testing ship models in accordance with the most modern and the most accurate methods.[1]

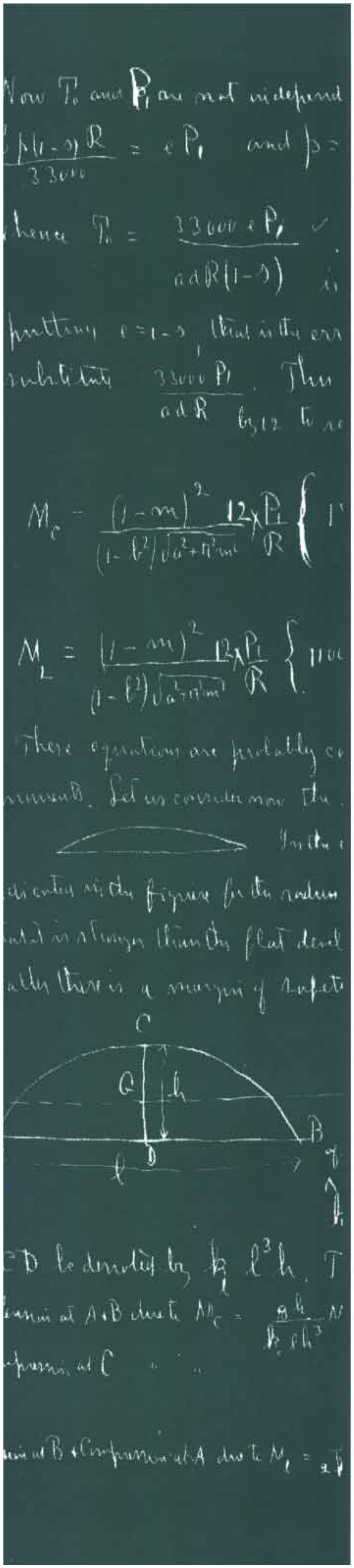
These models, which represent all types and sizes of vessels for the United States Navy, other Government departments, and the United States Merchant Marine, are run under special conditions in large model basins where their behavior in the water can be closely studied and where the forces to tow or to propel them can be accurately measured.

David Taylor Model Basin, West Bethesda, Md.

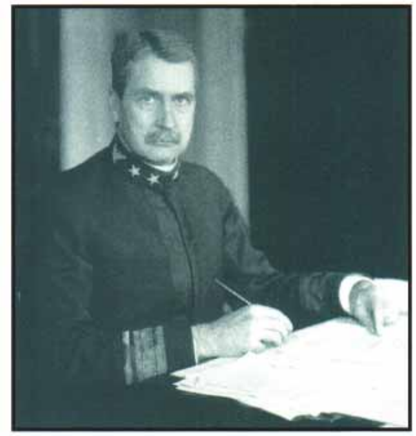
When the Model Basin carries out this work on the models it is able, in advance of the construction of the vessel, and at a relatively small cost, to furnish the ship designer with a prediction of the performance of the vessel, accurate to within a few percent. It frequently is possible for the ship designer, in turn, to make changes in the plans of the vessel which will improve the ship's performance, and for the Model Basin to confirm the effect of these changes by inexpensive changes to the model.

Research of this kind has become so useful that few, if any, naval or merchant vessels are laid down in this or any other country without careful preliminary study of their performance by means of models.





History and Development



David Watson Taylor was born on his father's farm in Louisa County, Virginia, on March 4, 1864, the son of Henry and Mary Minor (Watson) Taylor. Instrumental in convincing Congress of the value of towing tanks and of model tests in support of our nation's defense mission, Naval Constructor Taylor designed and supervised construction of the Washington Navy Yard's Experimental Model Basin (EMB). For fifteen years, he remained in charge of EMB.

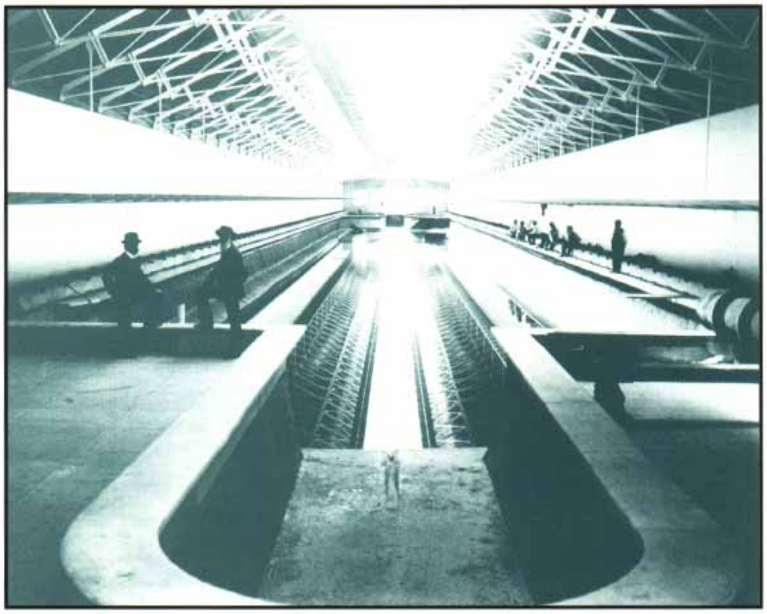
In 1896, Congress appropriated $100,000 to build a "Model Tank for Experiments." The site was the Washington Navy Yard, and supervising the project was a brilliant young naval constructor by the name of David Watson Taylor.

The Experimental Model Basin was state-of-the-art.[2] A carriage, powered by the four 450 horsepower motors, towed the models and carried photographic equipment so engineers could study how eddy and wave-making resistance were generated.

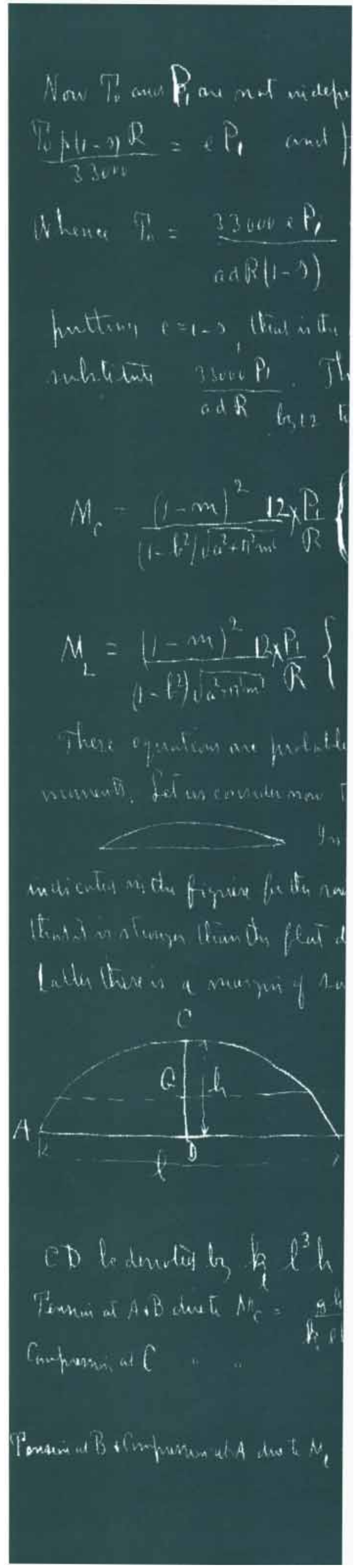
Rear Admiral Taylor served as Chief Constructor and Chief of the Bureau of Construction and Repair from 1914 to 1922. During this time he was responsible for the design and construction of naval aircraft as well as ships. More than 1,000 ship designs for all Navy and many civilian vessels were tested. He also designed and supervised construction of the Navy's first wind tunnel at EMB, contributing greatly to the advance of aeronautical Research and Development in this country.

Taylor insisted on using wooden models for his tests rather than the inexpensive paraffin ones used by other naval engineers. Usually made of white pine, his models were far more resistant to warping caused by the hot, humid Washington summers. But they were much more expensive – $80 each, opposed to 50 cents for wax, which could also be recycled. Models tested in EMB are still in existence today at Carderock.

The basin itself was 14 feet deep, 42 feet wide and 470 feet long – the longest of its kind. Housed in a long brick building in the southeast corner of the yard, it was filled with a million gallons of water, taken from the city water mains. It was treated with alum to coagulate any



View inside the newly completed Experimental Model Basin, 1898.



mud, then passed through a simple sand filter. Electricity came to the woodworking shop in 1905, enabling the Basin to better filter its water.

A grill work of wooden strips was built that gradually descended into the water to form an artificial "beach," which served to break the waves and smooth the water. A similar device is used today at the Center, more than 85 years later.

Despite the successes and technical developments wrought by the EMB during those early years, an emerging new era of air and sea power was demanding change. When it was built, the EMB was the largest and finest installation of its kind anywhere. But in 1929, Captain Ernest F. Eggert, officer in charge of EMB, wrote to the Chief Constructor: "In the period since 1910... it has become increasingly apparent that facilities which were considered adequate in 1896 are no longer . .."

The EMB was flawed – a fact that David Taylor fully realized. Natural springs undermined the basin's sandstone foundation, and proximity to the Anacostia River subjected the facility to periodic flooding.

By the 193Os, the Basin had become an inadequate site for research. Models crashed into the sides of the narrow tank during important turning tests. The carriage towed models at speeds of 15 knots or less. Temporary modifications for shallow-water tests impeded other work, and settling of the foundation made precise measurement of tests impossible.

Captain Ernest F. Eggert, Officer in Charge (1920-1924 and 1928-1938), and Rear Admirals George H. Rock and Emory S. Land, the

successive Chiefs of the Bureau of Construction and Repair, (1923-1937), knew about the physical deterioration and technical obsolescence of the Model Basin.

In 1933, Bureau Chief Land began an intensive lobbying campaign to build a new model basin. He enlisted the support of politicians, federal bureaus, professional scientific and engineering societies, and commercial shipbuilding establishments. Together with Secretary of the Navy Claude A. Swanson, Land attempted to persuade Secretary of Interior Harold Ickes to undertake basin construction as a public works project. President Franklin Roosevelt rejected this proposal because he thought the public would not accept further funding for the Navy.

Land regarded David Taylor as his “father confessor, inspiration and friend” and consulted with him before making important professional decisions. By combining the emotional appeal of naming the basin after the ailing Taylor (who suffered partial paralysis in 1932) with the obvious need for a new facility, Land was able to secure support for approval and funding. His handwritten comment on a memorandum indicates that naming the Model Basin for David Taylor was his final act as Chief Constructor. Land expressed pleasure when President Roosevelt sent him a memento, the pen used to sign the Model Basin Bill.[3]

Captain Ernest F. Eggert drafted plans for the new research facility. Captain Harold Saunders and the staff of the Model Basin worked on specifics of the design.

The Bureau of Construction and Repair’s requirements for the new basin included:

- An environment with minimal noise, ground vibration, smoke, and dirt.
- Location within easy access of the Navy’s offices in Washington.

View of Deep Basin looking West.

Interior of the Towing Tank.

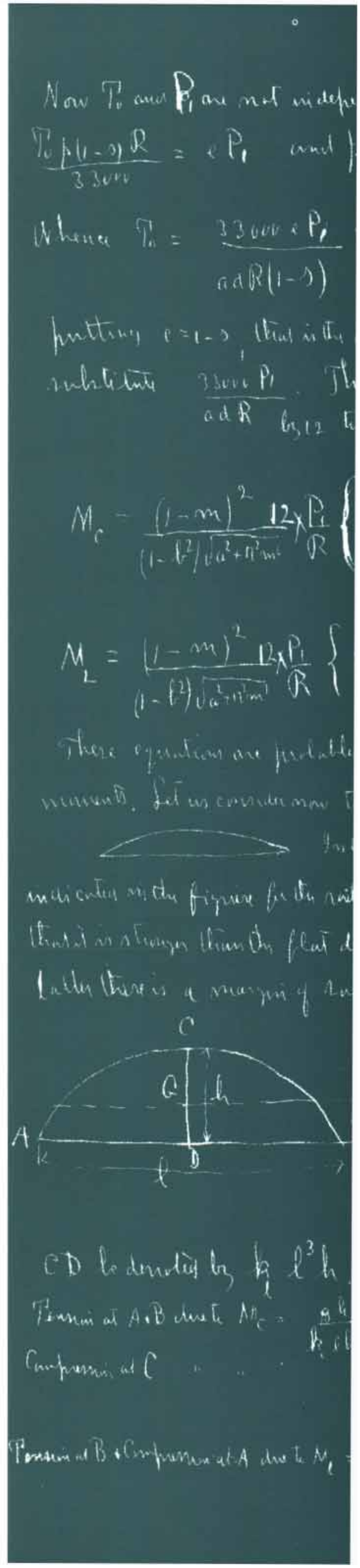
- Sufficient grounds to accommodate a doubling of work area.
- A firm and unyielding foundation, preferably bedrock, for basin walls and track supports.
- A group of individual model basins, each designed to accomplish specific functions.
- Basins within which to tow a model for eight seconds at constant velocity.
- An adequate freshwater supply for filling the basins.

A site in Carderock, Maryland about fifteen miles from Washington, D.C. satisfied these criteria.

The Navy broke ground for the new model basin on September 8, 1937. The new model basin constructed at Carderock is the finest of its kind in the world. On November 4, 1940 , Rear Admiral Taylor attended the dedication of the facility named in his honor, the David Taylor Model Basin, in the company of his wife, daughter, and many friends and colleagues. Research commenced several months after the dedication. By then, personnel had moved from the Washington Navy Yard to the new facility and sufficient equipment had been installed. Today's towing basin still retains his name as a living memorial to this distinguished naval architect and marine engineer.

Technical Background

The David Taylor Model Basin has been made sufficiently large to include equipment which is designed to accomplish each of the vari-



ous types of research on models with the greatest accuracy and reliability and to the best possible advantage.

The DTMB housed at the Naval Surface Warfare Center, Carderock Division (NSWCCD) is state-of-the-art in its construction, conception, and commitment. The DTMB combines five basins in order to make accurate and reliable predictions of the performance of ships by research on models.

- In a large deep-water basin, 1,886 feet long by 51 feet wide by 22 feet deep, models of large ships can be towed or self-propelled.
- In a shorter shallow-water basin, 303 feet long by 51 feet wide by 10 feet deep, models of tugboats, barges, river craft, and other types of shallow-water vessels can be tested.
- For the running of tests at high speed on models of motorboats, patrol boats, and similar craft, there is a special basin 1,168 feet long by 21 feet wide by 10 feet deep.
- A small model basin, 142 feet long, 10 feet wide and 5 1/2 feet deep, is provided for tests of special models and for unusual research problems.

BASIN CHARACTERISTICS

	Length (ft)	Width (ft)	Depth (ft)	Volume (gal)	Wavemaking Capability Length (ft)	Wavemaking Capability Height (in)
Shallow Water Basin	303	51	0-10		–	–
Deep Water Basin	1,886	1-17.5 51	22	15,820,000		
High Speed Basin	2,968	21	10-16*			
140 foot Basin	140	10	5	52.000		

** 10 feet for one-third of Basin length, 16 feet remaininq length*

TOWING CARRIAGE SPEEDS

	Maximum
Carriage No. 1 *(Shallow Water Basin)*	14 knots
Carriage No. 2 *(Deep Wafer Basin)*	20 knots
Carriage No. 3 *(High Speed Basin)*	32 knots
Carriage No. 5 *(High Speed Basin)*	50 knots
Carriage No. 6 *(High Speed Basin)*	> 50 knots
Carriage *(140 foot Basin)*	6 knots

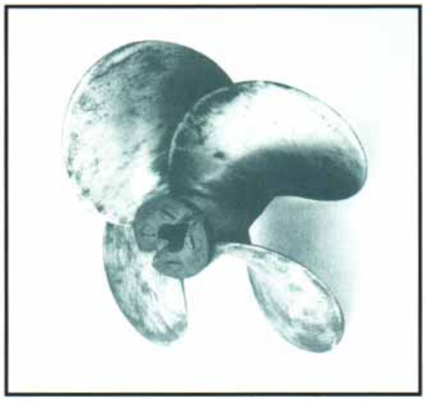
To meet requirements for uniformity in the speed of the carriages which tow the models, the rails on the basin walls upon which these carriages will run had to be far straighter and more level than the most perfect railroad track. In fact, to eliminate the effect of gravity on the motion of the towing carriage, the tracks are not straight in the usual sense, but follow the curvature of the earth.

To ensure that the rails laid remained straight and level, the basin walls upon which they rest are of a massive concrete construction and laid directly on bedrock.

By provision of the basic statute authorizing its construction, experiments on models may be conducted for naval architects and marine engineers, private firms and individuals, and other departments of the Government and foreign countries.

No efforts were spared to build every component part of the facility so that it would accomplish its purpose most efficiently and economically. The purpose of the David Taylor Model Basin is to make accurate and reliable predictions of the performance of ships by research on models. There is no facility in the world comparable in this area of research on models.

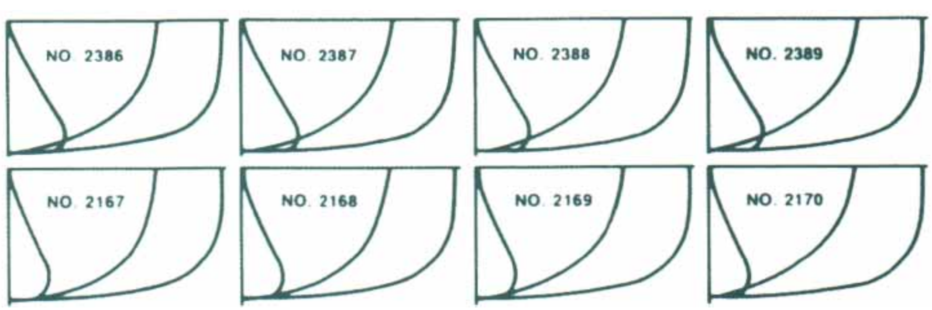
Contributions and Significance



Scale Model of Destroyer Propeller.

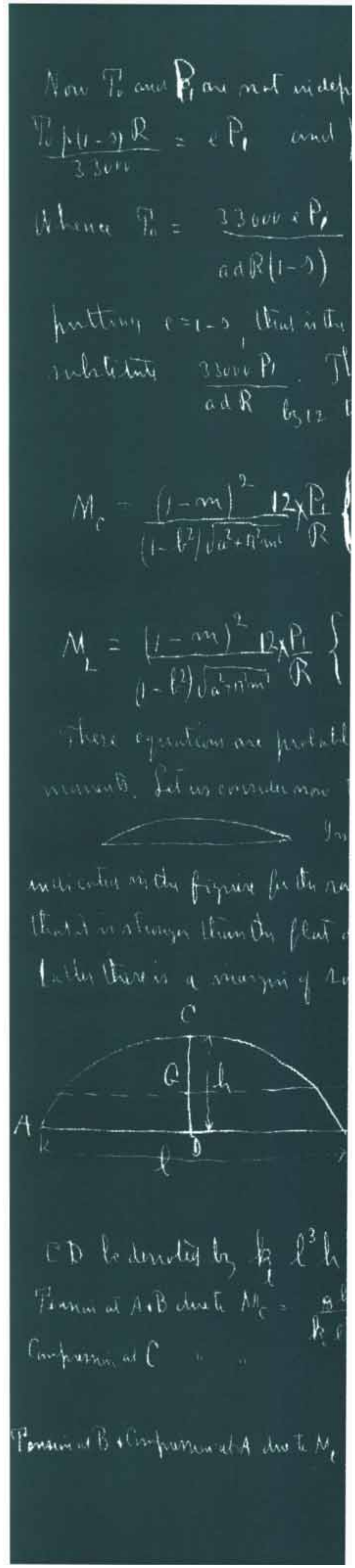
Some of the major areas of investigation at the Experimental Model Basin were under the direction of David W. Taylor. These include propeller and bow design, ventilating fans, and naval aviation. Propeller research dominated much of Taylor's career.

One notable achievement in early Experimental Model Basin work was the invention of the bulbous bow. Since a major source of water resistance had always been the massive bow, the staff devised a revolutionary idea – push the bow below the waterline forward, then sweep it back. The concept was so successful that nations all over the world adopted it. A modified form of this bow is still used today.



Bulbous Bow.

At DTMB a new set of submarine hull forms was developed. This set of Series 58 hull forms enabled submerged operations at speeds far in excess of those obtainable with more traditional WWII submarines and their predecessors. The development of Series 58 hull forms in the late 1940s and early 1950s proved to be a revolutionary development in that it led to the possibility of high speed submarines. The ALBACORE, which reached speeds well in excess of 30 knots,

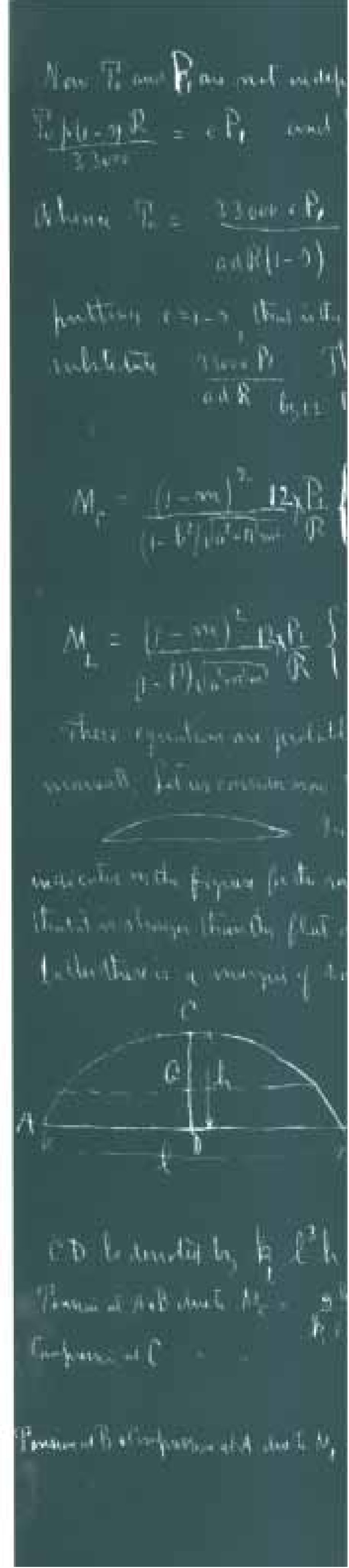


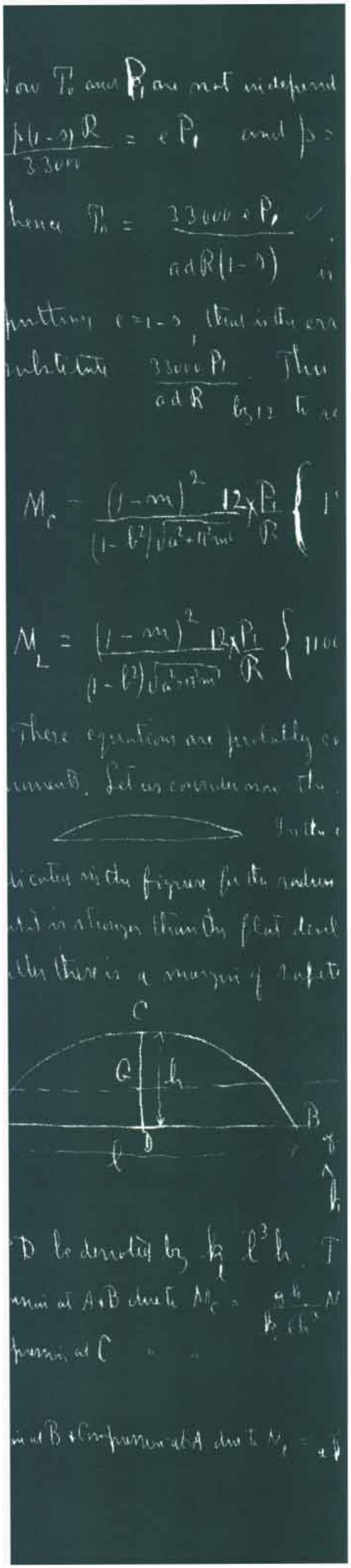
was the prototype. When combined with the parallel development of nuclear power, then being tested in the NAUTILUS, true submarines with high speed capabilities became a realistic alternative to the submersible surface ships in use at that time. The SSN 585 SKIPJACK class of high speed, nuclear powered attack submarines were the first to be deployed in the world. This set of revolutionary developments rewrote the book on submarine warfare and was emulated worldwide by friend and foe alike.

The path to achieving full-scale implementation of highly skewed propellers began in the late 1950s with the development of lifting surface theory at NSWCCD and Massachusetts Institute of Technology. This basic research and numerous other technology projects related to implementing highly skewed propellers, necessitated studies, analyses, propeller design, and verification experiments. These were of increasingly larger scales, over a period of about ten years: first in the hydrodynamics fields and then in related propeller loading and structural strength fields. As a result, a highly skewed propeller design that greatly reduced levels of fluid-borne vibration excitation on ships and submarines was developed. The highly skewed propeller, first introduced in the early 1970s made possible previously unachievable low levels of fluid-borne vibration excitation on naval and merchant ships. These results manifested low noise levels both in the water and inside a ship's living and work spaces. The technology also brought about significant reductions in structural, machinery, and shafting vibrations with the concomitant major effects on reduced maintenance costs and greatly increased habitability. The first naval application in the United States came with FFG 7 class ships in the mid-1970s. Highly skewed propellers are now widely applied to thousands of naval and merchant ships of all types worldwide.

Starting in the late 1960s, NSWCCD played leadership role in the development of the basic technology and design methods for the Small Waterplane Twin Hull (SWATH) ship concept. The inherently superior seaway motions of the SWATH concept are clearly demonstrated with the TAGOS 19 Class which is able to carry out its vital mission while operating in the winter Sea State 7. Weather and sea conditions such as these are well in excess of those that severely limit or preclude operation of the monohull counterparts of the TAGOS 19 ships. The SWATH concept also provides for increased habitability and improved arrangement flexibility for helicopters. This is accomplished with acquisition costs that are more closely comparable to monohulls than to other advanced ship concepts such as hydrofoils, ACVs, and SESs. SWATH technology enabled the emergence of the SEA SHADOW low observable ship concept demonstration. Its purpose is to explore new technologies for surface ships such as ship control, automation, structures, reduced manning, seakeeping and signature control. Since its development for the Navy, the SWATH ship concept has been adopted worldwide for a growing number of commercial applications. Offshore service ships and other applications where seakeeping and all-weather operability are at a premium also benefit from SWATH technology. Innovative design configuration capabilities were also developed to include the unique steering system embodied on the TAGOS 19 Class and a number of semi-active and active control system concepts. By the mid-1990s, about 40 naval and commercial SWATH ships had been built worldwide.

Additionally, at NSWCCD, a mathematical scientist named Charles Dawson, developed a revolutionary computational method, called the Dawson Method radically changing and improving the ability of hydrodynamicists to accurately and rapidly perform Kelvin wave system calculations for a ship. The method, developed in the late 1960s and early 1970s, has emerged from peer-review as a revolutionary step in the ability to compute wave drag and Kelvin wave system characteristics. The method requires many more singularities around the hull than previous methods. However, due to the simplicity of the singularities, the method will allow non-linear free surface calculations. Application of this development is now worldwide. Codes embodying the Dawson Method are now used routinely for developing efficient ship hull forms, including bulbous bows, and are also used for computing Kelvin wave patterns for remote sensing of surface ship wakes. Its application to seakeeping problems is increasing. Recent extensions of the Dawson Method to the seakeeping problem are producing similar improvements to the calculation of ship motions and radiated wave fields for forward moving ships in waves.





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1. *D.W. Taylor.* David Taylor Research Center, Public Affairs Office (Sep 1988).
2. Iler, John R., Ed., *Centerline.* David Taylor Naval Ship Research and Development Center, Anniversary Issue (Sep 1987).
3. Land, Emory Scott. *Winning the War with Ships, Land, Sea and Air-Most/y Land,* Robert M. McBride Co., passim., New York, NY (1958).

The ASME History and Heritage Program

The ASME History and Heritage Program began in September 1971. To implement and achieve its goals, ASME formed the History and Heritage Committee, initially composed of mechanical engineers, historians of technology, and the curator of mechanical and civil engineering at the Smithsonian Institution. The committee provides a public service by examining, noting, recording and acknowledging mechanical engineering achievements of particular significance. The History and Heritage Committee is part of the ASME Council on Public Affairs and Board of Public Information.

Since the ASME History and Heritage Recognition Program began, 184 Historic Mechanical Engineering Landmarks, 6 Mechanical Engineering sites, and 6 Mechanical Engineering Heritage Collections have been designated.

The ASME History and Heritage Program illuminates our technological heritage and encourages the preservation of the physical remains of historically important works. It provides an annotated roster for engineers, students, educators, historians, and travelers and helps establish persistent reminders of where we have been and where we are going along the divergent paths of discovery.

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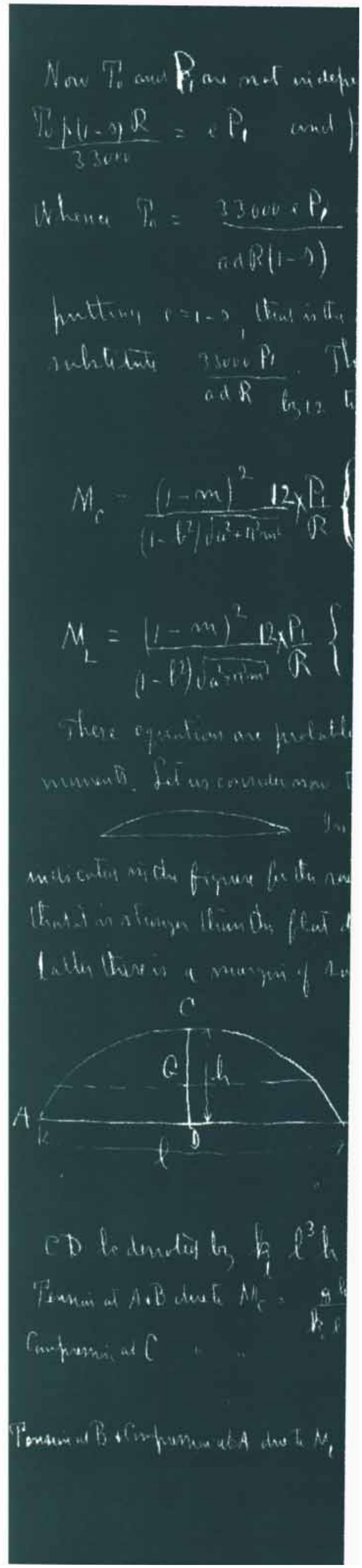

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