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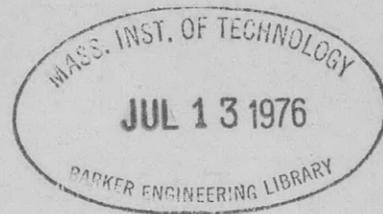
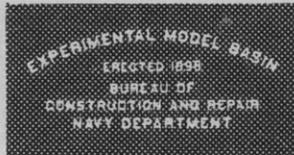
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# UNITED STATES EXPERIMENTAL MODEL BASIN

NAVY YARD, WASHINGTON, D.C.

THE CENTRAL TEST STATION ABOARD THE  
S.S. NJASSA

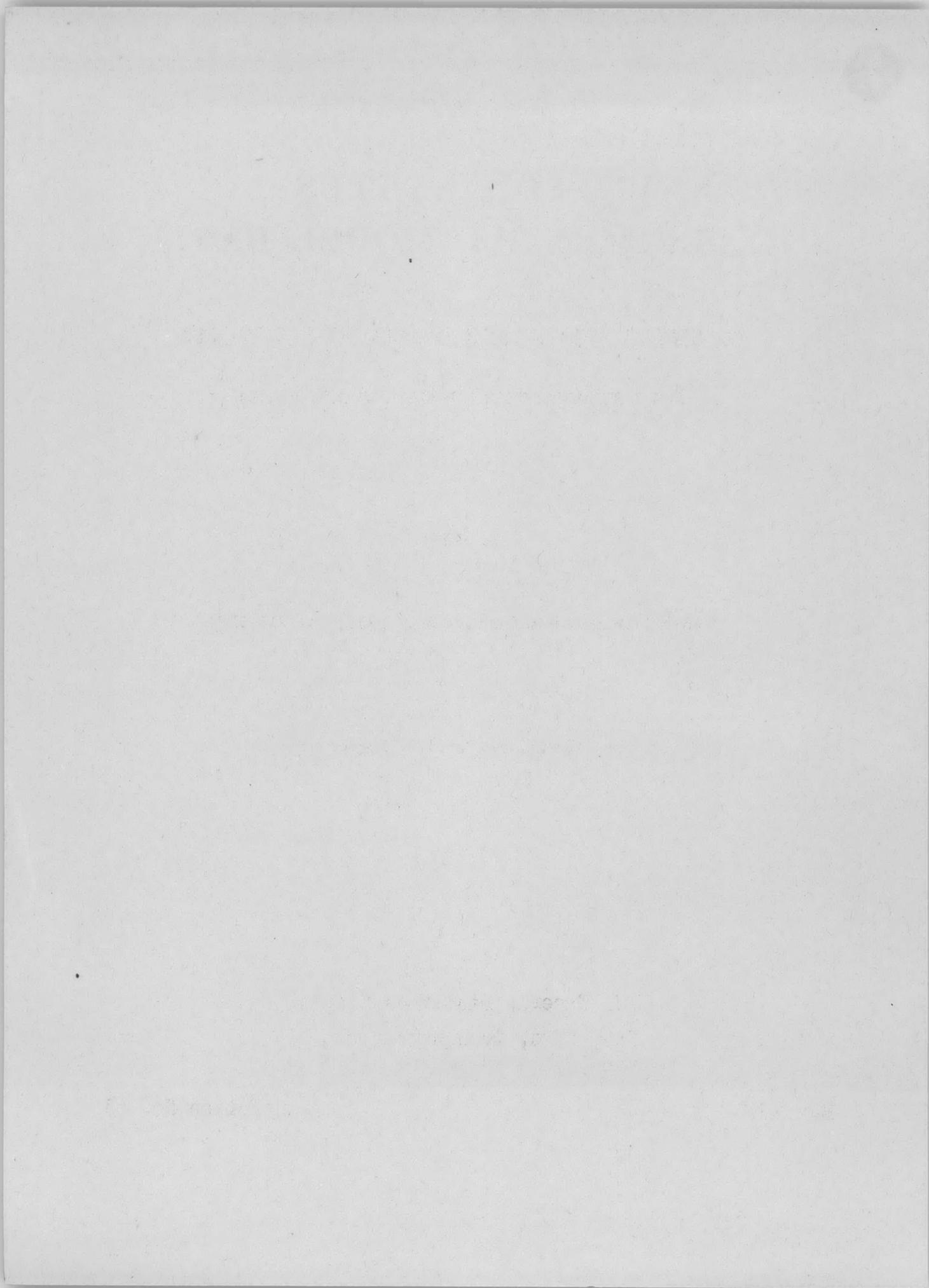
BY H. HOPPE



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MAY 1940

TRANSLATION NO. 63



THE CENTRAL TEST STATION ABOARD THE S.S. NJASSA

(DIE ZENTRALMESSTELLE AN BORD DES D.S. NJASSA)

by

H. HOPPE

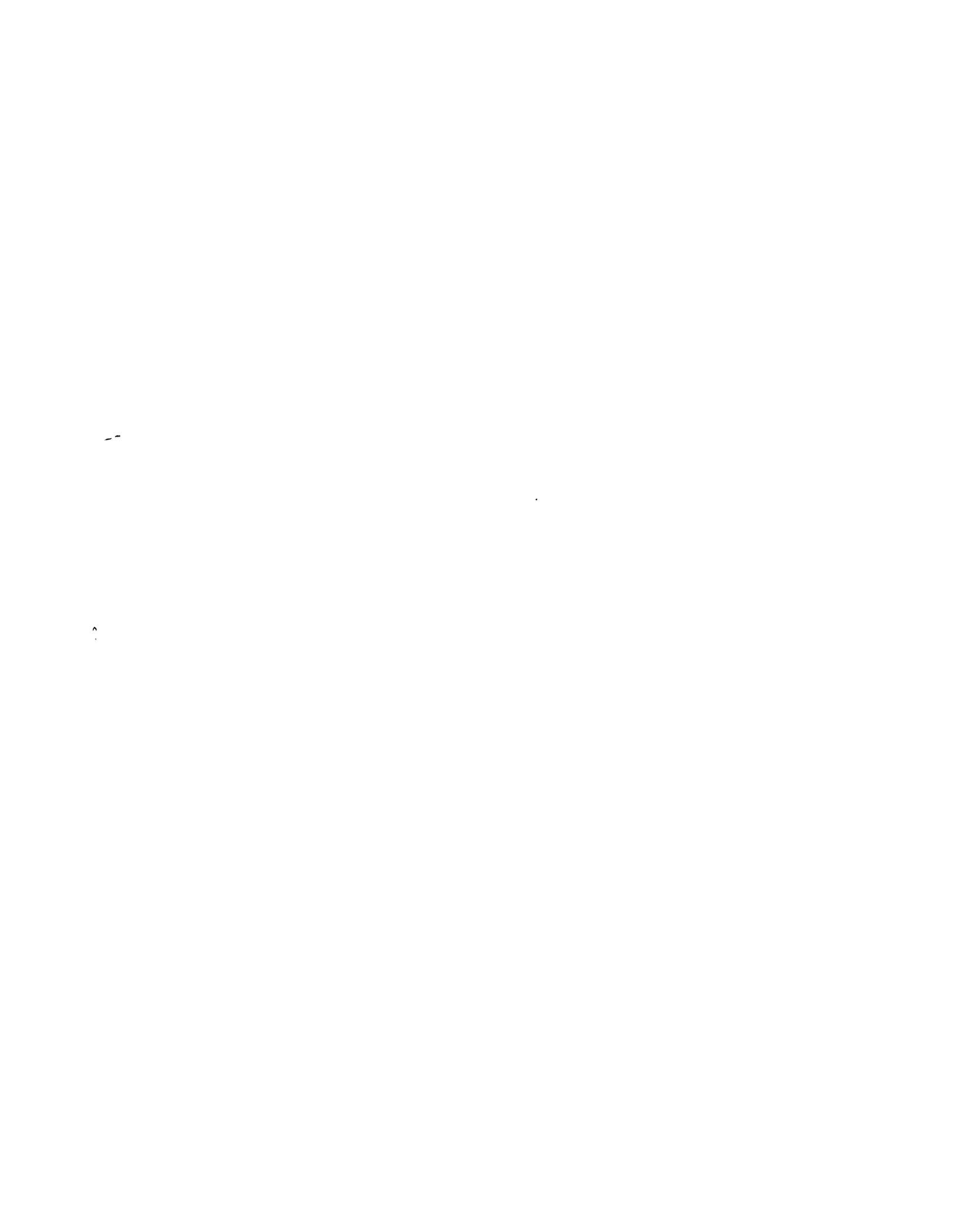
(Werft-Reederei-Hafen, 15 July 1938, pp. 217-222)

Translated by M.C. Roemer

U.S. Experimental Model Basin  
Navy Yard, Washington, D.C.

May 1940

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## THE CENTRAL TEST STATION ABOARD THE S.S. NJASSA

As part of the program of the seventeenth annual convention of the Society of Friends and Patrons of the Hamburg Model Basin in June 1938, members and their guests were given a demonstration of the central test station aboard the S.S. NJASSA of the German-African Line. This central test station was the first practical application of an idea which had originated ten or twelve years previously in the Division of Service Tests of Ships, organized by Dr. Gunther Kempf of the Hamburg Basin, and placed under the direction of H. Hoppe. As new instruments were developed, the original purpose (comparison of ship and model) of this Division was greatly extended, culminating in the installation of a central test station aboard ship.

The demonstration aboard the NJASSA was the first public one of a test station of this kind, in full working order, capable of continuous operation. The term "central test station" designates an arrangement by which the entire flow of propulsive forces, including the external forces acting on the ship, can be continuously measured and recorded in a compartment provided expressly for that purpose. The requisite instruments are assembled on a panel (Figure 1) and mounted in proper relative position. Many of the instruments were built on designs developed by the HSVA with the cooperation of commercial manufacturers, using information gained on previous tests at sea\*.

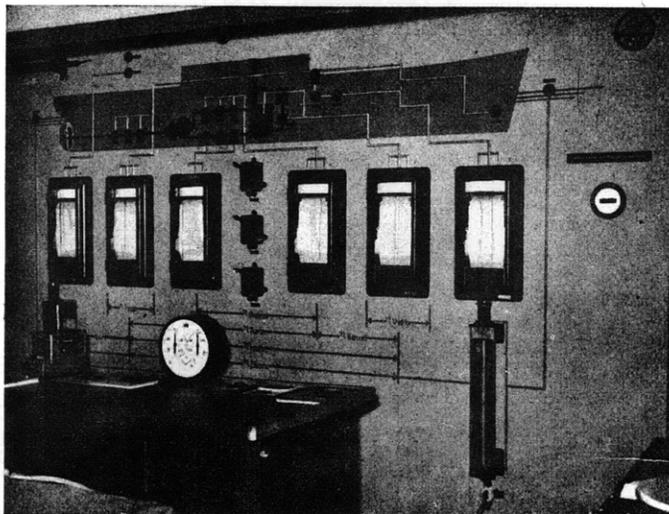


Figure 1. The Central Test Station

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\* Test Trip Aboard the HAMBURG, Kempf-Hoppe, WRH 1926, No. 17 - Trial Run Tests, Kempf-Sottorf, WRH 1928, No. 12 - Towing Resistance Dynamometer, Hoppe, WRH 1929, No. 4 - Performance Tests Aboard Ship, WRH 1930, No. 20, Von Gehlen and Hoppe. Performance Tests Aboard Ship, WRH 1931, No. 3, Von Gehlen and Hoppe. - A New Speed-measuring Method, Lerbs and Hoppe, WRH 1935, No. 4 - Results of a High Sea Test Trip, Hoppe, WRH 1935, No. 22 - Trial Run Test Instruments, Hoppe, RTA, 1936, No. 10 - Purposes and Possibilities of Speed Tests Aboard Ships, Lerbs and Hoppe, WRH 1938, No. 9.

Aside from preliminary scientific work carried out for the various divisions of the HSVA (Coordinating Office for Trial Data, Research Laboratory for Stability and Vibration, Laboratory for Research on Fouling, Hull Forms and Propellers, Maneuvering), the central test station has developed into an institution of great importance in the operation of ships. At the same time this innovation is important in the field of shipyard and shipping company practice, and has become an absolute necessity in the scope of problems of the Four-Year-Plan. Its preponderant aim is economy, but at the same time it fosters increased security of the ship and its engines. In recent years economy has been quantitatively discussed a number of times by other authors, although only the technical aspects of engine operation were considered\*. Ship's officers doubtless act according to the principles of economy, but much guesswork and "intuition" still prevails. Ships often arrive at the loading docks ahead of schedule and are forced to wait, others arrive behind schedule and are required to pay waiting shifts of laborers merely because the captain has no test instruments at his disposal which would permit him, for example, to know the run of his ship at any moment, and to act accordingly. Usually to insure punctual arrival at the port of destination, the speed is set in the home port with an excessive margin of safety. However, considering that fuel consumption increases approximately as the fourth power of the speed, it follows that when the speed is set  $2\frac{1}{2}$  per cent too high, 10 per cent too much fuel is consumed.

The question of the economy of engine-driven ships will not be discussed further here, but the installation of a central test station aboard ship will be justified by a comparison.

Ashore, central test stations are already regarded as regular items of equipment in power stations and the larger industries. Measurement and transmission of electrical quantities by electrical methods in industries ashore is comparatively easy and inexpensive. This may be one of the reasons for the advanced technical stage of efficiency control of shore industries, which has already reached such a high standard that a premium of 30,000 RM to 50,000 RM is paid to power station supply firms for every increase of 1 per cent above the guaranteed efficiency. The question "Why not aboard ship?" therefore suggests itself, particularly since in a large number of our ships the operating plants are larger with respect to output and value, and the fuel in most cases can not be obtained from domestic sources. These seagoing plants, with respect to operating conditions, mechanical resources, and the demand for absolute safety of operation, are obviously at a disadvantage.

The increasing need of tests aboard ship can further be deduced from the characteristic alteration of the shapes of efficiency curves, which - to exaggerate -

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\* Tests Aboard Ship, RTA 1936, Prof. Keinath.

are changing more and more from the semi-circular to the triangular.

Although the efficiency curves of various generative processes and conversions in the power circuit of a plant have improved considerably in the past 20 years (see "SCHARNHORST", "GNEISENAU", "POTSDAM", "WUPPERTAL", "WINDHUK", "PRETORIA", "PATRIA", etc., to name only a few well-known ships) they have nevertheless grown less elastic in their initial and terminal portions, i.e., at loads below and above normal. All the more necessary in modern operations is a knowledge of the economical operating condition of a plant, an insight into and contact with its operation, i.e., installation of dependable testing devices capable of continuous operation. Even some of these have passed through several stages of development during the past five years. Apparatuses suitable for use in shore plants, usually are not yet ready for installation aboard ship. It is necessary to point out only the vibrating system: the ship, its more or less vibrating foundations, fluctuations in temperature, some of them considerable, the insidious action of marine dampness, and finally the seaman's heavy hand which must operate the apparatus. The forces acting on the instruments must obviously be recognizable. The possibility of using means available aboard ship for overhauling must be kept in mind, etc. Thus new instruments were devised, based on mechanical and hydraulic principles, in which electricity was used exclusively for purposes of transmission to remote indicating or recording instruments.

With respect to methods of transmission, preliminary work was required, based on the operating requirements aboard ship. They had to be independent of the unavoidable voltage fluctuations of the ship's power plant and of the influence of temperature; the motion of the ship must not disturb the recordings; the transmitting element must be adapted to the most varied pick-up devices and test methods; the

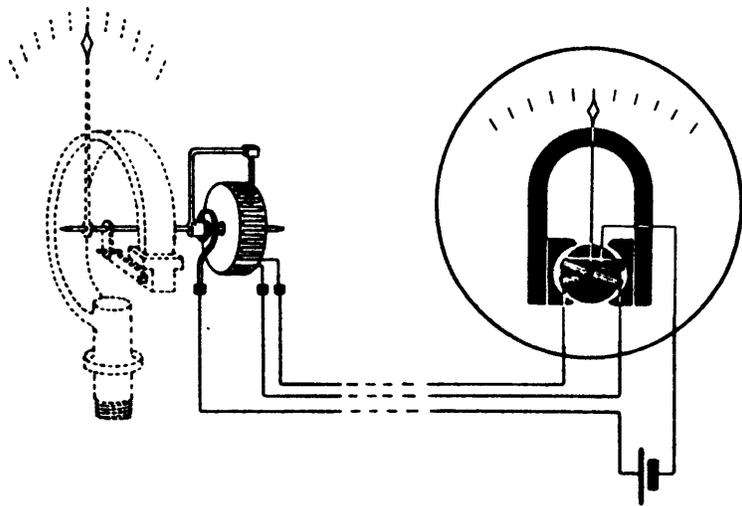


Figure 2. Method of Transmission Shown as Applied to a Hartmann and Braun Spring Manometer (Opposed Coil Hook-up).

mains must be few, and the hook-up as simple as possible for the ship's electrician; it must be possible to synchronize the record with the values measured by the pick-up in every sense, i.e., to increase or diminish the angle of deflection and, when required, to set it at zero or to its terminal value. The opposed coil method of resistance measurement was used (Figure 2) - a mechanized bridge hook-up, which delivers

large adjusting forces to the self-damping test apparatus. The remote transmitter itself requires for its operation an admissible torque of only about 0.2 cm-g. The instruments developed with these chief requirements in view were demonstrated aboard the S.S. NJASSA. With the exception of the recording log, steam gauge, and propeller thrust meter, which it was impossible to install because of expense, time and operating factors, all the other instruments were installed in working order. Some of these instruments had been used for years under shipboard conditions and are no longer a problem in designing a central test station. The test data were recorded in the central station with an accuracy of only about  $\pm 5$  per cent, since, preliminary adjustments could not be made, due to lack of time.

The scope of the installations was shown at the entrance to the exposition room in a cut-out model (Figure 3), in which the plant of the S.S. NJASSA, from fuel tank to propeller, was shown schematically. Placards with the names of firms and

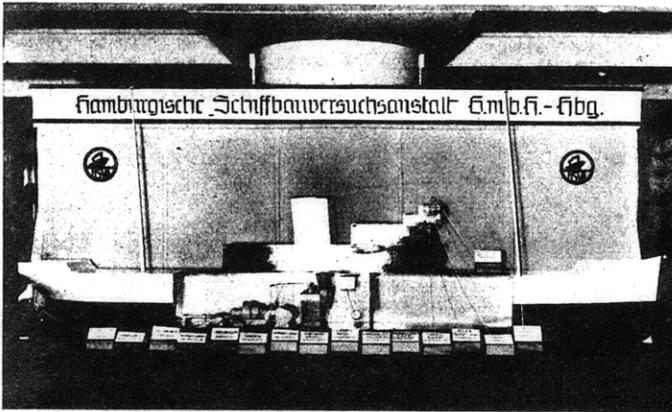


Figure 3. Cut-out model of the S.S. NJASSA to show schematic arrangement of plant.

nomenclature were attached to the points of the model plant at which test instruments had been installed. This gave a clear idea of the test instruments installed and the possibility of checking all important parts of the plant individually as well as in their collective relation to each other in governing economic performance.

Since it was impossible for obvious rea-

sons to show the visitors the machinery of the bridge and the engine-room in the harbor or at sea, the test apparatuses actually installed were shown separately in the exposition chamber (Figure 4). First, in the starboard corner was a vibration and oscillation proof compass and some sextants (Figure 5), among them one with an artificial horizon. A radio direction finder (Figure 6) and a depth indicator (Figure 7) conclude the series of instruments for determining position. Further, a new tachometer, operating by the inductor method and without collectors, and a small watertight rudder angle indicator were shown.

The next nautical appliance which attracted special attention was the HSVA stem log (Figure 8), a test method and device of remarkably advanced development, in which the distance indicator gives notice when a given space has been traversed. A statically and dynamically balanced streamlined weather vane, as well as a torsion

anemometer, which rotates about a certain angle according to the wind velocity and is balanced by a spiral spring, complete the bridge instruments.

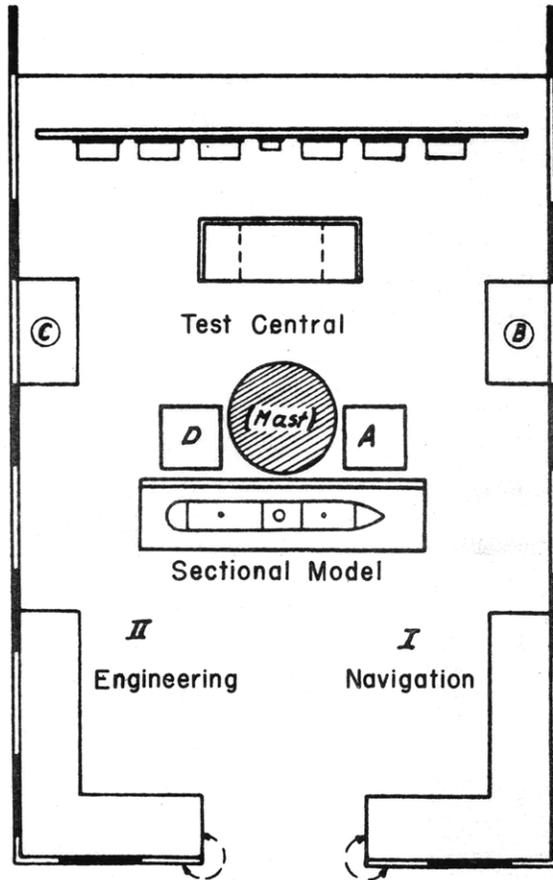


Figure 4. The Exhibition Hall.

I. Navigation Department

1. Position Finder
2. Radio Direction Finder
3. Depth Gauge
4. Speed Indicator
5. Wind Gauge
6. Inclinator
7. Rudder Position Indicator
8. Strength Gauge

II. Engineering Department

9. Pressure Gauge
10. Heat Gauge
11. Exhaust Meter
12. Volume Meter
13. Tachometer
14. Torque Meter
15. Thrust Meter

III. Research Department

- (A) Stability and Vibration
- (B) Fuel
- (C) Operating Statistics
- (D) Fouling

As a novelty there was shown a combined strain gauge, stress recorder and alarm, which was developed by the HSVA. At given cross sections of the ship's body the material strain is measured as a gauge of the stress. Mechanical dial indicators with attached transmitters are used, which show the stress differences on remote opposed coil receivers, report unpermissibly high stresses by buzzer signals, and record them by means of locking counters. For the

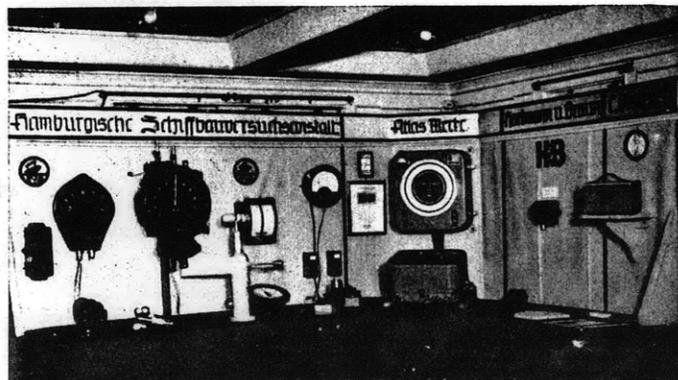


Figure 5. Testing Apparatus for the Ship's Officers.

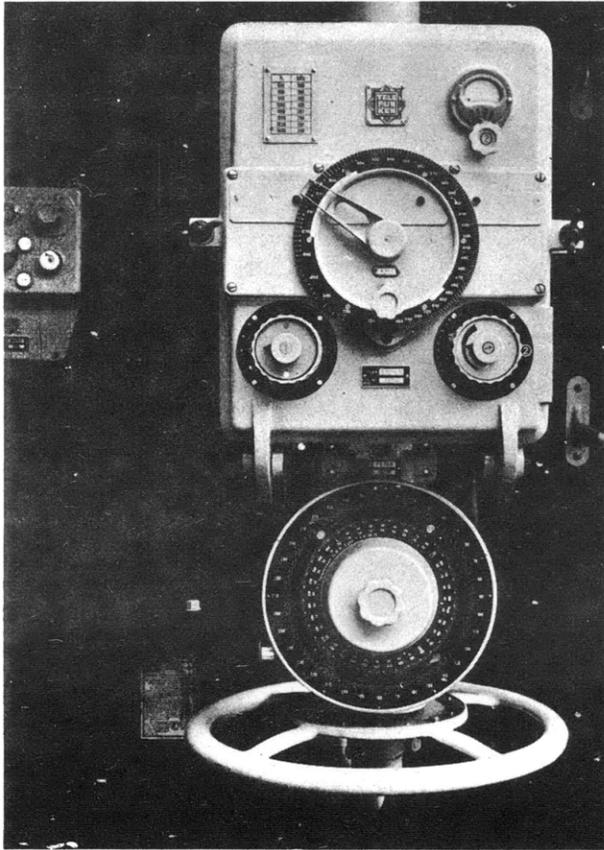


Figure 6. Debeg Radio Direction Finder.

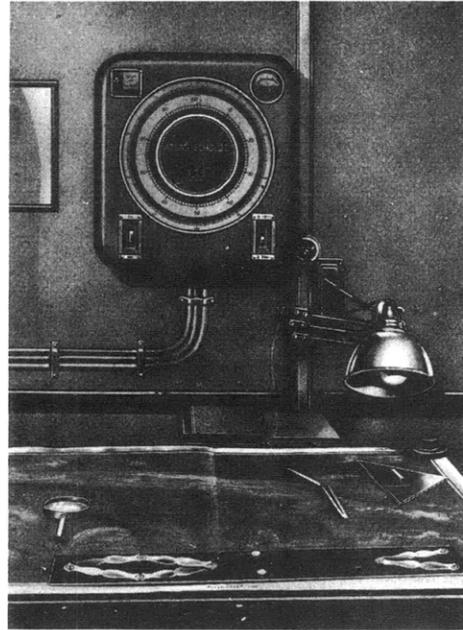


Figure 7. Atlas Works Sonic Sounder.

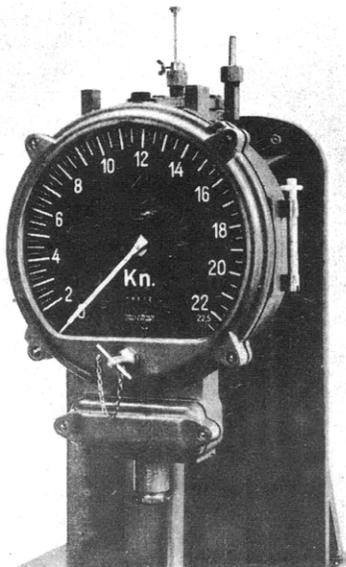


Figure 8. HSVA Stem log.

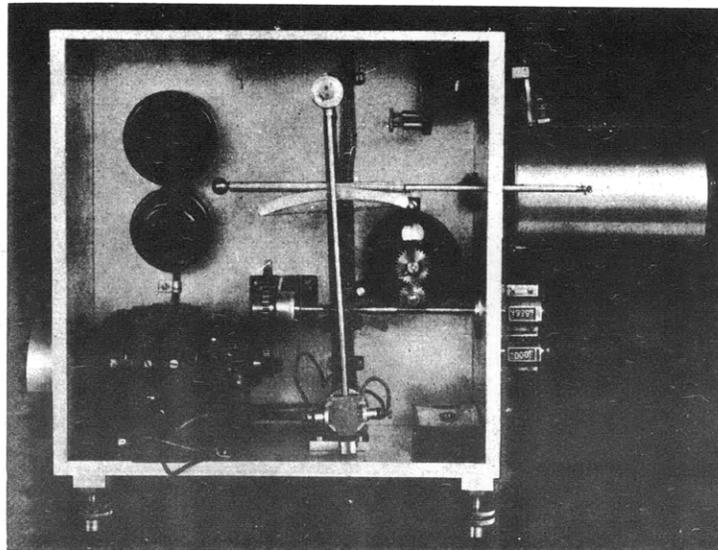


Figure 9. HSVA False Horizon.

first time this device gives the captain a means of gaining a quantitative knowledge of static "harbor" stresses and dynamic "seaway" stresses, and to take measures for saving the ship members (prolonging the life of the ship).

Since the exhibits of the three new departments of the HSVA relate to ships and engines, these will now be named first.

Department 1. This is the research laboratory for stability and oscillation, which has developed a so-called false horizon (Figure 9) for problems of ship operation. It is a pendulum suspended between contacts (consequently without natural vibration) which, by means of electrical control, maintains its point of support constantly in the directional position conceived as perpendicular by the passenger. A light-beam pendulum for problems of stability, is shown (Figure 10).

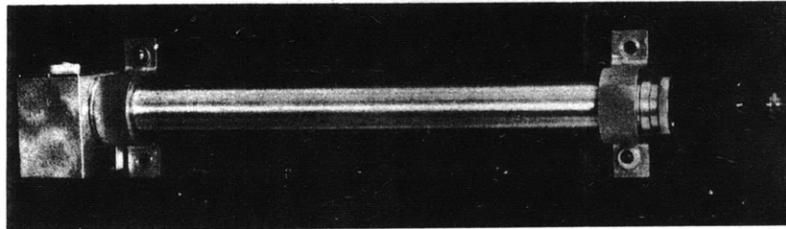


Figure 10. Siemens Light Beam Pendulum.

Department 2. The coordinating office for trial data is in a sense a subjective central test station. A number of empirical values obtained by junior officers aboard ship are here collected and the effects of external influences on the ship are separated into their component parts, in order to allow subsequent conclusions concerning the efficiency of ship hull forms in a seaway.

Department 3. The laboratory for fouling research shows the rapidity of marine growth on plates which had been covered with paints of various degrees of toxicity and suspended for some period of time in natural ocean currents. With respect to the problems of the central test station, the data are important in estimating the economical, punctual docking time, in which propeller thrust and RPM, naturally taking into account external factors such as position and wind, are factors.

In the port corner are shown the apparatuses of the engine room (Figure 11). They begin with those for inspecting

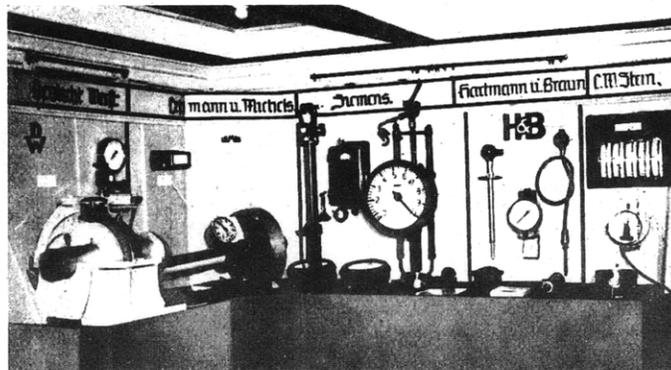


Figure 11. Testing Apparatus for the Engine Room Staff.

fuel, followed by pressure gauges with remote pick-up (Figure 12), heat gauges (Figure 13), steam and water gauges adjusted to wave motion and position (Figure 14),

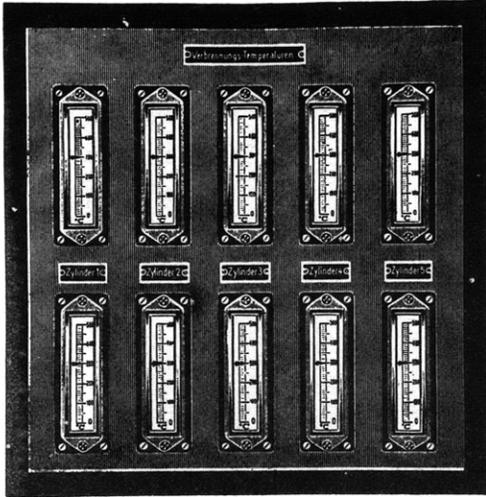


Figure 12. C.W. Stein and Son Pressure Gauges.

After lengthy shipboard tests these were found sufficiently safe and reliable in continuous operation to be installed for the purposes required of a central test station aboard ship.

Thus, nothing is included in the exhibits that has not been tested. There are no longer any obstacles from the standpoint of technique and instrument design to the materialization of a central test station aboard ship. In fact, a small scale central station has been used successfully over a period of four months in operating conditions. A report of this was published in 1935 by the GFF (High Sea Test Trip on the Motorship SAN FRANCISCO). (See Experimental Model Basin Translation 26).

The rear of the exposition hall was arranged to represent the central test station (Figure 1). It also shows the amount of space actually required. At the

as well as chemical and electrical exhaust gas gauges (Figures 15, 16, and 17) which continuously test the exhaust gases for unconsumed components, and inscribe a record. Next is shown a torsion meter (Figure 18), with remote transmission, then a thrust meter (Figure 19), which by means of oil pressure test gauges, indicates and transmits the pressure of the propeller, exclusive of external forces such as the weight components of wave slope, and the water pressure on the cross section of the stuffing box in the stern post.

Up to this point there

have been described the individual elements. After lengthy shipboard tests these were found sufficiently safe and reliable in continuous operation to be installed for the purposes required of a central test station aboard ship.

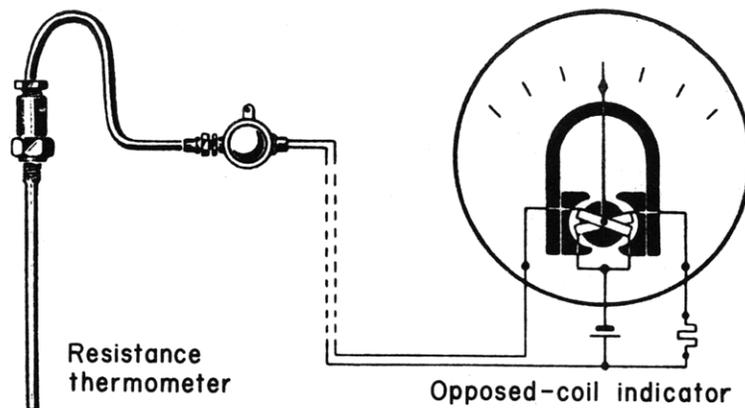


Figure 13. Remote Electrical Temperature Gauge. Hartmann and Braun Opposed Coil Indicator.

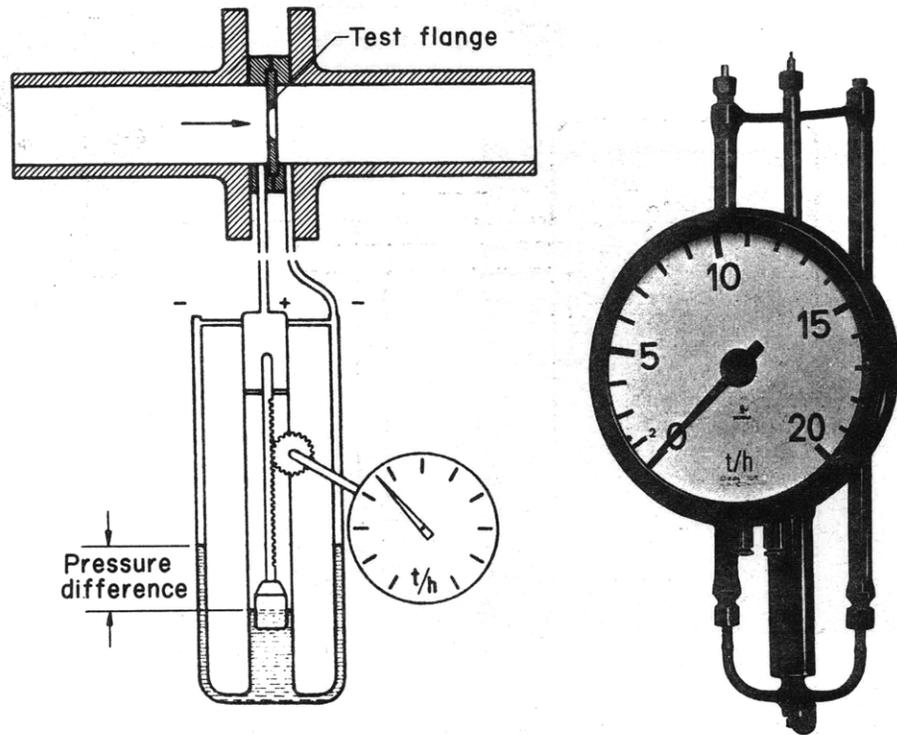


Figure 14. Siemens Steam Gauge.

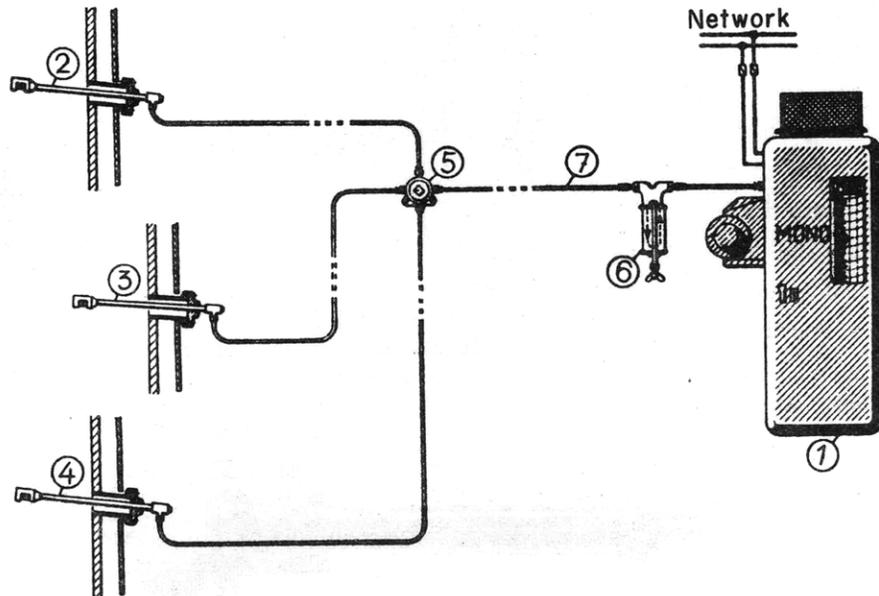


Figure 15. Hookup of the Maihak Exhaust Meter.

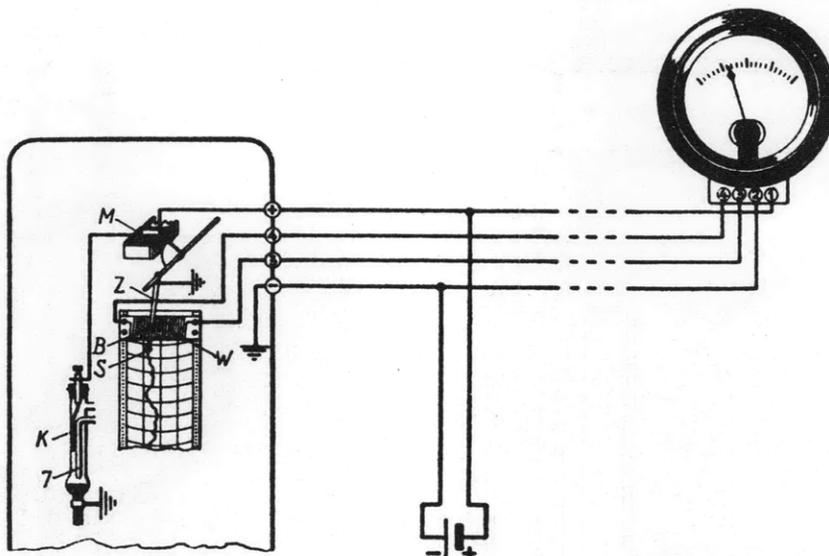


Figure 16. Recorder and Transmitter of the Maihak Chemical Exhaust Meter.

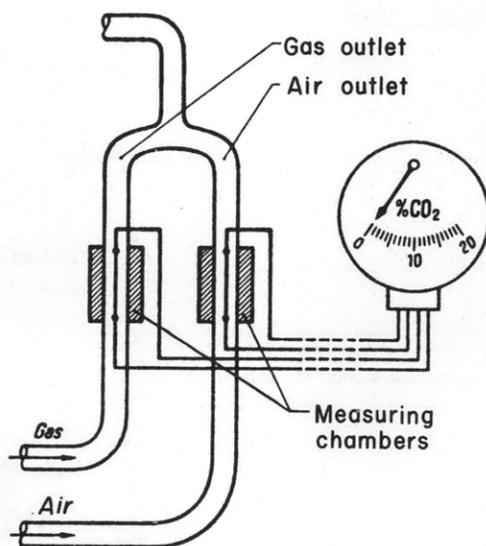


Figure 17. Working Chart of Siemens Electric Exhaust Meter.

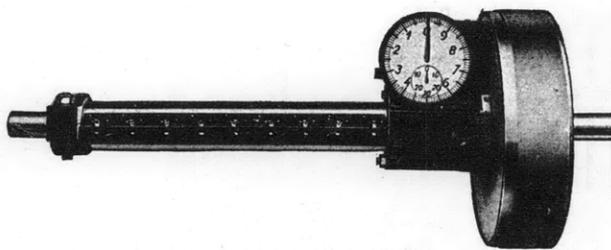


Figure 18. Lehmann and Michels Torque Meter

desk in front of the instrument panel, the officer and engineer together are intended to analyze what goes on in the entire ship. They study the causes of the most varied phenomena, and institute the proper measures tending to improve or maintain the already established standard of safety or efficiency of the ship and its engines.

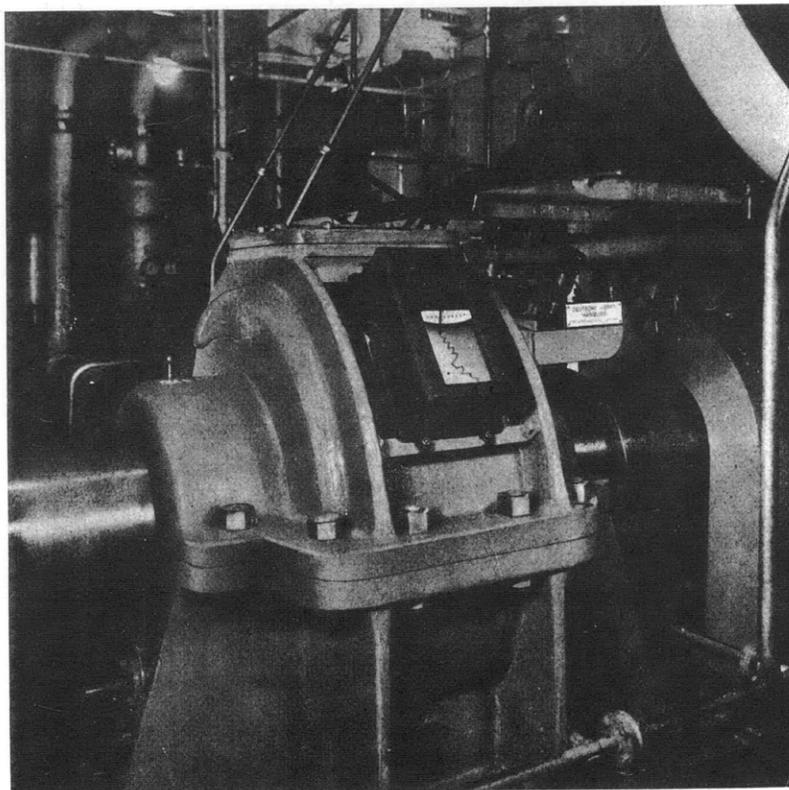


Figure 19. Deutsche Werft Propeller Thrust Meter.

On the instrument panel itself, the ship is schematically represented with its proper power lines in order to give a quick general view. The various actual test stations are duplicated by switches and plates on the panel. Grouped according to technical functions, they are connected by guide lines leading to the separate recorders, for example, Recorder (1) rolling, pitching, strength; Recorder (5) propeller thrust, ship velocity, torque, RPM; or Recorder (6) wind direction, wind velocity, etc.

The recorders are of the so-called multiple-point type. At intervals of 10 seconds they automatically shift to another test station and at the same time insert under the pointer a typewriter ribbon of the color assigned to the test station in operation at the moment. The pointer is in the form of a flat spring, and

by means of a drop arm extending over the entire range of the test, is depressed in the ninth second of the period, marking its position by a point on the paper. The sequence of all the points yields a clear curve for every test station, for instance, a red curve for steam pressure, a blue one for steam temperature, a green one for the volume of steam generated per minute, etc. The periods are sufficiently long to permit the test value to be recorded. As the periods change the recording ribbon is moved, winding itself completely on a roll in five hours. For the duration of a week, all the various processes thus remain visible and can give the officers and engineers going off watch information regarding all developments, tests, etc., that happened during the watch. Experience has shown that even the helmsmen and the stokers take an interest in "their" watch.

Various recorders contain partial performance records in themselves (Figure 20), for example, recorders of combustion or that of propulsion show thrust and speed, torque and RPM. But the recorders also have group relationships which,

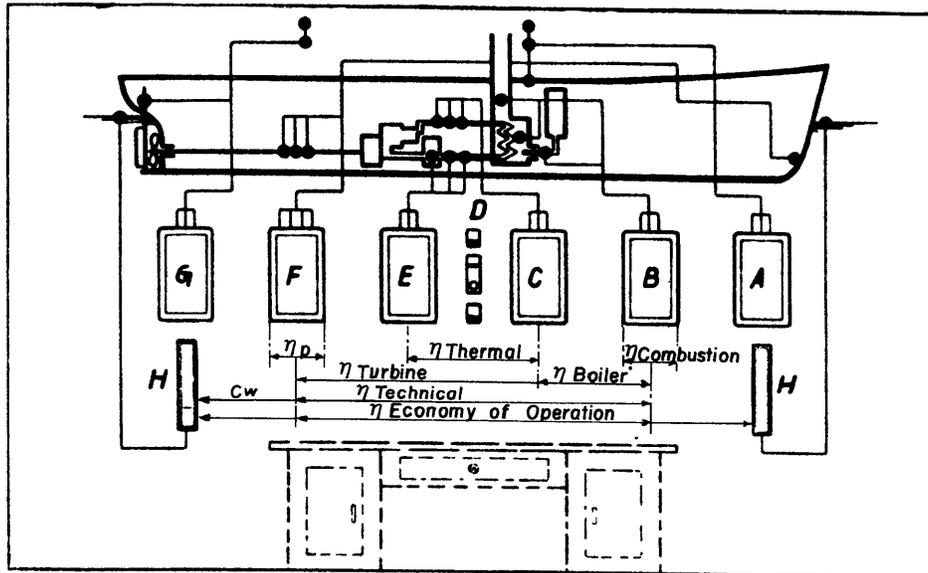


Figure 20. Instrument Panel of the Central Test Station.  
 (A) Rolling, heaving, strength. (B) Amount of fuel per hour, temperature, exhaust gas. (C) Steam pressure, temperature, amount of steam per hour.  
 (D) Revolution counter, distance meter, consumption meter. (E) Vacuum, temperature, feedwater per hour. (F) Torque, RPM, thrust, velocity.  
 (G) Direction of wind, velocity of wind, position of rudder. (H) Draught.

as is evident from Figure 1, are a guide to the performance of the boilers, thermal and mechanical turbines, and the technical over-all efficiency. By considering the draught of the ship together with the speed and fuel consumption, it is possible to determine the efficiency in which the industrialist is interested. Similarly, for a quick estimate of the  $C_w$  values, the so-called Admiralty constant can be found.

Probably there is no engineering problem that cannot be quickly solved by the facilities of the central test station, nor are there any navigational or propulsive reactions that cannot be grasped, or experimental data that cannot be obtained to improve the immediate operating efficiency.

From a working standpoint, it is not necessary that all the test stations and all the recorders be kept in operation. It will generally be sufficient for both staffs: bridge and engine room, to keep a check on the propulsive efficiency. Even this need not be determined exactly as to dimensions, but it would be sufficient to multiply and divide the distances of the curve from the point of origin in millimeters by each other. There will then appear for the given ship in each instance, a number which is the gauge of performance or the normal condition, determined, previously, on the trial run, or the first voyage. It is only when this value grows smaller that additional test stations and recorders will have to be cut in, in order to determine and trace the causes, which may be due to increased wind velocities, unfavorable winds, fouling (thrust and velocity), decreased efficiency, inexperienced helmsman, etc.

Furthermore, by using several counters, operated by exhaust, each recording the fuel consumption by weight and indicating the distance traveled, the RPM, and selective time periods, a number of important operating tests can be completed within the space of one watch. Thus it is not necessary to plot and analyze curves. Reaching the open sea, the captain cuts in these counters and acquaints himself with the performance factor mentioned in the foregoing, for the given draught and trim. By altering the trim of the water ballast, he may determine whether the vessel will sail faster when down by the head or the stern. In any event, the most favorable sailing condition can be determined rather quickly (not only after about 24 hours), and maintained for the next few hours until external conditions change and necessitate another operating test. It depends upon the type of vessel and on the problem set by the captain, whether speed data or fuel consumption will be allowed to preponderate in the analysis.

Avoidance of unfavorable oscillation phenomena or winds by slight changes in the course would be another obvious subject for an operation test to decide. Similar observations and tests of the engines are also conceivable.

Figure 21, a chart that records RPM and ship velocity, shows the increase in velocity with the ship down by the head. Other external conditions remaining equal, such as wind velocity, wind direction and depth of water, the ship's speed is shown to have increased from 13.3 knots to 13.6 knots in spite of a small decrease in RPM. This represents a 2 per cent increase in velocity within  $3\frac{1}{2}$  hours, during which time the forepeak fuel tank was full.

Figure 22 shows a chart of the engine performance, recording the losses in steam pressure and steam temperature while trimming the fires. It may be noted that a certain watch shows a markedly small loss in output. This chart, for example,

might lead to personnel changes, such as shifting good stokers and less efficient ones from one watch to the other, or checking working methods.

It is evident that an arrangement like the central test station may also have an educational value.

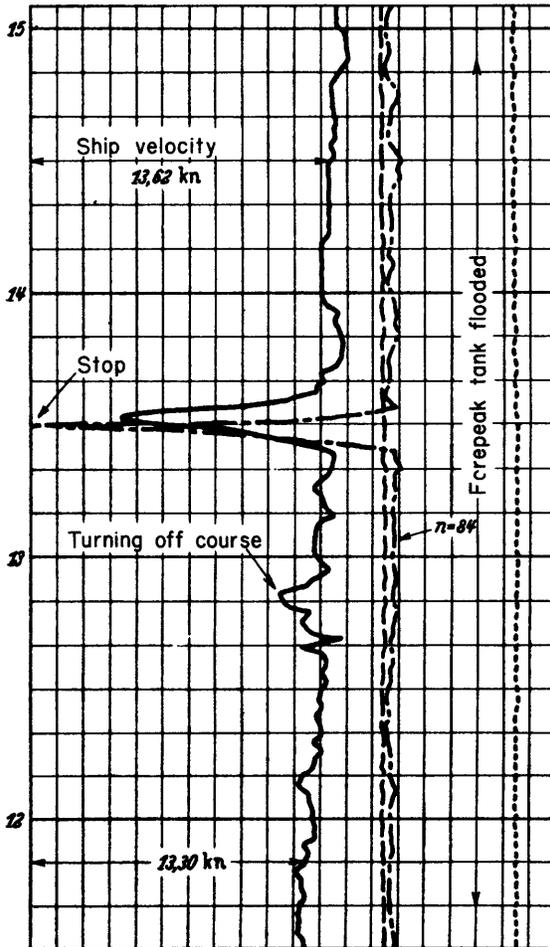


Figure 21. Chart Recording RPM and Ship Velocity.

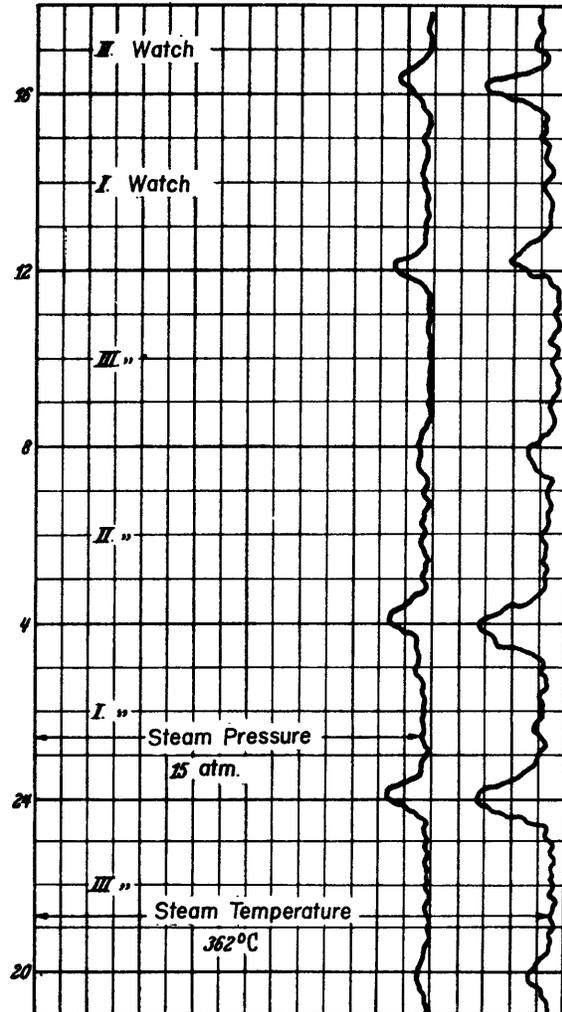


Figure 22. Chart of Engine Performance, Showing Loss in Steam Pressure and Temperature

In conclusion, it must be expressly stated that a technical arrangement of this kind is by no means intended to, nor must it be allowed to replace the experience and the sure instinct of the seaman. It is intended to supply officers at sea with technical test instruments not only as auxiliary tools, but to develop the central test station into a major implement and a foundation on which to base actions intended to assure economy and safety with a comprehensive guarantee of success.

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