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PRESIDENTIAL ADDRESS.
Three Score Years of Development in Marine Engineering.

READ

By STEPHEN J. PIGOTT, Esq., D.Sc.

On Tuesday, September 14th, 1937, at 6 p.m.

CHAIRMAN: MR. R. RAINIE, M.C. (Chairman of Council).

IN keeping with the usual procedure, the honour of serving as President of The Institute of Marine Engineers is, this year, the privilege of an engineer, and I accept my appointment to this high office as a graceful compliment to the firm I am associated with, which, for many years, has played a prominent part in the development and in the construction of machinery for the propulsion of sea-going vessels.

In my Address I propose to review the developments in marine engineering during the three score years from 1877 to the present day. As so vast a subject can be dealt with in the time at my disposal in a general manner only, I must ask your sympathetic indulgence if I make insufficient mention of or neglect entirely some developments which you consider should be included in such a review.

It is interesting to contrast the conditions which obtained at the closing years of the past century with the conditions of the present day. How, in the earlier years of engine building, the designer would indicate, often on a single drawing, only sufficient of the principal features and dimensions to enable the building of powerful engines by capable engineers usually qualified by much sea-going experience, while, in the present day, the designer must illustrate and fully dimension every engine detail and the workshops must be equipped with tools capable of great accuracy and controlled by men highly specialised in operation and production; how, in those earlier days the greatest anxiety of the sea-going engineer was the effective organisation of the stokehold best to ensure the steady output of steam from coal-fired boilers, the grate area and the quality of the coal being the determining factors of the power to be developed, while, in the present day, with oil fuel employed so largely, the stokehold presents little difficulty, and, of course, is non-existent in vessels propelled by oil engines.

The transition from the open type of engine of those earlier years, with drip lubrication and with the movement of the working parts such as the rotating of massive crankshafts and the oscillating of connecting rods, to the enclosed type of engine with forced lubrication and turbine machinery of the present day, where the reading of gauge and counter must serve to indicate movement of the working parts, can be likened to a transition from romance to mystery.

In those earlier days repairs to machinery at sea were of common occurrence, but to-day, with machinery parts more highly stressed and conditions accordingly more critical, a degree of accuracy is demanded which dictates the employment of special tools only available in workshops ashore.

The great progress in metallurgy during the period under review is, of course, closely reflected by the progress in machinery design, and much reduction of weight and great increase in power and speed of running have been rendered possible by the greater knowledge of the physical properties of the various materials used.

It was perhaps inevitable that these advances should produce new anxieties and the necessity for increased vigilance and forethought. The soundness of all materials must be confirmed by experiment and test, including the use of X-ray and wireless equipment, and the existence of any critical condition under service conditions must be determined and provision made for avoiding entirely or minimising its effects.

With the march of progress also have come more exacting demands, or it would perhaps be more correct to say that more exacting demands have brought about much of the progress. To provide the necessities of life in centres of large population, provisions of more or less perishable nature must be transported from overseas, and the schedule of sailing for vessels carrying such cargo must be regulated for arrival at the time best suited to market requirements. Accordingly, the duty of the engineers in charge of the refrigeration of the cargo has become as exacting as the duty of those in charge of the machinery which propels the vessel.

In the passenger and mail service, vessels must be operated with a precision in sailing schedule equal to that of express train service on land, and the exacting passenger must be given comfort and service at sea often greater than the comfort and service of his home or hotel ashore.

With liners equipped to satisfy the demands of such patrons, it is economically necessary that voyages must be as frequent as possible, the period in port being dictated largely by the minimum time required for re-fuelling and provisioning for the next voyage. Under such conditions, the marine engineer's home is virtually aboard the vessel and his time ashore can be counted in hours, excepting at periods necessary for overhaul or repair of the ship and machinery.

When embarking on this subject of marine engineering development, I had planned to confine the review to an even half-century, but I was wisely advised that such limitation would neglect the 1877-1887 decade in which developments were possibly more outstanding than in any other such span of years. For ocean-going vessels the paddle wheel had been abandoned for screw propulsion, but with the tank boilers constructed of iron supplying steam at pressure usually well under 100lb. per square inch, the conditions justified nothing more than the compound reciprocating engine.

1877-87.

The designation "The Advent of Steel in Engineering" can well be applied to this era. Twenty years spent by Sir Henry Bessemer in experiment and development of his process and development also of the Siemens-Martin open hearth process had now rendered the using the steel for parts formerly made of iron commercially possible. With boilers constructed of steel and with furnaces corrugated, the safe working at pressure of 125lb. per square inch was possible in 1881, and by 1887 cylindrical return-tube boilers delivering steam at 160lb. pressure had become general practice.

During this decade, forced draught came into almost general use with installations for naval vessels. The closed ashpit with cold air system had been in use previously, but in view of the difficulties encountered with this system and with primitive forms of induced draught, the closed stokehold system was evolved. The detrimental effects of high combustion on the boiler material would appear, however, to have retarded development.

Actually, as early as 1875, forced draught on the closed stokehold principle was used in an Austrian torpedo boat, but it was not until 1882 that closed stokehold draught was adopted in Her Majesty's ships "Satellite" and "Conqueror". These vessels were of 1,500 and 4,500 i.h.p. respectively, and although the steam trials only lasted a few hours there was serious injury to the boilers. The forced draught system was only accepted in view of the fact that it was only in emergency or for short periods that the forced draught would be used. It should be here observed that the closed stokehold is standard practice in naval vessels to this day. In merchant vessels natural draught was universal until the advent, in 1884, of Howden's system of forced draught which embodied closed ashpits and air supply heated by extracting heat from the waste gases on passage to the funnel.

The higher steam pressure consequent on the use of steel for boilers resulted in the introduction of the triple-expansion engine to both naval and merchant services. This type of engine was actually fitted in the s.s. "Propontis" in 1874, this vessel having water-tube boilers and a steam pressure of 150lb. per square inch, but the installation was not a success owing to the failure of the water-tube boiler and nothing further was done until 1881 when the s.s. "Aberdeen" was fitted with three-crank triple-expansion engines working at 125lb. per square inch steam pressure. These engines were most successful and had a great influence on future developments. By 1886 as many as 150 sets of triple-expansion engines had been built for British shipowners.

The Cunard vessels "Umbria" and "Etruria", built about 1885, were noteworthy in that they were the most highly powered of the single-screw Atlantic liners then in service.

At this time the auxiliaries were chiefly driven by the main engines for such purposes as the feed water supply to boilers, air extraction from and the supply of cooling water to the condensers and for removal of bilge water, but independent feed pumps and circulating pumps were gradually coming into use. Heating of the feed water was becoming general and both direct contact and surface feed heaters were employed for this purpose, the former being preferred because of its de-aerating effect on the feed water.

The use of electricity for the lighting of ships was experimented with and the preservation of perishable cargoes by refrigeration had beginning, the system in use being the Bell-Coleman, which supplied cold air to the cargo holds. Evaporators primarily for the production of drinking water when at sea were first fitted on board ship in 1884.

1887-97.

In 1888 the "City of Paris" and the "City of New York", designed for a sea speed of 20 knots and having triple-expansion engines driving twin screws, were built, followed in 1889 by the "Teutonic" and "Majestic" of similar design. This decade witnessed the development of the quadruple-expansion engine, an engine of this type having made its appearance as early as 1884.

In 1894 the "Inchmona" was fitted with a five-crank quadruple-expansion engine having two low-pressure cylinders. These engines were of only 948 i.h.p., but it is interesting to note that steam of 255lb. pressure, superheated by 60° F., was then available, and that the coal consumption was as low as 1·15lb. per i.h.p. per hour. The first mail steamer to be fitted with quadruple-expansion engines was the "Tantallon Castle", built in 1893.

For vessels of relatively high speed, such as cross-Channel steamers, the three-crank triple-expansion engine was generally favoured and proved highly successful, but with increasing powers and the desire for smoother running, the four-crank triple-expansion engine was gaining in favour for high-speed vessels.

The employing of two low-pressure units served to reduce the weight of the reciprocating parts and the arrangement of four cranks gave better balance of the engine as a whole.

Many notable cross-Channel steamers and numerous torpedo boat destroyers of this period were propelled by four-cylinder triple-expansion engines with highly satisfactory results. The piston speed of these engines is worthy of note, being as high as 950ft./min. in merchant vessels and 1,200ft./min. in naval vessels.

During this period boilers in merchant ships were of the cylindrical return-tube type with pressures up to about 200lb./sq. in., and the adoption of Howden's system of forced draught made rapid strides.

In 1887 H.M.S. "Speedy" was fitted with water-tube boilers of an early design having small tubes all delivering into the steam drum above the water level. This was followed in 1893 by H.M.S. "Daring" with water-tube boilers of a modified design as regards disposition of drums, but still adhering to tubes delivering above the water line.

Experimental work in connection with Yarrow boilers was carried on from 1880 to 1890 and this type was first fitted in 1891 in torpedo boats built for a foreign government.

This decade also witnessed the public demonstration of Messrs. Yarrow & Company's well devised experiments to demonstrate that the circulation of water in boilers having only straight tubes joining the steam drum with the water drums would be satisfactorily maintained without the use of separate down-comer pipes for the downward flow of the water. These experiments had the effect of very considerably strengthening confidence in water-tube boilers.

The use of independent auxiliaries became more general, the pumps, except the air pumps, being separately driven and of the direct-acting type.

Improvements in the electric lighting systems were introduced, directed towards the prevention of breakdown while at sea. The introduction of the ammonia and CO_2 types of refrigerating machines brought about improved conditions of transport for the rapidly increasing quantities of goods liable to deteriorate during a voyage.

1897-07.

The earlier part of this period witnessed the further advance of the quadruple-expansion engine and its use for the propulsion of high-powered passenger vessels such as the "Saxonia", "Deutschland", "Kaiser Wilhelm der Grosse" and "Caronia". Balancing, which had formerly been done by the fitting of balance weights opposite the cranks, was accomplished on the four-crank engines by adjustment of the relative angular position of the cranks on the Yarrow-Schlich-Tweedy system.

Reciprocating steam engines had, however, attained their maximum dimensions and entirely different types of engines saw their inception in this decade.

An important event was witnessed in the year 1897, as steam turbines, which had previously been successfully used for the generation of electric power, were for the first time used by the late Sir Charles Parsons for ship propulsion. The experimental boat "Turbinia", built by The Parsons Marine Steam Turbine Company to test this method of propulsion, made its debut at the Naval Review held in 1897, and by attaining a speed of about 34½ knots demonstrated the possibilities of steam turbines for marine purposes. This demonstration with the "Turbinia" was followed by turbine installations in the destroyers "Viper" and "Cobra" with highly successful results on trial. Unfortunately, both of these vessels were lost through mishaps at sea.

The destroyer "Velox", laid down in 1901, had turbines for main power and small triple-expansion engines for combining with the turbines for greater economy at low powers, while the "Eden", which closely followed, had separate small turbines in place of the small powered reciprocating engines for combining with the main turbines to utilize more economically the steam at low powers.

The successful trials of the Clyde passenger steamer, the "King Edward", in 1901 marked the beginning of the use of steam turbines for the mercantile service and led to the construction in 1902 of another Clyde steamer, the "Queen Alexandra" and in 1903 of the "Queen" for service between Dover and Calais.

Although much had been already achieved by these earlier demonstrations, the series of exhaustive trials of the turbine-driven small cruiser "Amethyst", conclusively showing superiority both in speed and in fuel consumption as compared to a sister vessel, the "Topaze", fitted with triple-expansion reciprocating engines, served definitely to establish the turbine for ship propulsion and inevitably led to its consideration for the propelling of large ocean liners. The first of this class of ship to be so propelled was the Allan Line vessel "Victorian", built in 1904, and this was followed by the sister ship "Virginian".

Meanwhile the Cunard Steamship Co., with the help of a technical committee composed of the country's leading marine engineers, decided in 1904 that the use of steam turbines would be justified for the large ships then being contemplated, and as a result the "Carmania" was equipped with a high-pressure turbine driving a centre line shaft and exhausting to a low-pressure turbine driving each wing shaft.

The close of this decade saw the completion of the sister vessels "Lusitania" and "Mauretania" propelled by a high-pressure turbine on each wing shaft exhausting to a low-pressure turbine on each inner shaft. Until very recent years the "Mauretania" held supreme position on the Atlantic service.

Turbine propulsion was adopted by the British Admiralty for the battleship "Dreadnought" laid down in 1905.

No change can be recorded in the type of boiler fitted in merchant ships, but pressures were still rising, 210lb./sq. in. being used generally and in some cases 220lb./sq. in.

Water-tube boilers were further advanced for naval vessels, the large-tube Belleville boiler which had already been developed in the French Navy being generally favoured for battleships and cruisers and small-tube boilers such as the Thornycroft and the Yarrow in smaller vessels.

In this period controversy arose as to the comparative merits of the various water-tube boilers which had been installed, culminating in the appointment of a Boiler Committee to consider the whole question. As a result of their findings the Belleville boiler was abandoned and subsequent battleships and cruisers were fitted with large-tube boilers of the Babcock & Wilcox and Yarrow types, in combination with cylindrical boilers. It was also during this period that the burning of oil fuel in conjunction with coal was introduced.

The adoption in 1898 of motor-driven forced draught fans appears to be the first instance of the use of electrically-driven auxiliaries in connection with the propelling machinery.

The introduction of turbine machinery had the effect of making the use of independent auxiliaries necessary with such installations. These were generally steam driven and of the reciprocating type, although electric generators in the "Mauretania" and "Lusitania" were turbine driven.

During this decade a prime mover of a new and revolutionary type made its appearance. I refer to the Diesel or heavy-oil engine. In 1893 Rudolf Diesel first introduced his rational cycle for obtaining high efficiency in internal combustion engines, and in 1898 the M.A.N. Company of Augsburg completed the first successful Diesel motor.

The belief is widely held that enterprise and development in Russia has been left to the present regime, and it is therefore all the more noteworthy that the first appearance of a Diesel engine on shipboard should have taken place on the Volga in 1903 when a small tanker—the "Vandal"—was so equipped to ply down that great waterway to the Caspian Sea. It is still more interesting to note that the system was analogous to the present-day Diesel-electric type. The "Vandal's" engine was a land type Diesel, but in 1904 a sister ship the "Ssarmat" was built and equipped with the first marine-type Diesel direct-driving engine. The engine was designed for ahead driving only, while astern working was accomplished by electro propulsion.

1907-17.

During these years, the latter half of which fell within the period of the Great War, there was little if any progress in the development of the reciprocating steam engine, but many modifications were made to machinery in which the turbine principle entered.

The cargo vessel "Otaki", built in 1908, had reciprocating engines combined with low-pressure turbines in order to increase the power obtainable by the expansion of steam beyond the limits possible with reciprocating engines only, and several vessels were subsequently fitted with this arrangement, notably the Canadian liner "Laurentic" which immediately followed the "Otaki" and later the White Star vessels "Olympic" and "Titanic".

The advent of reduction gearing in 1909 with the s.s. "Vespasian" equipped with turbines operated at high revolutions for greater economy of steam and with reduction by gearing to slow turning propellers for greater propulsive efficiency provided one solution which made possible the high-powered installation of future years. Among the early vessels fitted with this type of drive were the cross-Channel steamers "Normannia" and "Hantonia" in 1911 and in the Navy the t.b.d.'s "Leonidas" and "Lucifer" in 1912.

While turbines designed on the principle of steam pressure reaction were employed with all earlier marine installations, the principle of the impulse action of the steam had made much progress in power plant equipment ashore, and marine development of the Curtis type on this impulse principle had advanced in Germany and America.

In 1910 impulse turbines were fitted in H.M.S. "Bristol", and the success of the experiment justified the adoption of impulse turbines in naval vessels of all classes, beginning with direct drive in the earlier installations and continuing with reduction gearing. The most highly-powered naval vessel, H.M.S. "Hood", is propelled by impulse turbines driving through reduction gearing.

With direct-drive turbines the design was such that the steam thrust load on the turbine rotor opposed the thrust load resulting from the propeller action in driving the vessel, but with the adoption of reduction gearing the opposing of these forces did not obtain and the full force of the propeller thrust was transmitted by the shafting to the block affixed to the ship's framing. Even under the condition of opposed thrust forces the multi-collar thrust block had been a source of trouble and anxiety. The adoption of the Michell principle of pivoted thrust pads rendered possible the taking of such thrust loads on a single collar. While it is possible that this invention may not be classed as a major development, its use has made possible the transmission of high powers through both geared and electrical reduction which without Michell thrust blocks would seem almost impossible.

It is of interest to note that the U.S.A. Navy collier "Jupiter" was fitted in 1912 with a turbo-electric drive for propulsion purposes, the turbines being of the impulse type.

The s.s. "Aquitania", completed in the autumn of 1914, was quite free of innovation excepting that the turbines were designed and arranged on what may be likened to the four-cylinder triple-expansion principle. The h.p. turbine on one wing shaft exhausted to an i.p. turbine on the other wing shaft which in turn exhausted to two l.p. turbines driving the two inner shafts. These turbines were direct connected to the respective lines of shafting. The large cylindrical boilers followed well-tried practice.

For naval vessels boilers of the three-drum type with fully submerged tubes had become general practice, with tubes of larger diameter where weight considerations permitted and with tubes of smaller diameter for lighter and higher-speed vessels.

In naval vessels the use of oil fuel had now become general practice.

In this decade the use of water-tube boilers in fast Channel steamers was introduced, notably in the "Riviera", "Engadine" and the "Paris".

The growing practice of employing independent auxiliaries had the effect of making designers turn their attention to the use of the steam turbine for driving these machines, and in 1912 the turbine-driven feed pump and forced-draught fan were becoming usual equipment.

Although the oil engine was fitted on board ship in a relatively short space of time after its success ashore, a longer period elapsed before its adaption was decided upon for the much more exacting and hazardous duty of propelling an ocean-going vessel, and it was not until 1910 that this momentous step was taken, when the tanker "Vulcanus" was put into service equipped with Werkspoor four-stroke engines. In 1910 the m.v. "Toiler" with Polar type Diesel engines passed the acid test of seaworthiness by making the first Atlantic crossing for a ship so propelled. It was not until two years later, however, in 1912, with the appearance of the large ocean-going ship "Selandia", equipped with Burmeister & Wain engines, that the Diesel-engined ship became definitely established as a competitor with steamships in the merchant fleets of the world.

1917-27.

In the immediate post-War years naval shipbuilding was almost at a standstill and progress in marine propelling machinery was centred in equipment for mercantile vessels. There was a general increase in the application of superheaters of the smoke-tube type to cylindrical boilers with working pressure increased to about 250lb. and steam superheated to about 600° F., while in water-tube boilers, which were introduced in ocean-going vessels in this period, pressures of 250lb./sq. in. and 650° F. temperature were adopted. In naval vessels superheaters were added to the small-tube boiler with pressures of 250lb./sq. in. and steam temperature of about 600° F. The use of oil fuel in the boilers of merchant vessels was much extended during this period and for high-class ocean-going liners oil became the prevailing fuel.

In 1926 the Clyde passenger steamer "King George V" was equipped with a somewhat experimental installation of a water-tube boiler for a pressure of 550lb./sq. in. with steam superheated to 750° F. The turbines were of special design to utilize the increased energy.

In this period also water-tube boilers having forced circulation made their appearance and records show that the Loeffler and the La Mont boilers subsequently adopted for marine work mainly abroad were installed on land in 1925.

The use of superheated steam in reciprocating engines led to the adoption of drop valves and special forms of valve gear as being more suitable for the utilization of superheated steam.

High-speed turbines designed to work with steam of moderate superheat and driving through double-reduction gearing were fitted in many vessels of moderate speed.

The use of the turbo-electric drive was further developed and the application of turbines taking the exhaust steam from reciprocating engines and driving through gearing mounted on a common propeller shaft, as in the Bauer-Wach system, made headway, especially with lower-powered vessels.

The closed-feed system was increasingly adopted in both naval and mercantile vessels with the object of reducing the quantity of air in the feed water and so retarding the deterioration of the boilers. With this system turbine-driven feed pumps and extraction pumps were generally employed. There was now a movement towards the more general use of electric power for driving the auxiliary machinery and by the end of this period ships were being fitted with practically all electric equipment, the pumps being usually of the rotary type.

The Diesel generator was also being adopted for power and lighting, although in many cases turbo-generators were also installed.

The next important event in the history of the marine oil engine was the placing in service in 1924 of the m.v. "Aorangi", equipped with a six-cylinder Sulzer type single-acting engine on each of the four shafts. She has the distinction of being the first fast passenger liner propelled by Diesel engines.

Another big step forward occurred in 1925, when the Swedish American liner "Gripsholm", fitted with Burmeister & Wain four-stroke double-acting engines, went into service.

1927-37.

During this last decade of the three score years covered by this review no development has occurred which, in my opinion, can be regarded as epoch-making. Rather has this been a period of utilization of the developments of the earlier years and of steady progress.

With Diesel engines it would appear that the two-cycle type has gained somewhat at the expense of the four-cycle. The passenger and cargo liner "Amerika", with two-cycle double-acting engines, created much interest about 1930, but the "Britannic", of about the same period, fitted with large four-stroke double-acting engines, is notable as being the first British-built motor ship for the North-Atlantic passenger service.

Mention must also be made of the "Prince Baudouin", with high-speed two-cycle single-acting solid-injection engines for cross-Channel service.

With reciprocating steam engines, the further extension of the use of superheat steam and the adoption of special valve mechanism would appear the more outstanding features.

Marked advance has occurred in the use of water-tube boilers in merchant vessels with gradual increase of boiler pressure and of steam temperature.

The design of turbine machinery has kept pace with the boiler development for the effective utilization of higher pressures and temperatures.

The turbo-electric installation of the "Viceroy of India" created much interest and comparison with the more general practice of reduction by mechanical gearing.

The high order of fuel economy attained with the installation of water-tube boilers and geared turbines in the "Empress of Britain" justifies special mention.

The s.s. "Normandie", with turbo-electric propulsion, marked a very great increase over the use of similar machinery in the "Viceroy of India" and subsequent ships, and, if for such reason only, this installation must be of great interest to all marine engineers.

Likewise the "Queen Mary", with geared turbine machinery of much advance in power over similar installations in other merchant ships, has been a source of much interest.

In closing this Address I am conscious of a feeling that my survey covering the long period of sixty years has dealt inadequately with many marine engineering developments, and that some developments of outstanding merit have been missed entirely. Even so, the Address is longer than I had originally intended.

I desire again to assure you of my appreciation of the very great honour conferred upon me by your choosing me as President of The Institute for this year and to express my sincere thanks.

Prior to the reading of the foregoing Address, the **Chairman of Council** (Mr. R. Rainie, M.C.), introducing the President who was most warmly welcomed by the large audience, said: "Once again we are met to be addressed by our President. This Institute has been fortunate, both as to the type and the character of the gentlemen who have occupied the Presidential Chair. We have had generally in rotation shipbuilders, shipowners and engineers as our Presidents, and this year we look forward to an Address from one of the most prominent engineers in this country—Mr. Stephen J. Pigott.

We have had many prominent engineers in the Presidential Chair, but to-day to my mind is a somewhat unique occasion. Not only have we a prominent engineer, but we have one who did not commence his career on the Bristol Channel, the North East Coast or the Clyde, but whose career started in the country of his birth, the United States of America. Mr. Pigott's work since he came to this country in 1908 at the invitation of the British Admiralty is well known to marine engineers, and I am sure that the Address we are about to listen to will be one worthy of your keenest attention and interest".

At the conclusion of the Address the **Chairman of Council** again rose and said: "It is with the greatest pleasure I rise to propose a vote of thanks to our President for the Address to which we have listened.

Our President in opening his Address said that he accepted his appointment to that high office as a graceful compliment to the firm with which he is associated. I am sure that I speak for you all when I tell our President that it is the man himself we desire to honour; and incidentally, in honouring him we had in mind the notable work he has accomplished in association with the great firm with which he is connected.

Mr. Pigott chose a subject which must always be of interest to marine engineers. In one part of his Address he described the developments in marine engineering as the transition from romance to mystery. I, conscious of my ignorance, have always looked on the whole matter of marine engineering development as mystery. To those better informed on this subject I think each one of the decades into which our President segregated the period covered by his Address, in itself provides transition from romance to mystery, and I would add to further romance. Be that as it may, it is our privilege to have listened to the story of power propulsion from a man who assisted in the development of one of the most radical and progressive changes in the propulsion of ships. I know you all appreciate this fact and I am sure that when Mr. Timpson has duly seconded this motion, you will show that appreciation in the recognised manner".

The **Vice-Chairman of Council** (Mr. A. F. C. Timpson, M.B.E.) seconded the proposal, which was accorded to the accompaniment of prolonged applause.

The **President** suitably replied, again expressing his appreciation of the honour conferred upon him by his election to the Presidential Office.

INSTITUTE NOTES.

CORRESPONDENCE.

London,

September 17th, 1937.

To the Secretary, The Institute of Marine Engineers.

Ignition Delay in Diesel Engines.

Sir,

In the Transactions of August, 1937 is an interesting *article by Dr. Ing. W. Lindner on the above somewhat controversial subject.

As is well known, one effect of ignition delay is detonation, and despite the thought and research that have been given to the subject this fault still remains. My personal contention is that it has been almost universally accepted that the culprit must be the fuel; it is on this premise that investigators have based their research, and in my opinion it is for this reason that no progress has been made. I consider that the source of the fault is not the fuel but the method of injection usually employed.

It is well known that it is very difficult to ascertain the ignition point of oils as this varies with conditions; I have never allowed this factor to have any significance. If we limit our investigation to the ignition of a sprayed charge of oil there are only two factors to consider, the temperature of the air into which the oil is sprayed and the degree of pulverisation.

* Vol. XLIX, Extracts, p. 156, "Experiments on the Behaviour of Fuel in Diesel Engines", reprinted by permission from "The Motor Ship", August, 1937.

In my investigations I eliminated any doubt on the former point by employing as an ignition agent a bunsen flame, let us assume at 1,350° C., which left me with only one factor, that of droplet size. I employed a flame 1in. wide, and to obtain pulverisation and spray velocity I used a small rifle firing a very light cartridge of fulminate of mercury. As the gas volume generated was a little less than the capacity of the barrel the discharge of gas through the muzzle would be sonic. We may therefore assume a velocity of 1,000ft. per second at the muzzle. By placing a few drops of oil in the muzzle and firing the rifle it was noted that the spray was very fine; it was only just visible and it floated. If the muzzle was placed almost in contact with the flame and then fired it did not matter what oil was used—even coal gas tar oil—the spray was ignited.

This also applies to solids—wood, charcoal, sulphur, etc.; they will all ignite as they pass through the gas flame and as this only occupies ·00008 second (one degree of crankshaft movement at 2,000 r.p.m.) the ignition delay under these circumstances need not be considered. It is possible that this time varies with the oil used, but as the ignition time of all the combustibles lies within ·00008 second this variation can be ignored for this phase. If sulphur is used there is a definite "burned sulphur" smell, while the pyrotechnic mixtures show their characteristic colours.

The above only applies providing the solids are

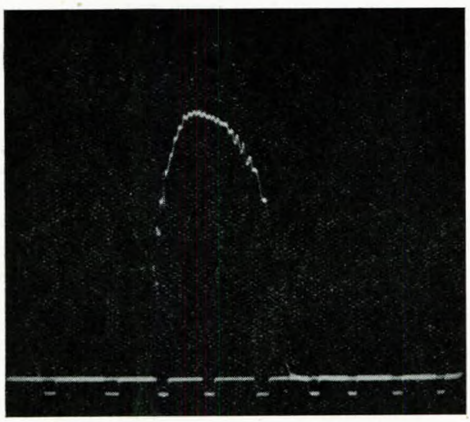


Fig. X.—Delivery card—vertical ordinate equals 1/2 MV^2; base line notches equal 6 degrees.

ground very fine. If ordinary fine (FF) gunpowder is tested it will pass through the flame without ignition, in fact if the flame is placed in a horizontal position a fall of 6in. will suffice to prevent ignition, yet if this powder is fully pulverised it will ignite from the rifle as described above. I therefore feel justified in putting forward the contention that pulverisation from the commencement of injection is the first essential.

In Fig. 1 in Dr. Lindner's article the pressure rise in the fuel line occupies no less than 12·0 degrees, but the issue is complicated by the differential fuel valve, as when this leaves its seat the added capacity of the plunger tends to cause a pressure fall. To

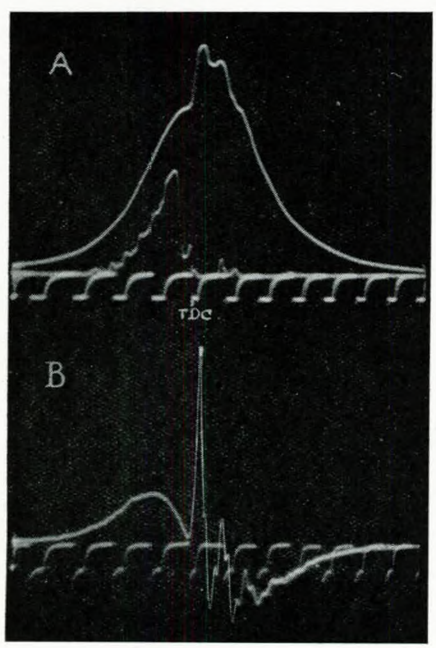


Fig. Y.—"A" engine and fuel line pressure on same time base (vertical ordinates not comparable); "B" rate of change of engine pressure; speed 700 r.p.m.; light load; notches spaced 12 degrees of crank angle apart.

be of real value the diagram should be of the actual oil flow through the jet, from which a computation of the pressure can be made. Fig. X is an example of such a diagram.

In the apparatus shown in Fig. 2 of Dr. Lindner's article it is possible that the results are confused by this incorrect injection. My contentions are supported by the actual results on an engine using alternatively an incorrect method of injection and a correct one, the fuel and other conditions being equal. With the normal injection equipment the detonation was excessive, and a card obtained under these conditions, Fig. Y, shows the gradual pressure rise in the fuel line and the abrupt rise in the cylinder, the differentiation shown in B of this figure giving a measure of the detonation.

With the correct injection shown in Fig. Z it will be seen that the initial pressure rise is very

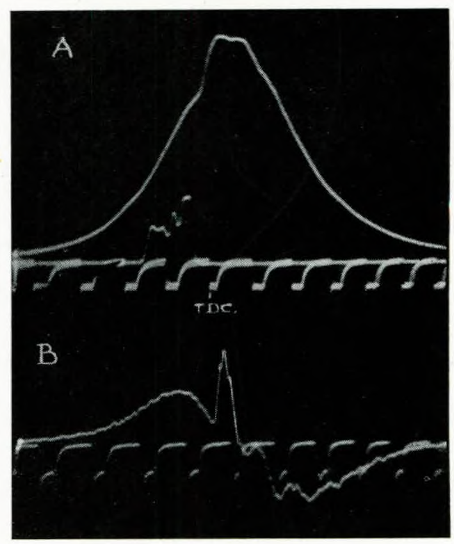


Fig. Z.—"A" engine and fuel line pressure on same time base (vertical ordinates not comparable); "B" rate of change of engine pressure; speed 700 r.p.m.; light load; notches spaced 12 degrees of crank angle apart.

abrupt; therefore a differential valve is not required in the injector, with the result that the ignition curve is faired and the engine is nearly free from detonation.

If the first part of the oil charge is delivered at high pressure it will enter the cylinder in a fully pulverised state and will ignite, perhaps not in .00008 second but early enough to prevent detonation. On the other hand if this oil passes in at low pressure, and therefore in a coarse spray, it will probably not be ignited until the fine spray arrives, ignites, and the flame is propagated to the early charge. This is no doubt why certain combustion chambers modify the detonation—they more readily propagate the flame.

It does appear that the root of the evil is to be found in the injection, and there is every indication that far too much is assumed from the shape of the diagram from the fuel pipe line.

I shall be very gratified to learn Dr. Lindner's views upon the above.

ARTHUR F. EVANS (Member).

AUTUMN GOLF MEETING.

The Autumn Golf Meeting was held at Hadley Wood on Friday, October 1st, 1937, by kind permission of the Hadley Wood Golf Club.

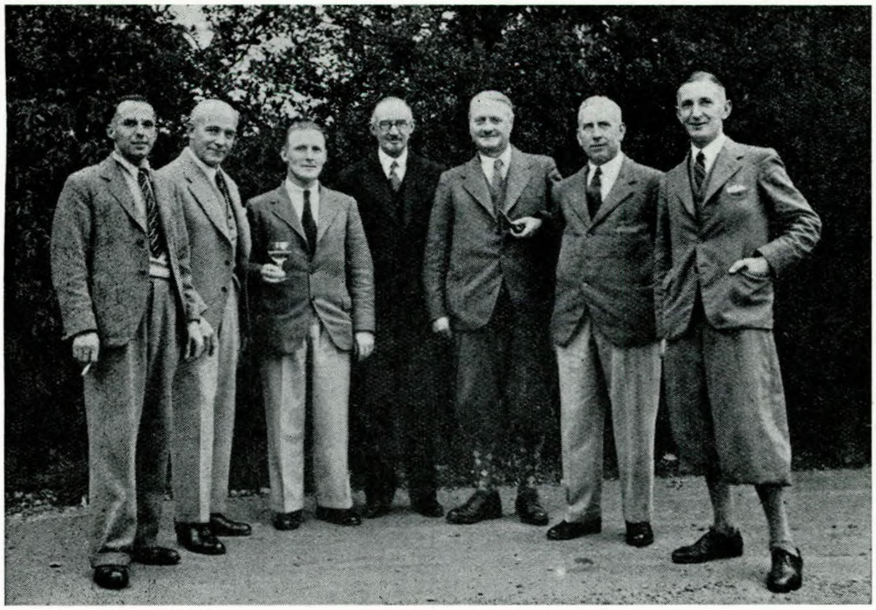
Fine weather prevailed throughout the day. Thirty members took part in the medal competition held in the morning. The first prize, presented by Eng. Capt. R. D. Cox, R.N. (ret.), was won by Mr. J. R. Henderson with a net score of 69. The second prize, presented by Mr. J. A. Watts, was won by Mr. L. G. Hughes with a net score of 73, and Mr. R. Rainie won the third prize, presented by Mr. A. Robertson, C.C., with a net score of 74.

The prize for the best scratch score in both summer and autumn meetings, presented by Mr. R. Rainie, M.C., was won by Mr. A. N. Harnett with an aggregate score of 150.

A four-ball greensome, in which 28 members participated, was held in the afternoon. The two first prizes, presented by Mr. J. R. Richmond, C.B.E., were won by Messrs. A. N. Harnett and J. R. Henderson, who finished two up; the second prizes, presented by Messrs. A. N. Harnett and J. R. Henderson, were won by Messrs. H. S. Humphreys and R. Rainie, who finished one up; and the third prizes, presented by Mr. A. F. C. Timpson, M.B.E., were won by Lieut.-Col. H. Gordon-Luhrs and Mr. W. E. Loveridge, who also finished one up, the awards being decided on the best score for the last 12 holes.

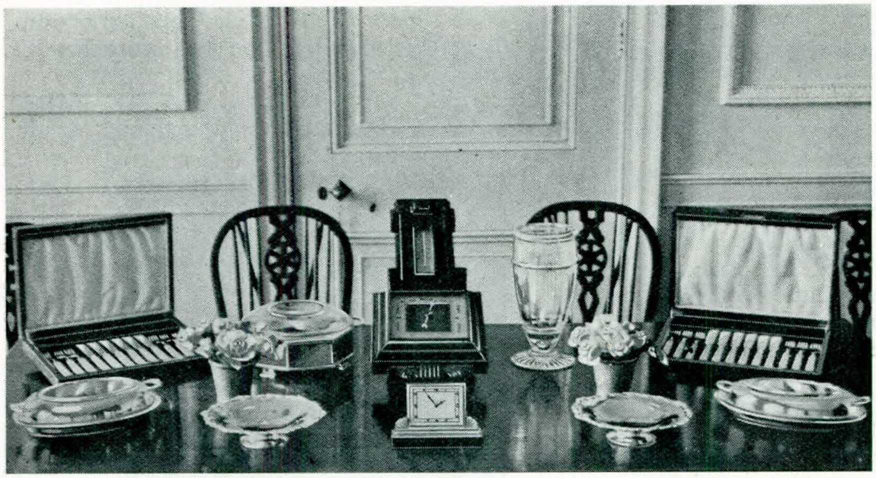
The prizes were presented by Mr. Alfred Robertson, C.C., who expressed the thanks of the players to the donors of the handsome prizes and to the Committee and Secretary of Hadley Wood Golf Club for the excellent accommodation which had been provided. Mr. R. Rainie (Chairman of Council) voiced the thanks of those present to the Social Events Committee and particularly to the Convener (Mr. A. Robertson) to whose arrangements the success of the meeting was attributable. Mr. Robertson suitably replied on behalf of the Committee.

J. R. HENDERSON.
Winner of the Medal Competition and (jointly with A. N. Harnett) of the afternoon Greensome.



SOME OF THE PRIZE WINNERS.
(Left to right): L. G Hughes, R. Rainie, J. R. Henderson, A. Robertson, Lt.-Col. H. Gordon-Luhrs, W. E. Loveridge and A. N. Harnett.

The following members participated in the day's events: Messrs. E. F. J. Baugh, F. M. Boyes, G. A. Bradshaw, R. K. Craig, D. M. Denholm, R. M. Gillies, J. A. Goddard, Lt.-Col. H. Gordon-Luhrs, A. N. Harnett, D. J. Harris, E. C. Hatcher, J. R. Henderson, S. Hogg, R. E. Huggan, L. G. Hughes, H. S. Humphreys, E. B. Irwin, W. C. Jones, W. E. Loveridge, J. Main, Eng. Rear-Admiral W. R. Parnall, D. J.



THE PRIZES.

Paterson, R. Rainie, W. Ridley, A. Robertson, J. Robinson, H. V. Senior, W. Tennant, and W. G. Thomson.

Visit to the Engineering and Marine Exhibition, Olympia.

The official visit of The Institute to the biennial Engineering and Marine Exhibition, Olympia (formerly known as the Shipping, Engineering and Machinery Exhibition) took place on Wednesday, 22nd September, 1937. The more healthy conditions at present obtaining in the engineering industries were reflected in the increased space taken up by exhibitors, on this occasion all the stands in the gallery being occupied.

The Members of Council and Vice-Presidents of The Institute as well as those of several other institutions, were the guests of the Organisers (Messrs. F. W. Bridges & Co.) at a luncheon at which Lord Dudley Gordon presided and welcomed the visitors. Mr. R. Rainie, M.C. (Chairman of Council) responded as representing the senior of the institutions present.

Subsequently the Members of The Institute, who attended in gratifying numbers with the object of touring the highly interesting exhibits, were entertained to tea, the occasion proving most congenial.

ELECTION OF MEMBERS

List of those elected at Council Meeting held on Monday, 4th October, 1937.

Members.

John Anderson, 238, Turney Road, Dulwich, S.E.21.
Francis Scott Banner, Eng. Com'r., R.N.(ret.), 50, Park Road, Rosyth, Fifeshire.
William Blacklock, Eng. Lieut., R.N.(ret.), Cleadon, 21, Downs View Road, Swindon.
James Clifford Couper, Haughend, Meigle, Perthshire.
Edward Donnelly, 669, Moss Park Drive, Glasgow, S.W.2.
John Massie Finlayson, 163, Nicolson Road, Durban, S. Africa.
Henry Donald Liebmann, 7, Village Road, Vancluse, Sydney.
Marcel Porn, 2, Strathray Gardens, Hampstead, N.W.3.
Henry Pratt, Kenrig, Lynnbank Road, Liverpool, 18.
Joseph William Ridley, Taiping & Dindings, Mines Dept., F.M.S.
Francis William Roper, Star House, Feniscowles, nr. Blackburn.
John Speirs, 6, The Avenue, Girvan, Scotland.
Ernest Edward Vick, 36, Ilford Avenue, Great Crosby, Liverpool, 23.
David Kyffin Williams, 46, Station Road, Upminster, Romford.
Robert Yates, 14, Studley Road, Wallasey.
George Young, 1, Leigh Mansions, Oakmount Avenue, Southampton.

Associates.

William James Barrie, 116, Dogkennel Lane, Langley, near Birmingham.
William Henry Connor, 50, Rosebery Avenue South Shields.
William Henry Dann, 60, Pagitt Street, Chatham, Kent.
William Murphy, Lislea, Armagh, Co. Armagh.
David Price, 13, Springfield Road, Broken Cross, Macclesfield.
Robert Charles Heurtley Reed, 1317, Harwood Street, Vancouver, B.C., Canada.
Edmund Godfrey Russell-Roberts, Fir Knob House, Beacon Hill, Hindhead, Surrey.
Clifford William Smith, Windy Ridge, Cuxton Road, Strood, Kent.
George Hadden Timmis, 133, High Street, Haslington, near Crewe.
William Walter Warren, 27, Central Park Road, East Ham, E.6.
Henry Carmichael Williamson, 1, Lowden's Alley, Hawkhill, Dundee.

Probationer Student.

Walter Keith Buttery, 134, Centenary Road, Goole, Yorks.

ADDITIONS TO THE LIBRARY.

Presented by the Publisher.

"The Centenary of the Screw Propeller", by H. W. Brady. Syren & Shipping, Ltd., 6d. net.

"German Copper and Brass Welding Practice". Copper Development Association.

The following British Standard Specifications :

No. 88, 1937. Electric Fuses up to 800 Amperes and 250 Volts to Earth.
No. 209, 1937. Fuel Oils for Diesel Engines (Petroleum and Shale Oils) including Methods of Test.
No. 742, 1937. Fuel Oils for Burners (Petroleum and Shale Oils) including Methods of Test.
No. 735, 1937. Sampling and Analysis of Coal and Coke for Performance and Efficiency Tests on Industrial Plant.
No. 749, 1937. Underfeed Screw Type Stokers.
C.E. (EL) 4693. Dimensions of Insulated Annealed Copper Conductors for Electric Power and Light (corrigendum).
C.E. (ME) 4173. Multitubular Horizontal Boilers (Dryback and Waste Heat) (corrigendum).
C.E. (ME) 3982. Lancashire and Cornish Boilers (corrigendum).

Lloyd's Register of Shipping—Rules and Regulations, 1937/38.

The Journal of the Institute of Metals, Vol. LX, containing the following papers:—

"Metal Spraying: Processes and Some Characteristics of the Deposits", by Rollason.
"An Aluminium Statue of 1893: Gilbert's 'Eros'", by Hutton and Seligman.
"The Effect of the Addition of Small Percentages of Iron and Silicon to a High-Purity 4 per cent. Copper-Aluminium Alloy", by Gayler.
"Note on the Influence of Small Amounts of Titanium on the Mechanical Properties of some Aluminium Casting Alloys", by Schofield and Phillips.
"Stress-Strain Characteristics of Copper, Silver and Gold", by McKeown and Hudson.
"The Effect of Manganese on the 'Annealing Brittleness' of Cupro-Nickel", by Bose.
"The Resistance of Some Special Bronzes to Fatigue and Corrosion-Fatigue", by Gough and Sopwith.
"Directional Properties in Rolled Brass Strip", by Cook.
"A Study in the Metallography and Mechanical Properties of Lead", by Jones.
"Creep of Lead and Lead Alloys. Part I—Creep of Virgin Lead", by McKeown.
"The Effect of Cast Structure on the Rolling Properties of Zinc", by Northcott.
"The Theory of Age-Hardening", by Gayler.
"The Estimation of Grain-Size in the Region above 10 cm.", by Stephen and Barnes.
"The Control of Composition in the Application of the Debye-Scherrer Method of X-ray Crystal Analysis to the Study of Alloys", by Hume-Rothery and Reynolds.
"An X-ray Study of the Chromium-Aluminium Equilibrium Diagram", by Bradley and Lu.
"Alloys of Magnesium. Part V—The Constitution of the Magnesium-Rich Alloys of Magnesium and Cerium", by Haughton and Schofield.
"The Solubility of Silver and Gold in Solid Magnesium", by Hume-Rothery and Butchers.
"Alloys of Magnesium. Part IV—The Constitution of the Magnesium-Rich Alloys of Magnesium and Silver", by Payne and Haughton.
"The Constitution of Silver-Rich Antimony-Silver Alloys", by Reynolds and Hume-Rothery.
"The Constitution of the Alloys of Silver, Tin and Mercury", by Gayler.
"Dental Amalgams", by Gayler.
"The Flow of Metals", by da C. Andrade.

"Electrical Installation Rules and Tables for Rapid Reference", by W. S. Ibbetson, B.Sc. E. & F. N. Spon, Ltd.

In the review of the above book which was published on page 178 of the September Transactions, the price was indicated as 3s. 6d. This is incorrect, the book being published at 2s. 6d.

"Lectures on the Mathematical Theory of Electricity", by F. B. Pidduck. Oxford University Press, 110 pp., illus., 7s. 6d. net.

Although the book deals with electrical phenomena it is essentially an advanced mathematical treatise. The scope of the book goes beyond that normally required for an electrical degree course, but the book may be of assistance for research work. While the marine electrical engineer will not obtain any practical assistance from the book and an advanced knowledge of mathematics is required to follow the subject matter, the topics treated have a certain amount of physical interest.

"Effect of Impurities in Copper", by S. L. Archbutt, F.I.C. and W. E. Prytherch, M.Sc., Research Monograph No. 4 of the British Non-Ferrous Metals Research Association, Regnart Buildings, Euston Street, London, N.W.1, 134 pp., illus., 12s. 6d. net, postage 6d.

In recent years the British Non-Ferrous Metals Research Association has published three Research Monographs, dealing respectively with "Tin Solders" (No. 1), "Metallurgical Analysis by the Spectrograph (No. 2) and "The Casting of Brass Ingots" (No. 3). These are now followed by a fourth, "Effect of Impurities in Copper". When the Association was formed seventeen years ago its Research No. 1 was devoted to the effect of impurities on the properties of copper. The investigation was carried out for the Association at the National Physical Laboratory, and went on for a number of years. The effects of various elements and combinations of elements were investigated in turn, and the results were made known to members of the Association in a series of reports (more than 20 in number), some of which were published. The value of a single publication summarising and reviewing the whole of the work in the light of the latest knowledge, and setting out the final conclusions reached, will be apparent to all who are interested in this important practical subject. On this account, at the request of the Association, the present book has been written by Messrs. Archbutt and Prytherch, who were closely connected with the research.

The book opens with an account of the scope of the investigation and of the methods of preparation and testing of the materials used, followed by a short chapter on commercially pure copper. The bulk of the book gives a detailed discussion of the effects of various impurities, including oxygen, oxygen plus hydrogen, sulphur, iron, phosphorus, silicon, bismuth, lead, arsenic, antimony, nickel and silver, individually and in various combinations; the combined effect of nickel, antimony and oxygen; and of bismuth, arsenic, antimony, nickel and oxygen, two or more together. Examination was made by tensile, impact, hardness, fatigue, and bend tests on the mechanical side, and on the physical side by density and electrical conductivity measurements. Finally, after a discussion of the segregation of impurities, the authors give a chapter in which the comparative effects of the various impurities are summarised.

The value of the book is enhanced by the numerous tables provided, in which results obtained in all the tests of the various materials examined are set out in detail; these tables are a mine of practical information. There are numerous photomicrographs and other illustrations. Literature references are provided at the end of each chapter, and the book is rounded off by an index which has been arranged so that the effects of any given impurity or group of impurities can be found very readily.

"Examples in Thermodynamics Problems", by W. R. Crawford, M.Sc., Ph.D. Sir Isaac Pitman & Sons, Ltd., 165 pp., 56 illus., 5s. net.

In this book the author provides an extensive collection of useful problems in thermodynamics, suitable for students preparing for the Higher National Certificate examination, the qualifying examinations of The Institute and of the Institutions of Civil and Mechanical Engineers, and for engineering degree examinations. It is not wholly suitable for the Ordinary National Certificate, but with slight modifications some of the problems could be adjusted to the calibre of this particular examination.

The examples are classified under nine separate sections giving a varied range to the subject. A feature of the book is the large number of "worked problems" which should prove valuable to both students and lecturers. The arrangement of the sections gives a valuable lead to the reader as to the order in which this subject at this stage should be treated. The first three sections dealing with heating and expansion of gases, entropy, air cycle efficiencies and properties of steam are followed by examples of a more practical nature, e.g., the steam engine, compressors and refrigeration, steam turbines, boiler and internal combustion engine trials. The last section, which deals entirely with valve diagrams and valve gears, gives a suitable description of the construction of the valve diagram with each solution.

The solution giving the heat balance sheet of an internal combustion trial on page 131, question 6, is worked in the orthodox style, which includes the small amount of frictional heat due to the piston movement in both the i.h.p. heat equivalent and the cooling water heat.

The book should prove a valuable aid to students studying for the examinations for which it is intended, since it contains in addition to the worked problems, a number of questions and answers to be solved by the student.

"Calculus", by J. V. McKelvey. The Macmillan Company, 420 pp., illus., 12s. net.

Although there seems to be little room nowadays for another text book covering the elements of the Differential and Integral Calculus, yet the present work succeeds in presenting these subjects to the beginner in a logical and interesting manner. A feature of the book is the clear statement, after the text has been developed, of the series of steps necessary to apply the text to the solution of the exercises which follow each chapter.

The opening chapters on the Differential Calculus deal clearly with functions, limiting values, and continuity, and lead on to the fundamental idea of a Differential Coefficient. Differentiations of algebraic, trigonometrical, and logarithmic functions are adequately developed. After considering equations in parametric form, there is a chapter covering Rolle's Theorem, the Mean-value theorems, and Indeterminate forms. Subsequent chapters cover functions of more than one variable, curvature, and curves with singular points.

The early chapters on the Integral Calculus deal in the conventional manner with the standard indefinite integrals which are developed from first principles and tabulated. Integration by "parts" is separately considered. After discussing the definite integral, integration as a process of summation is exemplified with numerous practical examples including lengths of arcs, areas of surfaces of revolution, moments, work, etc. Multiple integrals are dealt with in a separate chapter. Infinite series and tests for convergency and divergency are covered very fully in one of the later chapters, and the work closes with a chapter introducing the student to the solution of some of the simpler forms of Differential Equations. Answers to all the examples appear at the end of the book.

"Brown's Nautical Almanac, 1938". Brown, Son & Ferguson, Ltd., 52-58, Darnley Street, Glasgow, S.1, 3s. 6d. net.

The 1938 issue of this Almanac has been carefully edited to ensure accuracy in detail consistent with that comprehensive brevity which is essential in nautical works of practical utility. The nautical tables have been thoroughly revised and several new tables added, while the lights, buoys and beacons have again been carefully compiled and presented in a manner which should be acceptable to mariners. The port information section, which includes pilotage for British ports, has been extended and should prove of great utility to navigators. The technical articles on statutory regulations, meteorology, nautical instruments, etc., deal with modern requirements and are features of much value. Containing 795 pages, the Almanac is really extraordinary value for its modest price of 3s. 6d.

"Foundry Organisation and Management", by J. J. Gillespie. Sir Isaac Pitman & Sons, Ltd., 237 pp., 41 illus., 12s. 6d. net.

This is a valuable contribution on a subject which has not in the past received the attention which its importance merits. The contents of the book are presented in a manner such as to make most interesting reading and to convince the reader that the author is writing from first-hand knowledge. He has presented alternative points of view with lucidity and every endeavour has been made to bring the contents thoroughly in line with modern practice covering general principles of organisation and management, modern methods of labour selection and training, foundry layout, technical organisation, work planning, purchasing, estimating, and sales organisation, as applied to the large and small foundry. The chapters devoted to foundry costing are particularly complete. The novel addition of a chapter which the author refers to as the most important in the book, chapter 1, which covers social, economic, psychological and management principles, is of particular interest to the young student.

Produced on a sound logical basis, this is a welcome treatise for those who wish to acquire a general knowledge of the subject, and will be useful to the practical foundryman as well as to the theoretical reader. It is well printed and very commendably indexed; it is a book for easy reference and can be thoroughly recommended.

"Mechanics", by William F. Osgood, Ph.D., LL.D. The Macmillan Company, 495 pp., 157 illus., 21s. net.

The author, in his preface, claims that this book is adapted to the needs of a course in mechanics given for first year university men, and culminating in a full study of dynamics of a rigid body in two dimensions. He makes no apologies for availing himself to the fullest extent of that which the old Cambridge Tripos papers contributed to training in mechanics.

He begins very simply with the parallelogram of forces but quickly passes through statics and dynamics of a particle of a rigid body on to Lagrange's equations, Hamilton's equations, contact transformations, etc. In fact, it is a comprehensive survey of the subject suitable for a student reading for an honours degree in applied mathematics. The treatment throughout the book is entirely mathematical, and in the opinion of the reviewer only those with a profound knowledge of pure mathematics will obtain the fullest benefit from this textbook. It may be said quite definitely that this is a masterly book on mechanics, written by a mathematician, and as such it should find a place in the library of all teachers of mathematics. It is not suitable for use in technical colleges where students are preparing for National Certificates. The book is well printed and the text well laid out, the illustrations provided being clear and definite.

ABSTRACTS OF THE TECHNICAL PRESS.

The Seagoing Rhine Ships "Duisberg" and "Ruhrort".

The author gives some particulars of the first ships built for coasting in addition to river work, and discusses the conditions governing their principal dimensions. A ship drawing 11·5ft. can always reach Cologne, and can reach Mannheim during part of the year, although the maximum permissible draft below Mannheim is sometimes as low as 9·2ft. A deadweight of at least 1,000 tons is desirable for economic reasons for ships trading to London or Hamburg. Considerations of strength and freeboard fix a limit to the length and depth, consistent with 11·5ft. draft, of 220ft. and 14·8ft. respectively. This length is also near the limit for river navigation. Greater depth would reduce scantlings, but increase total weight, and hence reduce deadweight, and the increased hold capacity is not of great importance in this trade. The beam is not closely restricted, but should not much exceed 36ft., to avoid excessive stability when in ballast. Maximum speed is restricted not only by the impracticability of fining the form below about 0·7 block coefficient, but by the inability to use full speed in the river. The height above water in the ballast condition must not exceed 28ft. to clear the bridges. The two ships named have slightly less draft and depth, 10·5ft. and 14ft. respectively, with 34·8ft. beam, as they are intended to be able to carry a part cargo to Basle, where the depth of water is about 3ft. less than at Mannheim. They carry 1,300 tons. Strength is secured by a continuous trunk extending from poop to forecastle, in spite of the extreme proportions, and this construction keeps down the tonnage measurement. Ballast is carried in deep tanks forward and amidships. Two 400 h.p. Diesels give a speed of about 11 knots. The ships have triple underhung balanced rudders (illustrated).—*H. Volker, "Werft, Reederei, Hafen"*, vol. 18, p. 260-262.

Design—Form, Carrying Capacity, and Speed.

The author briefly states the conditions of hydrostatical equilibrium in smooth water, namely that weight must equal buoyancy and that the centres of gravity and buoyancy must lie on the same vertical line. He explains the manner in which undulations of the water surface, i.e. a swell or seaway, induce pitching and rolling and points out that considerations relating to the effect of wave motion largely determine the difference of the above water forms of sea-going and river vessels. Thus pitching, and the consequent large fluctuations of the drafts forward and aft, makes it necessary or at any rate desirable to provide sheer at the ends and the legal requirements regarding reserve buoyancy increase the vessel's ability to withstand the effects of rolling and taking over masses of water. The reserve of buoyancy may also be provided by deck erections subject to the condition that a seagoing vessel must possess a freeboard of 5 cm. (1·97in.) in salt water irrespective of the extent of the erections, which means that in fresh water the vessel will be immersed practically to the deck edge like a river vessel. One might conclude from this that a river vessel could be made seaworthy by the addition of erections, and this would be the case were it not for the fact that the changes of the vessel's position in a seaway induce considerable fluctuations of the hull stresses. These fluctuations in the stress condition, viz.: hogging and sagging, are absent in river vessels, with the result that those may be given a length/depth ratio of 20 or even more as compared with a maximum of 14 in sea-going vessels. The author further points out that the hatchways and coverings of seagoing vessels must be of much stronger construction than those of river vessels in which they merely serve to afford weather protection to the cargo or may be dispensed with altogether in certain services. Freeing ports must also be fitted in the bulwarks of seagoing vessels. From the point of view of speed performance the underwater form is of great importance in all cases. The above water form is of no importance in river vessels but it strongly influences the performance of seagoing vessels. The pitching motion in particular affects the speed and has a very unfavourable influence on the loading of the propeller and the engine. This motion can be reduced by making the vessel's ends V shaped, viz.: by flaring the sections and raking the stem forward and by fitting a cruiser stern aft. The propeller diameter must be kept small enough to prevent the screw from breaking the surface at small pitching amplitudes, especially in the ballast condition. The author considers that the propeller diameter should not exceed 70 per cent. of the ballast draft aft, and where as large a diameter as possible is desired with a view to high efficiency a large ballast draft aft may be provided subject to the immersion of the vessel forward being at least 3 per cent. of the vessel's length. The loaded vessel should not trim by the head, a trim by the stern of 15 cm. to 30 cm. (6in. to 12in.) in the departure condition being preferable, to provide as much reserve buoyancy forward as possible in a head sea. In coasting vessels one is further obliged to keep the machinery at the after end together with the fuel oil, fresh water and stores, the consumption of which will involve a tendency to trim by the head, and on long voyages the water ballast available in the after peak is not always sufficient to correct this. A vessel trimming by the head will also steer badly. *—L. Merhottein, "Technisch Vakblad voor den Noordelijken Scheepsbouw", September, 1937 No. 9; p. 3.*

Carbonisation of Lubricating Oils.

The author discusses in detail the bearing which the nature of a lubricating oil has upon the amount of carbon formed and the various methods of testing which have been devised to give an indication of the way an oil will behave when in an internal combustion engine cylinder. These may be divided roughly into three groups:—(1) Volatility tests based on the supposition that the more volatile the oil the less likely is it to yield carbon deposits; (2) coking tests founded upon the assumption that the oil is destructively distilled to coke; (3) tests put forward by workers who look upon the process in the cylinder so far as the oil is concerned as one primarily of oxidation and who argue that the oils which are least oxidised outside the cylinder will form least carbon within it. In the summing up of the discussion the following points emerge:—(1) Coking tests fail to indicate adequately the behaviour of the oil in the engine with relation to carbon deposition, and are useful mainly for sorting out oils of the same base, but arrived at by different blending. (2) Oxidation tests (e.g. by blowing the oil with air whilst it is maintained at an elevated temperature) are satisfactory only when straight distillates are concerned, and fail when oils are blended with residual cylinder stocks with the object of improving the viscosity curve. (3) The carbonisation index (the temperature at which 90 per cent. of the oil is distilled off under 1 mm. absolute pressure) gives a fair indication of the probable behaviour of the oil under working conditions, provided that the oil is not one which cracks easily. (4) Solvent refining of oils gives products which are less easily oxidised than oils refined by conventional methods, and which leave less carbon residue in the cylinder. Further work is still required, however, in order to develop a test which is easily carried out and which is of fairly satisfactory reproducibility. At present the coking tests and the various oxidation tests are generally used, but the limitations which have been mentioned are serious. If these can be overcome in some way users of cylinder oils, both in steam and in internal combustion engines, will be much helped.—*"The Engineer", Aug. 13th, 1937; pp. 176-178.*

Diesel Engine Fuel.

The writer observes that the fuel required for the variety of engine types now invading successfully the field of mechanical transport must be selected with almost as much care as that required for high duty carburettor engines. In a modern high-speed compression-ignition engine carburation occurs in the cylinder and after the period of delay required for the charge to become a mixture, with air, of fuel vapour and residual drops, auto-ignition occurs throughout a considerable volume because of this physical state and the high compression temperature. If now the delay period preceding auto-ignition is so long that an unduly large proportion of the charge reaches the physical state promoting rapid combustion before it ignites, then fuel knock will occur. A fuel is therefore required that in set conditions of compression, temperature, and time will vaporise sufficiently to form an inflammable mixture with air while part of it remains as residual drops to promote ignition. Thus, if the fuel is too "heavy" it will be nearly all drops with little inflammable vapour, if too "light" it will tend to vaporise completely, self-ignition temperature will be relatively high, and combustion if started will proceed with great rapidity in conditions leading to detonation. The light fuels of the carburettor engines are ruled out for the additional reason that the relatively low viscosity and high vapour pressure introduce difficulties in pump metering, on the accuracy of which the whole economy of the engine depends. To promote ignition in fuels which do not possess the property of inflammability in the requisite degree there are available such substances as amyl nitrite and ethyl nitrate and it has been shown that these in the concentration of 2 to 3 per cent. tend to eliminate fuel knock by shortening the delay period. The cost of thus "doping" Diesel fuel is, however, at present greater than that of selecting and blending petroleum fractions of the gas and lamp oil variety to provide smooth engine running. The writer discusses and commends the method of fuel rating proposed by Hetzel which consists in observing the compression ratio required to cause ignition just at top dead centre, the fuel being injected always at the same angle of advance. The fuel is then "rated" in terms of the blend of standard reference fuels requiring the same compression period for the fixed ignition delay period. The history of the development of the method of rating carburettor engine fuels in terms of a blend of iso-octane and heptane is thus repeating itself and the writer considers that this similarity may well be attributed to the Diesel tending to revert to the carburettor type of engine to satisfy the demand for a high ratio of power to weight.—*"Engineering", August 6th 1937; p. 153-154.*

The Increasing Complexity of an Engineer's Education.

Considering editorially the present position and further trends in the education of engineers, the writer sees cause for a considerable amount of thought and a certain amount of disquiet in the fact that in comparison with conditions obtaining sixty or seventy years ago courses of instruction have become greatly ramified and that they are spreading to an ever widening range of subjects. Not only have the advent of the internal combustion engine, of the turbine, and of electricity as a driving agent greatly enlarged the scope of the young engineer's studies, but he must also make himself acquainted with developments in fuel technology, metallurgy, reinforced concrete construction, hydraulics, geology, and aeronautics. In addition surveying and geodesy, workshop management, economics, and at least one foreign language are to be found in the curricula of certain centres. Apart from this the study of chemistry and physics must be pursued over a greatly extended range. Modern methods of instruction further increase the complexity. Lectures and private reading are no longer considered sufficient, laboratory courses, "drawing office work", geological and surveying expeditions commonly absorb well over half the hours covered by the official curriculum. Some relief from the consequences of all these developments would be afforded by a proportionate increase in the time allowed for it. The procedure adopted by many students of devoting an extra year to their studies cannot, however, be regarded as wholly satisfactory, for it is evident that within the framework of the existing three-year system the extra year must be devoted wholly or largely to a repetition of earlier studies which the student has failed fully to assimilate. The writer considers that such efforts as are being made by the Universities to deal with this problem are likely to produce either of two undesirable results, viz. : the average student would either be endowed with only a superficial knowledge of the scientific side of engineering or he would be obliged to curtail the invaluable formative part of his training represented by his period of apprenticeship. The writer agrees that the drafting of an engineering curriculum which would meet all requirements would almost certainly be an impossible task. But—he asks—would not the nearest approach to the ideal be found in a course of study which, concentrating on the full development of a few carefully selected subjects, would endow the student with the mental equipment requisite to enable him to familiarise himself rapidly with the special intricacies of the particular branch with which he subsequently becomes associated.—*"The Engineer", August 13th, 1937; pp. 181-182.*

A National Fuel Problem.

Commenting, in an editorial, on the question of the country's fuel supply in a national emergency, the writer observes that failure to solve this problem would threaten to stultify all the vast preparations now being made to restore the national defences. At the present time not only the Navy, the Army, the Royal Air Force, but also civil aviation and the widely ramified system of road transport depend on oil. In addition, 50 per cent. of the tonnage of the British Mercantile Marine is to-day committed to oil fuel either for boiler furnaces or internal combustion engines, and there is every indication that this percentage will continue to rise. From official utterances it appears that the Admiralty feels reasonably confident of the Navy's ability to safeguard its own oil supplies either by storage of reserves or by convoy of tankers. The writer finds it difficult to believe, however, that supplies sufficient for the needs both of the fighting services and the mercantile marine could be guaranteed in a war with a power possessing naval and air forces of commanding rank. He points out that it is the pressure of economic forces which impels British shipowners to turn from coal to oil and that, unless something is done to make coal more attractive as a technical and commercial proposition, we shall drift nearer and nearer to what may be a national disaster. The experience so far gained in the development of domestic sources of oil production is not very encouraging, quite apart from the fact that its expansion would involve the erection of inordinately expensive plants all over the country, which would provide inviting targets for hostile aircraft. Alternative methods for relieving the situation must therefore be sought and among these the writer considers the dual firing of marine boilers to be one of the most promising. Excepting very fast passenger liners there seems thus to be a good case for the proposal to equip merchant vessels with boilers capable of using either solid or liquid fuel at will. Another possible, if only partial, solution lies in the wholesale production and marketing of the so-called "colloidal" fuel which has been developed by the Cunard Steamship Company in collaboration with the Wallsend Slipway and Engineering Company. This is a blend of crude oil and powdered coal in the ratio 6 : 4, including a chemical element which keeps the coal dust in suspension and prevents the formation of sediment when the fuel is stored in bunkers or shore tanks. In a recent report of the Fuel Research Station of the Department of Scientific and Industrial Research doubts were raised as to whether the chemical problem involved had at that time—a year ago—really been solved. The new fuel has, however, been tried with excellent results in a number of Cunard-White Star ships, including the "Berengaria" and the "Aquitania", and the owners are satisfied that it can be burned in marine furnaces with greater economy than either of the constituents alone. The introduction of colloidal fuel, even if yet in an experimental form only, thus appears to open up possibilities which, in view of the gravity of the whole question of the national supply, deserves to be thoroughly explored.—*"The Engineer", 10th Sept., 1937, p. 285.*

Research at the William Froude Laboratory.

Some comparative tests on three models of a 400ft. cross-Channel steamer indicated that whilst at speeds below 24 knots an advantage could be gained in smooth water by adopting U-shaped fore-body sections, and at higher speeds by adopting V-shaped fore-body sections, there was no advantage in rough water in departing from the normal form. In a head sea, with waves 6ft. high, the increase in water resistance was 5 per cent. at 17 knots, falling to 3 per cent. at 25 knots. The increase in resistance due to air drag at the corresponding wind speed of about 20 knots would be approximately 9 and 2 per cent. respectively at the two speeds. An approximate relation between wind speed and wave height is: wind speed $= 8\sqrt{\text{wave height}}$. A wind speed of 20 knots, with waves 6ft. high, represents average rough-weather conditions, according to a series of observations at sea. The performance data obtained in these observations, carried out on ships ranging from Atlantic liners to tankers, are summarized in the table.

help in this respect. Some tests have been made on the best form of ship's lifeboat for dryness in a rough sea.

An analysis of frictional resistance data is being carried out with a view to improving the extrapolation to full-scale. Work on the calculation of waves-resistance is proceeding, and the advantage of a particular form which should theoretically have a low resistance has been verified, subject to the qualification that increased form resistance nullifies the gain at the lower speeds. The effect of bow contour in the case of a form of 9·78 prismatic coefficient is being investigated, both from the the resistance and propulsion point of view. Coaster forms are being studied, particularly the effect of a cruiser stern, and of increased propeller r.p.m.

COMPARATIVE DATA UNDER "AVERAGE" CONDITIONS OF ADVERSE WEATHER.

Name of ship.	Block coefficient.	Ratio: shaft horse-power. / displacement.	Loss of speed due to adverse weather. (Knots).	Additional power (per cent.) required to maintain smooth water speed.	Power absorbed (per cent.) By wind.	By rough water.
Berengaria ...	0·60	1·27	1·0	13	3	9
Montcalm ...	0·71	0·48	1·1	25	10	12
London Mariner...	0·73	0·33	1·05	24	9	10
Oroya	0·70	0·38	1·1	29	11	12
Oropesa	0·745	0·28	1·35	33	10	19
San Alberto ...	0·742	0·23	1·7	50	13	24
San Tirso ...	0·785	0·12	2·15	91	7	42
San Gerardo ...	0·83	0·17	3·7	224	16	53

The loss of speed due to rough water can be minimized in full ships by reducing the bow angles and easing the shoulders fore and aft of the parallel body, according to tank tests. Part of the loss in speed is due to falling-off in propeller efficiency with increased slip, and there is a further drop due to slowing-down of the engine, with consequent decrease in power. A design of engine which permits the torque to be increased to counteract the effect of lower r.p.m. gives better maintenance of speed, and an adjustable-pitch propeller would also

As regards vibration, the conclusion is being reached that whilst for flush-deck and similar types agreement between calculated and observed frequencies can be obtained, in other types the stiffening effect of discontinuous superstructures tends to raise the frequency above the calculated value.—*"Engineering", 3/9/37, p. 263-4.*

EXTRACTS.

The Council are indebted to the respective Journals for permission to reprint the following extracts and for the loan of the various blocks.

Welded Steam Pipe Lines.

"Shipbuilding and Shipping Record", 2nd September, 1937.

Perhaps one of the greatest difficulties associated with the use of high-pressure, high-temperature steam on board ship is the design of the flanged joints. The pipe line itself represents a comparatively simple problem, but at the joints not only do thick and heavy flanges have to be employed, but to ensure steam tightness, heavy bolts, very closely spaced, must be used. Further, in view of the fact that high superheat temperatures are generally associated with high initial pressures, a thick covering of insulating material is necessary at the joints which tends to make them bulky in the extreme. It is apparent that the use of welding will eliminate all these objections, and realising this, engineers have for many years past been studying the problem of producing the all-welded steam pipe line. This is particularly the case in the United States.

From accounts published in the American Technical Press, we gather that in one particular power station, the arc-welded system has been adopted for main and auxiliary steam lines operating at 650 lb. per sq. in. and 850 deg. F., and for the feed water lines where the pressure is 900 lb. per sq. in. and the temperature 500 deg. F. It may be noted in passing that the first part of this installation has been in operation for more than two years, and as each successive section has been completed there has been an appreciably greater use of welded piping. In the main superheated steam line, there are no bolted joints between the superheater-header outlet and the turbine stop valve, intermediate valves being welded into the line, while, in order to obviate any need to remove them—which could only be done by cutting them out—the valve seat rings are welded in place before the final heat-treatment of the bodies, to prevent leakage past the seats when in service. The pipe-to-pipe and pipe-to-valve joints in pipes $2\frac{1}{2}$in. diameter and upward are of the circumferential butt type, split steel backing about 2in. wide fitted inside the pipe being used. For wall thicknesses not exceeding $\frac{1}{2}$in., the pipe ends are formed with a simple vee-bevel, having a total included angle of 90 deg., but for greater thicknesses a bevel is used giving a greater width at the roof of the weld and in both cases, the centre of the weld is built up to a thickness about 20 per cent. greater than that of the parts being joined. For the smaller pipes, fillet joints are used, an external sleeve being employed for pipe-to-pipe joints, the pipe being recessed into the fitting for other joints. In the construction of branch pieces, a fabricated welding system has been adopted.

The actual welding process was carried out with direct current, shielded arc electrodes being employed having a mild steel core of 0·1 to 0·15 per cent. carbon content. It was specified that there must be at least one layer per $\frac{1}{8}$in. of pipe thickness with a minimum of two layers. The surface of each layer had to be thoroughly cleaned before depositing the next layer, pneumatic tools being used for this purpose. It is apparent that special attention must be given to the question of welding stresses, and in this kind of work a sort of local annealing process was adopted. Finally, it may be mentioned that the power company in question trained its own operators for this kind of welding work.

Castings or Forgings.

"Shipbuilding and Shipping Record", 9th September, 1937.

There are very many reasons why, apart from strength consideration, the engineer would invariably choose a casting in preference to a forging for any particular job. In the first place, a casting can be made to almost any desired form, whereas there is definitely a limit to the complications which can be included in the shape of a forging. Secondly, for similar patterns, the casting will always be far cheaper to produce than the forging, and, thirdly, the cost of machining the former will always be considerably less than that of the latter. In spite of all this, however, there are very many parts in the construction of a marine engine and its auxiliaries where a casting cannot safely be employed and a forging has to be specified instead. Thus, where the material is subjected to the continued effects of high temperature, or where even at normal temperatures excessive tensile stresses have to be resisted. Again, where a complex system of fluctuating stresses is encountered calling for a maximum resistance to the effects of fatigue, cast iron in its ordinary forms is of little practical value. For these and for other reasons which might be mentioned, the more expensive forging has to be employed in preference to the cheaper and far more convenient casting. Metallurgists have for many years been working on the problem of improving the qualities of cast iron and of developing a more exact foundry technique, but while considerable progress has been made, what may be termed commercial cast iron is still in many respects a very inferior material to commercial steel.

It is an unfortunate scientific fact that the greater the purity of iron, the poorer are its casting qualities and the lower is its strength; and to surmount the disadvantages implied in this statement, the metallurgist has had to have recourse to the process of alloying some of the rarer metals with iron in order to obtain greater strength, resistance to high temperature and so on. This method of procedure has already been carried to great heights in the production of high-grade steels, and now attention is being directed to the problem of producing alloy cast irons which while having improved physical and mechanical properties will not lose the very desirable property of "castability". In order to determine what could be produced in this direction a co-operative research committee was formed comprising representatives of the British Cast Iron Research Association, the Institution of Automobile Engineers and various industrial firms, and an investigation was put in hand at the National Physical Laboratory with a view to obtaining an alloy cast iron suitable primarily for the production of crankshafts, although it is obvious that if the material can be found which is capable of being cast and which in addition can withstand the complex system of fatigue stresses met with in the crankshaft of a motor-car engine, it will have many additional applications in engineering design, where the conditions are perhaps not so severe, but where steel is at present being employed. The results of this investigation, which has extended over a period of nearly two years, were embodied in a paper by Dr. H. J. Gough and Mr. A. V. Pollard entitled "Properties of Some Materials for Cast Crankshafts, with Special Reference to Combined Stresses", which was read at a recent meeting of the Institution of Automobile Engineers.

Some idea of the extraordinary properties of these alloy cast irons can be gathered from the data given in the paper, although, of course, this must necessarily be regarded as only an indication of the suitability of the material for any particular application. In all, five commercial alloys were investigated, the alloyed metals including copper, nickel, chromium and molybdenum, and three of them were tested in the as-cast condition. The usual static tensile and torsion tests were carried out and, in addition, the resistance of the materials to fatigue stresses was measured with the aid of a new type of high-speed combined fatigue stress testing machine which has been designed at and installed in the National Physical Laboratory. Space will not permit of a detailed survey of the results obtained, but it may be noted that ultimate tensile strengths were obtained ranging from 18·8 tons per sq. in. for nickel-chromium iron up to 32·3 tons per sq. in. for copper-chromium iron. Under reversed-bending stresses the endurance ratio—which is obtained by dividing the fatigue limit by the ultimate tensile strength—was in the region of 0·55 for all the irons tested, and this value, as the authors state, would be considered normal for high quality ductile steel.

New Hull Form for Fast Ships.

(From a special correspondent).

"Shipbuilding and Shipping Record", 30th September, 1937.

Considerable secrecy has surrounded the construction in a Northern shipyard of a vessel with new hull-lines which, it is claimed, will exceed 40 knots. I have been able to obtain from an authoritative source details of certain characteristics of the ship, though these are admittedly incomplete, and also particulars of some model-tests which were recently carried out.

The new ship is a motor-cruiser, 110ft. in length, the beam being 15ft. The draught is not disclosed, but it is emphasised that the design has nothing in common with the hydroplane or the skimming boat. She will be driven by two high-speed Diesel engines of 1,000 h.p. each, and the designed speed is 45 m.p.h. The radius of action will be 1,500 miles.

The designer's aim has been to reduce skin-friction to the lowest possible extent, and to this end the hull is so devised that when moving at high speed the bows of the vessel are lifted dynamically, but the stern does not settle down in the water as with other ships, but is actually lifted vertically to some extent. There is no visible bow wave and no stern wave.

The practicability of the design was demonstrated in the model tests. Owing to the high speed developed, these could not be carried out in an experimental tank, so special permission had to be obtained from the London County Council for the runs to be made on a big lake in one of the London parks. The model hull was built to scale, but the engine used was an ordinary toy petrol-engine of 30 cc. capacity and about 1 h.p. This was far smaller in proportion than the engines building for the ship herself. The average speed over a series of runs was 25·8 m.p.h., and at one time it exceeded 28 m.p.h. (Model boat racers do not reckon in knots.) The tests were supervised by an expert in motor-boat racing, who was convinced by thirty years' experience that no model could travel at more than 15 m.p.h., owing to the drag at the stern. At 16 m.p.h. and more, every known model is pulled under and goes to the bottom stern first, owing to the drag. Nothing of the sort happened at these tests. The model remained on an even keel throughout the circuits of the lake, she made no external bow wave and very little wash. The tests were recorded by cine-camera and I have been privileged to see the pictures.

The inventor of the new hull form, Mr. F. Gordon Pratt, M.I.N.A., though he declined to disclose many details of the new ship, told me that it would be possible to build an Atlantic liner to this design which would travel at 40 knots without increase of the power installed in existing ships, and that destroyers could be built which, with to-day's engine power, would move at 70 knots. More important, however, is the saving in engine space and weight and in fuel consumption, which he foresees.

Dew Point.

"Shipbuilding and Shipping Record", 7th October, 1937.

The term dew point usually suggests something which comes within the province of the meteorologist or the physicist, certainly it is not regarded as being a term of practical importance to the marine engineer. Actually, however, it may be considered as the danger signal which gives a very clear warning of the possible incidence of corrosion. The physicist defines dew point as that temperature at which moisture begins to appear in a vapour, or, in other words, the temperature at which the same chemical substance can exist in both the liquid and the gaseous state. Applying this to the chemical substance H_2O, and remembering that the presence of moisture can be regarded as an essential to chemical action, and that, provided certain other substances are also present, the existence of moisture represents the starting point of corrosion, then the importance of a knowledge of the dew point will at once be understood.

In the steam engine, the dew point is that temperature at which, during the process of expansion, moisture begins to appear in the steam, and in the non-superheat engine, even assuming that the steam is 100 per cent. dry when it enters the cylinder, as soon as expansion begins, the fall of pressure is accompanied by a fall of temperature and water is formed, the dew point being identical with the saturation temperature. The older generation of marine engineers is thoroughly familiar with the phenomenon of water formation in steam pipe lines and cylinders and, apart from the loss of efficiency due to the existence of this moisture, he was always eager to eliminate it because any undue accumulation might lead to water-hammer with possibly disastrous effects. The adoption of superheating has, among other advantages, led to a very substantial lowering of the dew point, the exact figure depending, of course, upon the initial superheat temperature employed, and thus in the high-pressure and, generally speaking, the intermediate-pressure, cylinders the steam remains perfectly dry. But it is not practicable to utilise so high an initial temperature for the steam that it will remain dry throughout the expansion right down to condenser pressure; in other words, sooner or later a dew point occurs, and at this point particularly in turbine installations, the evil effects of the presence of moisture are at once apparent. In large turbine installations on land, these effects are overcome by the process of re-heating the steam at the appropriate point, which is usually the receiver pressure between the intermediate- and the low-pressure cylinders. This idea has not so far, we believe, been tried on board ship, but experience on land has shown that it not only eliminates the evil effects of moisture in the l.p. cylinder, but yields a substantial increase in efficiency as well.

But a knowledge of the dew point is not only of importance in steam-engine operation, it is a matter of some concern on the combustion side of the installation. Every fuel, whether solid or liquid, contains a certain proportion of hydro-carbons, and the hydrogen during the process of combustion is converted into H_2O. Normally, owing to the high temperature of combustion, this H_2O will exist in the state of highly superheated steam. In the internal-combustion engine there is no likelihood of the dew point occurring in the cylinder itself, but during the passage of the exhaust gases through the silencer and up the funnel, since the pressure is only slightly above that of the atmosphere, if they come into contact with any surface at or below a temperature of 212° F., some of this H_2O will become water and depositing on the surfaces in question may set up active corrosion. This will be particularly the case if the fuel contains a certain percentage of sulphur, since this, as a result of the combustion, is converted into gaseous sulphur dioxide (SO_2) and in the presence of moisture and excess air, this gas may ultimately become sulphuric acid. A similar series of reactions takes place in the furnace of a steam generator, and here also, when the flue gases come into contact with the cool surfaces of air heaters, economisers, etc., active corrosion is liable to occur. It is impossible to eliminate this moisture, but the point can always be kept in mind when considering the lay-out of exhaust systems and uptakes, that low-temperature surfaces should be avoided. It is also of advantage to choose a fuel having as low a sulphur content as possible. The question of dew point is also of considerable importance to the refrigerating engineer, but here we are concerned with that temperature at which moisture settles out from the atmosphere.

A New Dual-fuel-burning Diesel Engine.*

By John W. Anderson.

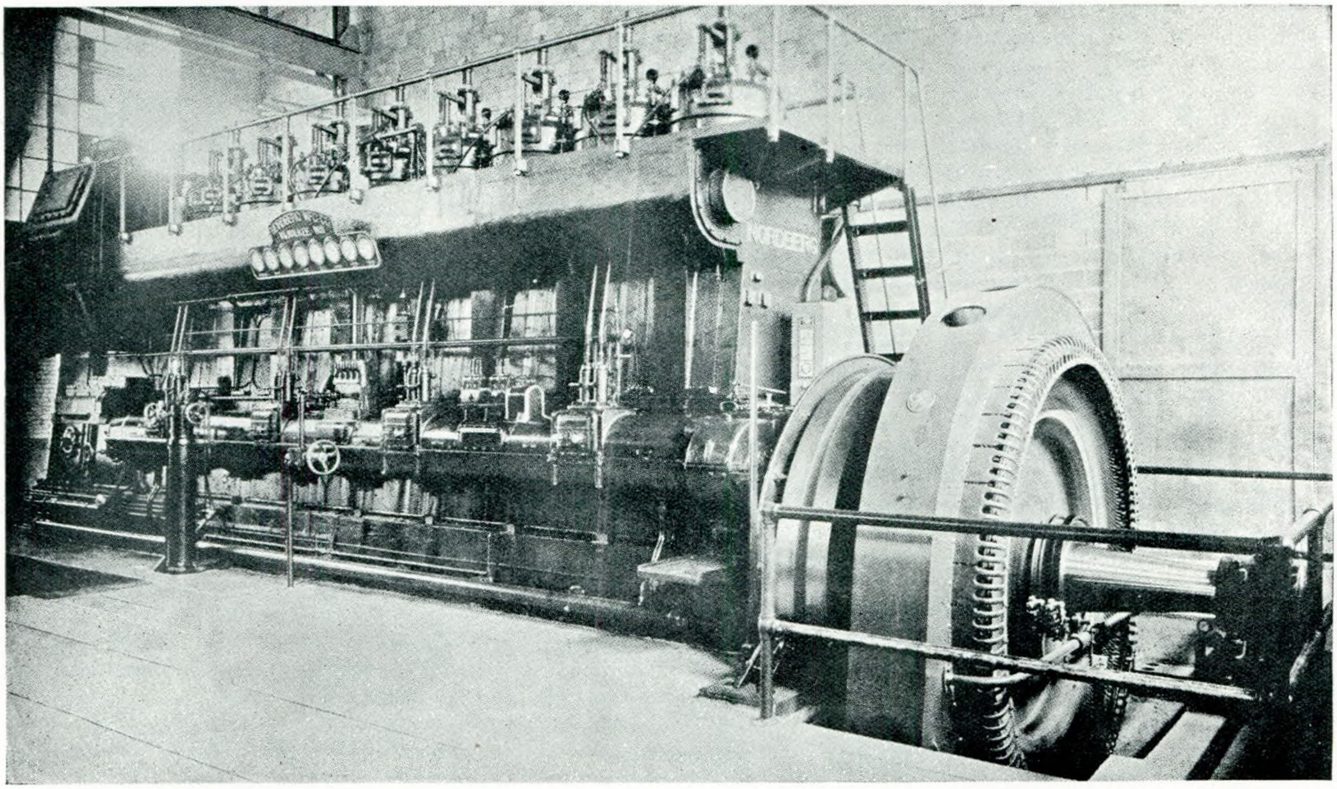
"Gas and Oil Power", August, 1937.

Diesel engines have universally come to be associated with the use of liquid petroleum non-volatile fuels. Numerous attempts to use other fuels have never become widely used commercially; in fact many of the attempts have never gotten beyond the experimental stage. Similarly, the use of natural gas as a fuel is associated with low compression engines using spark ignition and working on the explosive or Otto cycle. So when an engine is developed that uses natural gas as fuel, works on the diesel cycle, and does it commercially, it is something novel—it is news.

Convertible engines.

Many engines are made to be convertible for the use of either natural gas or liquid fuel; that is to say, convertible from a gas engine to a diesel engine. But in all such cases, the changeover requires the substitution of such major parts as the cylinder heads or pistons (and sometimes the cylinders are changed), to say nothing of the different parts needed to handle the difference in fuels. In contrast, this

* From the August issue of "Diesel Progress", New York.



The dual-fuel-burning Nordberg diesel installed at the Lubbock plant.

Nordberg engine makes no changes in the major parts of the engine and very few other details need attention, but it does involve the use of the air injection type of diesel.

Although this engine is called a dual-fuel-burning diesel engine, it is essentially a natural gas burning diesel engine. A small amount of diesel fuel is also used and injected at every working stroke, but this is a "pilot charge" employed for smoother combustion and amounts to only a small percentage of the total fuel.

Injection arrangements.

The method of operation of the injection system is well shown in the accompanying diagram. The engine itself is of the two-cycle, air injection, diesel type, with the piston scavenging pump and the three-stage air compressor at the end of the engine opposite the flywheel. The general view of the engine shows the eight working cylinders with the scavenging pump and compressor beyond, and also the camshaft running along the front of the engine at a convenient height above the floor level. As a diesel engine this shaft is used to drive the fuel pumps and operate the spray valves in the cylinder heads by means of the tension rods extending up to them.

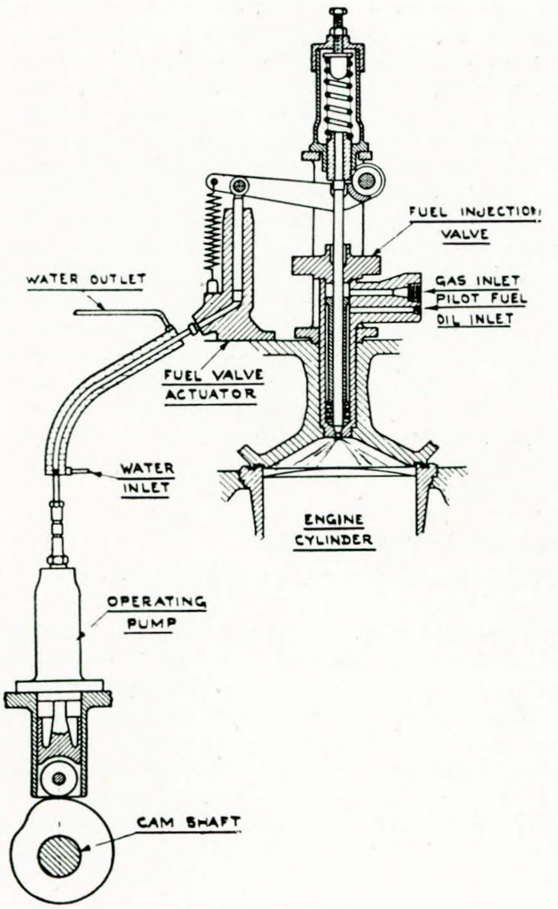
As a gas engine, the camshaft still drives the fuel pumps, but they are no longer fuel pumps, rather they are hydraulic pumps for operating the spray valves. This method substitutes the direct governor control of the fuel pumps used on the diesel for the control of the spray valves on the gas engine. In other words, the normal way of controlling the diesel is to vary the quantity of fuel fed to the spray valves, accomplished by the governor control of the fuel pumps. But in the gas engine, the control of the fuel is by varying the time the spray valve is open, and this is done hydraulically.

The natural gas fuel is compressed in the engine compressor to about 1,100lb. per sq. in., and enough of it is handled to supply the load requirements and maintain a nearly constant pressure at the spray valves in the cylinder heads. This compressed gas is supplied to the valves through the regular air injection piping so that no changes are needed for these parts.

But the mechanical operating mechanism for the spray valves is removed, and substituted for it are the fuel valve actuators and levers for lifting the spray valve, plus the high pressure tubings between the former fuel pumps and the fuel valve actuators. In addition there are fuel pumps added for supplying the pilot fuel, one pump for each cylinder. However, no quantity control over these pumps is needed since the same amount of pilot fuel is used regardless of engine load.

Injection valve operation.

Lubricating oil is used in the piping between the operating pumps (the former fuel pumps) and



Injection arrangements of the Nordberg dual-fuel engine.

the fuel valve actuators, and the tubing is water jacketed so as to maintain as even a temperature as possible in the operating fluid. The action of these operating pumps is to deliver into the tubing a certain quantity of fluid, that builds up a pressure in the valve actuator and lifts the spray valve. When the operating pump releases the pressure, the spray valve is promptly closed by the springs. It is obvious that the greater the quantity of fluid delivered into the tubing, the higher the spray valve lift and the longer it remains open; thus the greater the quantity of gas fuel injected into the working cylinder. But this action of the operating pump is precisely the behaviour of the same pump acting as the fuel pump on the normal diesel engine under the control of the same governor.

Pilot fuel.

The action of the pilot fuel oil is as a combustion stabilizer. During the development of this method, the experiments showed the necessity for it in order to get good mixing of the fuel and air in the combustion chamber and a smooth combustion. Patents have been granted the Nordberg company for the use of this pilot fuel and the burning of the natural gas fuel on the diesel cycle.

The results of this method are interesting and the chart* shows the performance under test of the first of these engines as installed at Lubbock, Texas. It should be remembered that Lubbock is at 3,200 ft. elevation. Rated at 1,500 h.p. at full load, the curves show the performance from one quarter load upward. The decreasing percentage of total heat contributed by the pilot fuel and the flatness of the fuel curves between half and full load are shown.

The performance of this engine in service is no less interesting. The nine months record is given in the tabulation of operating figures. During this period, the engine was operated on base load service and the load factor over the entire period was about 75 per cent. The variations in station load were taken by the diesel engines in the station using regular diesel fuel. As the figures show, the gas engine ran almost all of the time. In none of the months was this engine shut down more than a total of a few hours, and the average operating time over the entire period was 98·5 per cent. of the total hours in that period. This reliability record speaks for itself.

* Not reproduced.—[Ed. "G. & O.P."]

NORDBERG DUAL-FUEL ENGINE.

NINE MONTHS OPERATING RECORD.

Date 1936-37	kW. hours generated.	Gas used 1,000 cub. ft.	Gas cub. ft. per kW. hr.	Cost of Fuel. Gas.	Cost of Fuel. Pilot oil.	Cost of Fuel. Total.	Fuel cost per kW. hr.	Gals. lub. oil used.	Engine h.p. hrs. per gallon.	No. of hrs. run.	No. hrs. in month.	% hrs. on Line.
Sept. ...	535,700	5,813	10·88	$831·50	$133·36	$964·86	$·00180	216	4,920	708	720	98·25
Oct. ...	553,600	6,101	11·02	844·54	139·68	984·22	·00178	192	5,780	742	744	99·75
Nov. ...	528,100	5,831	11·03	803·50	135·24	938·74	·00178	186	5,790	718	720	99·75
Dec. ...	560,800	6,277	11·20	816·01	139·20	955·21	·00171	193	5,740	739	744	99·50
Jan. ...	535,700	5,912	11·03	768·56	134·10	902·66	·00169	186	5,750	713	744	96·0
Feb. ...	503,200	5,383	10·70	699·79	125·45	825·24	·00164	179	5,580	666	672	99·5
March...	560,600	6,122	10·92	795·86	139·20	935·06	·00167	211	5,250	739	744	99·5
April ...	547,800	6,175	11·38	802·75	134·80	937·55	·00172	198	5,420	715	720	99·5
May ...	560,900	6,321	11·29	821·73	136·00	957·73	·00171	212	5,120	722	744	97·0
Total ...	4,886,400	53,935	11·05 average	$7,184·24	$1,217·03	$8,401·27	$·00172 average	1,773	5,483 average	6,462	6,552	98·6 average

Total kW. hrs. generated	4,886,400	B.Th.U. content of pilot oil	19,200 per lb.
Total cub. ft. gas consumed	53,935,000	Cost of gas	13 to14 cents per 1,000 cub. ft.
Average cub. ft. gas per kW. hr.	11·05	Cost of pilot oil	4 cents per gallon
B.Th.U. content of gas	975 per cub. ft.	Total B.Th.U.'s per kW. hr. generated	11,670

The showing made by these figures brings out the reasons for adopting this combination—the use of natural gas fuel in a diesel engine. Lubbock has had a municipally-owned diesel power plant for many years. As the city has grown and the load has grown, it has been necessary to install larger and larger engines. Even before this new gas-diesel engine was installed, there was a 1,250 h.p. and a 1,500 h.p. engine, both of them two-stroke cycle air injection crosshead type Nordberg diesels. This last engine is similar to the 1,500 h.p. diesel already there.

Operating costs.

But natural gas at low rates, 13 and 14 cents per 1,000 cubic ft. in the quantities used, became available and a means was sought to gain the advantage of this and lower the cost of generating power. As shown by the tabulation, the cost of fuel in the new gas-diesel engine has been proven to be 1·72 mills per kW./hr. While the station records show that the diesel engines using fuel costing 3·1 cents per gallon gave a fuel cost of 3·2 mills per kW./hr. This saving of 1·5 mills per kW./hr. amounts to 46·2 per cent. on a percentage basis, but it is an important reduction in mills cost and in overall cost of power.

Another item shown by the operating record tabulation is the economical performance on lubricating oil. This of course comes from the mechanical construction of the engine and has nothing directly to do with the use of gas as fuel. The crosshead type of construction brings a separation of the cylinders from the running gear in the crankcase and a control over lubricating oil consumption, with beneficial results. The table shows a consistent performance over the entire period recorded.

This brings out another point in connection with operating reliability and cost. The heat and fuel consumption figures, the efficiency percentages, the exhaust temperatures, all show a normal performance as for the same type of diesel engine. There is no indication of anything abnormal or especially different from the diesel. This confirms the normalcy of the lubricating oil consumption figures and indicates that other items of operating cost should be the same as for the same engine as a diesel. Costs for such items as cooling water, supplies, and the important one of repairs should be the same. There is nothing about the gas operating mechanism that should give any operating difficulties, any increased cost of operation, nor require any added attention from the operating crew.

As far as operating behaviour is concerned, these engines are as responsive as any diesel engine using liquid fuel. The reason for using this engine on the base load at Lubbock is its operating economy. It was naturally desired to take full advantage of this.

The field for the use of engines of this type is where there is an abundance of natural gas available at low cost, especially as compared with the cost of suitable liquid diesel fuel. There is the additional advantage, however, that should there be an interruption to the supply of natural gas, or should the price differentials between natural gas and fuel oil change, the engine can be readily and rather quickly converted to the normal type of diesel engine. It is a versatile power unit, capable of using a choice of fuels; the choice depending upon the relative costs. And these costs can be figured confidently beforehand, because the unit costs and consumption of fuel are known and other cost items are independent of the fuel used.

The Nordberg company is prepared to furnish other sizes of this same type within the range of 750 to 3,000 h.p. per unit; but as gas engines, there is a reduction of about 10 per cent. in the power developed.

Taper-sided Piston Rings.

An interesting Wellworthy development is discussed.

"Gas and Oil Power", August, 1937.

Improved forms of piston ring have occupied the attention of designers for some considerable time and, as readers are aware, many interesting modifications of the ordinary Ramsbottom ring have been evolved for use in diesel and other internal-combustion engines. Most of the improved rings which have attained commercial success are of the duplex type, although the new development which we are about to describe is a single ring of normal form apart from a single departure from ordinary practice—a departure, in passing, of the greatest interest.

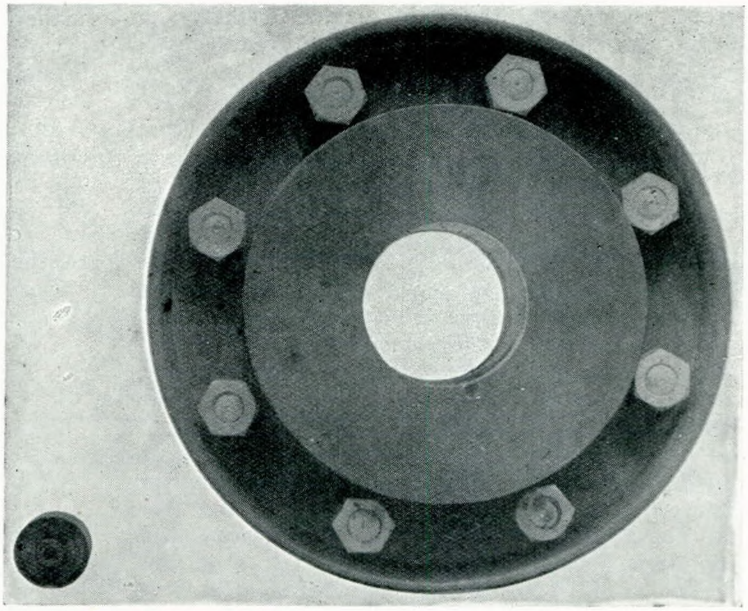
Following a study of the problem of ensuring ring freedom over long periods irrespective of the difficulty of operating conditions, Wellworthy Piston Rings, Ltd., Lymington have carried out experiments with taper-sided rings. We recently approached the firm for information on this new development and we understand that they have made rings of this type for various engines of cylinder size ranging from 6in. to 22in. in diameter.

Commenting upon this new development, Mr. F. Blackith, the technical manager of Wellworthy Piston Rings, Ltd., writes:

"It will be readily appreciated that pistons, no matter how well fitted into the cylinder bores, must move across from thrust to non-thrust wall of the cylinder at the top and bottom of the stroke, the amount of movement varying according to the temperature of expansion of the piston in the cylinder. When running at full power the pistons of an engine should, as near as it is possible, completely fill the cylinder and the movement mentioned above is, at such times, of course, very small, but at other times when this clearance increases the rings are carried with the movement of the piston and blow-by takes place, which raises the temperature of the rings. This, in our opinion, is very largely responsible for the formation of carbon around the rings, ultimately causing them to stick in the grooves.

"It has been found, however, that by providing rings with the sides at a very slight angle to the axis of the piston, the actual angle, by test, proving to be about 5 degrees, it is found that as the piston moves from the non-thrust to the thrust and *vice versa,* the ring is not carried with the piston, but tends to slide down the side of the ring groove, maintaining at all times a definitely positive contact both with the side of the ring groove and with the cylinder wall.

"Reduction in gas blowing past the piston fitted with these rings is most marked, and up to the moment of writing we have never heard of a case of one of these rings sticking in its groove, and we would mention in passing that on one particular 8½in. bore engine under certain conditions of running it is possible to stick any piston ring which has been fitted in a matter of five to six hours, but when fitted with a taper sided ring both sides of the ring being tapered to an included figure of 10 degrees, then after 150 hours' running it was found that the ring was absolutely clean and free from carbon, as also was the groove, and although this engine has been running for some considerable time since the rings were fitted these are still perfectly free, which we think is conclusive proof that the taper sided ring is worth a very thorough investigation by anyone who may have engines which suffer with rings being stuck in the ring grooves".



The larger of these couplings can transmit 250 b.h.p.

Silentbloc Couplings for High Powers.

"Gas and Oil Power", August, 1937.

The use of rubber for flexible and cushion couplings is proving its value in a wide variety of duties, including mountings for diesel engines and in flexible couplings between diesels and pumps, etc.

Some idea of the range of sizes now available is evident from the illustration. The smaller coupling shown is of the flexible type and while it by no means represents a limit to size at this end of the scale, it makes a useful comparison with one of the large cushion type couplings suitable for transmitting 250 b.h.p. at 100 r.p.m. The diameter of this coupling is 21in. and it is bored for shafts of 7in. and 5¾in.

Rubber in Tension.

Both types of couplings employ the Silentbloc method of construction, so that the rubber is constantly in tension and consequently it does not perish, nor can wear or deterioration take place on account of the presence of dirt and water. Oil, too, appears to have very little effect upon rubber which is handled in this manner. This was recently demonstrated by cutting a Silentbloc bush after it had been working for a continuous period of five years in particularly arduous service, and amid conditions calculated to create rapid deterioration. Examination showed the rubber to be equal to new except for minute surface cracks at the extreme ends, which in no way reduced efficiency.

A Converted Vessel on Lake Zurich.

An interesting starting arrangement is used in the S.L.M.-Winterthur-engined "Thalwil".

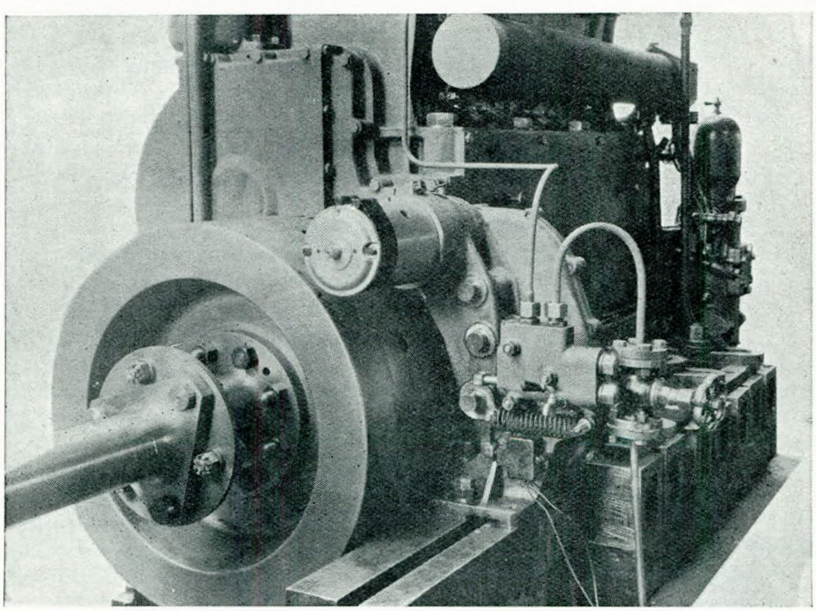
"Gas and Oil Power", September, 1937.

In view of the various articles which we have published during the past two years on the subject of starting arrangements for small and moderate-sized diesel engines, the starting arrangements which we recently saw on the small motorship "Thalwil", operating on Lake Zurich, are of especial interest. This boat, incidentally, was steam driven until some 18 months ago, when the Steam Ship Co. of Zurich re-engined and modernised her at their own establishment at Wollishafen.

With a view to increasing the speed of the vessel she was lengthened by some 6 or 7ft., in the interests of economical propulsion at the rather higher speed required, and is now about 66ft. long between perpendiculars. The bows have been redesigned and rebuilt by the owners' own staff, and the steam engine has been replaced by a three-cylinder four-stroke cycle airless-injection diesel engine of 130 b.h.p. at 500 r.p.m. This engine was supplied by the Swiss Locomotive and Machine Works of Winterthur, and is one of their standard totally-enclosed marine propulsion units, in which, it may be recalled, the main framing is open at the front, with easily removable frame members, in order that the engine crankshaft may be removed and replaced without difficulty.

The starting air compressor, cooling water pump, bilge pump, forced lubrication pump, and fuel transfer pump are driven off the forward end of the engine. Driven by means of Vee-belts off the shaft between the engine and the S.L.M.-Winterthur oil-operated reverse gear is the lighting dynamo. This dynamo supplies current to two batteries connected in series and having a total capacity of 100 ampere hours. The three-bladed propeller is interesting in that the blades are adjustable for three different pitch positions. Such adjustment, however, can only be made when the vessel is in dock.

Control of the engine, including starting, is effected from the wheelhouse and is particularly interesting. Starting of the engine is by compressed air but as it is a three-cylinder four-stroke cycle unit it is, of course, not possible to start it from any position. Accordingly, there is a small starting motor which gears with the toothed rim of the flywheel, as shown in the accompanying testbed illustration of the engine, there being a suitable device alongside the flywheel for automatically admitting the starting air into the cylinders as soon as the electric motor has brought the engine into the starting position. Simultaneously, of course, current is cut off from the starting motor. The whole sequence of starting operations is performed by a small lever in the wheelhouse and subsequent speed control is carried out by means of a hand wheel on the bridge, while a second lever operates the hydraulically-controlled reverse gearbox. There is a vertical governor driven off the camshaft and further speed control of the engine between specially wide limits is effected from the wheelhouse through chain gearing to the governor. The customary tachometer and other gauges are located on the bridge and the whole control arrangements have worked most satisfactorily, thus enabling one man to control the vessel with ease. The economy and speed of the re-engined vessel are much superior to the results obtained with steam drive and the trials gave results which were a satisfactory improvement over the guarantees in respect of speed and manœuvrability.



Showing the special starting motor for bringing the S.L.M.-Winterthur engine of the "Thalwil" to the position where starting air can be employed.

More Motorships with Electric Couplings.

Details of Asea electro-magnetic slip couplings installed in the "Dagmar Salen", "Astrid Thorden" and "Astri".

"Shipbuilding and Shipping Record", 2nd September, 1937.

As a means of transmitting the drive from high-speed diesel engines to the comparatively slow-running propellers of cargo vessels, the Asea electro-magnetic slip coupling, in conjunction with suitable reduction gearing, offers many advantages.

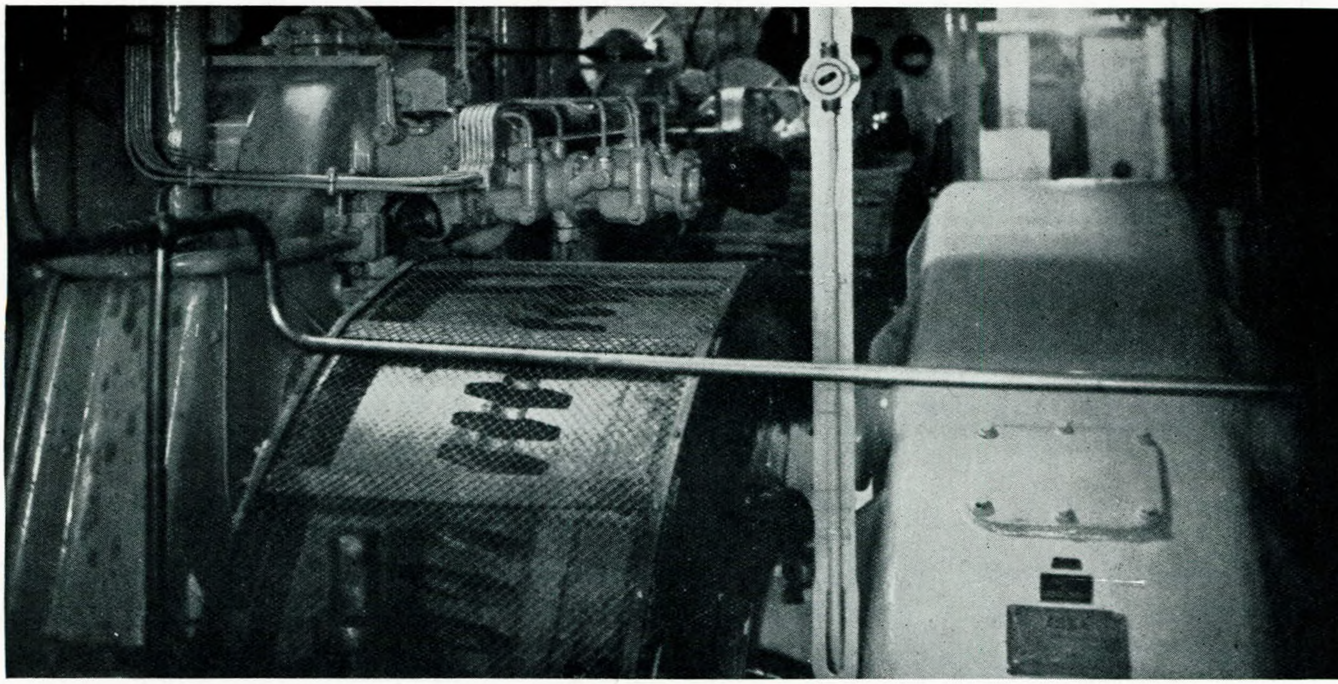
The first vessel to be fitted with these couplings was the "Werna", built by Oresundsvarvet A/B., Landskrona. This vessel was the first of four similar ships built for the Stockholms Rederi A/B., Svea, and drawings and a description of the vessel were published in "Shipbuilding and Shipping Record" of April 22nd and July 15th, 1937.

In the "Werna", the propelling machinery consists of two sets of two-stroke Atlas diesel engines coupled through Asea electro-magnetic slip couplings to reduction gearing, driving a single propeller shaft. On trials a speed of 13·5 knots was obtained with two engines running, while with only one unit in operation, 11·5 knots were recorded.

As briefly mentioned in our issue of 15th, July, 1937, the coupling consists of an inner multipolar magnet ring (primary) connected to the high-speed side of the reduction gear, and an outer part or ring provided with a short circuited winding (secondary) coupled to the diesel engine.

No mechanical connection.

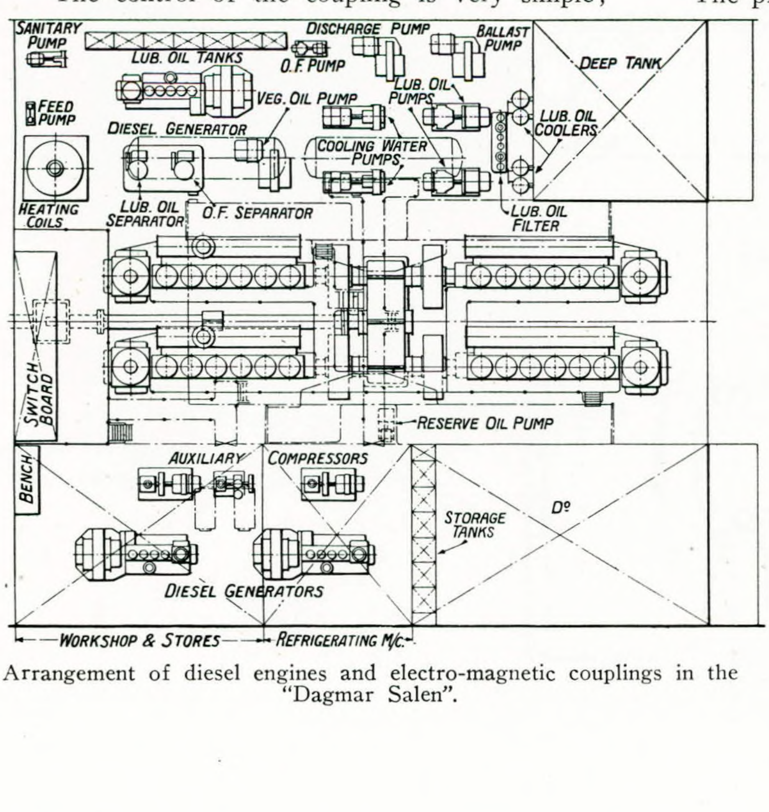
The two parts are overhung on their respective shafts and have no mechanical connection between them. Each winding is carried by a suitable magnetic system of iron to enable the sufficiently strong magnetic field to be obtained. The excitation is applied to one winding from the ship's lighting system and current is produced in the second winding by means of induction. The magnetic field produced when the primary windings of the



One of the Asea electric couplings and gearing on the motorship "Astri".

coupling, are excited passes over the air gap and the secondary windings. When the primary windings are supplied with current and rotated, a current is induced in the secondary windings and a torque results from the interaction of these currents in the magnetic field which causes the secondary system to rotate.

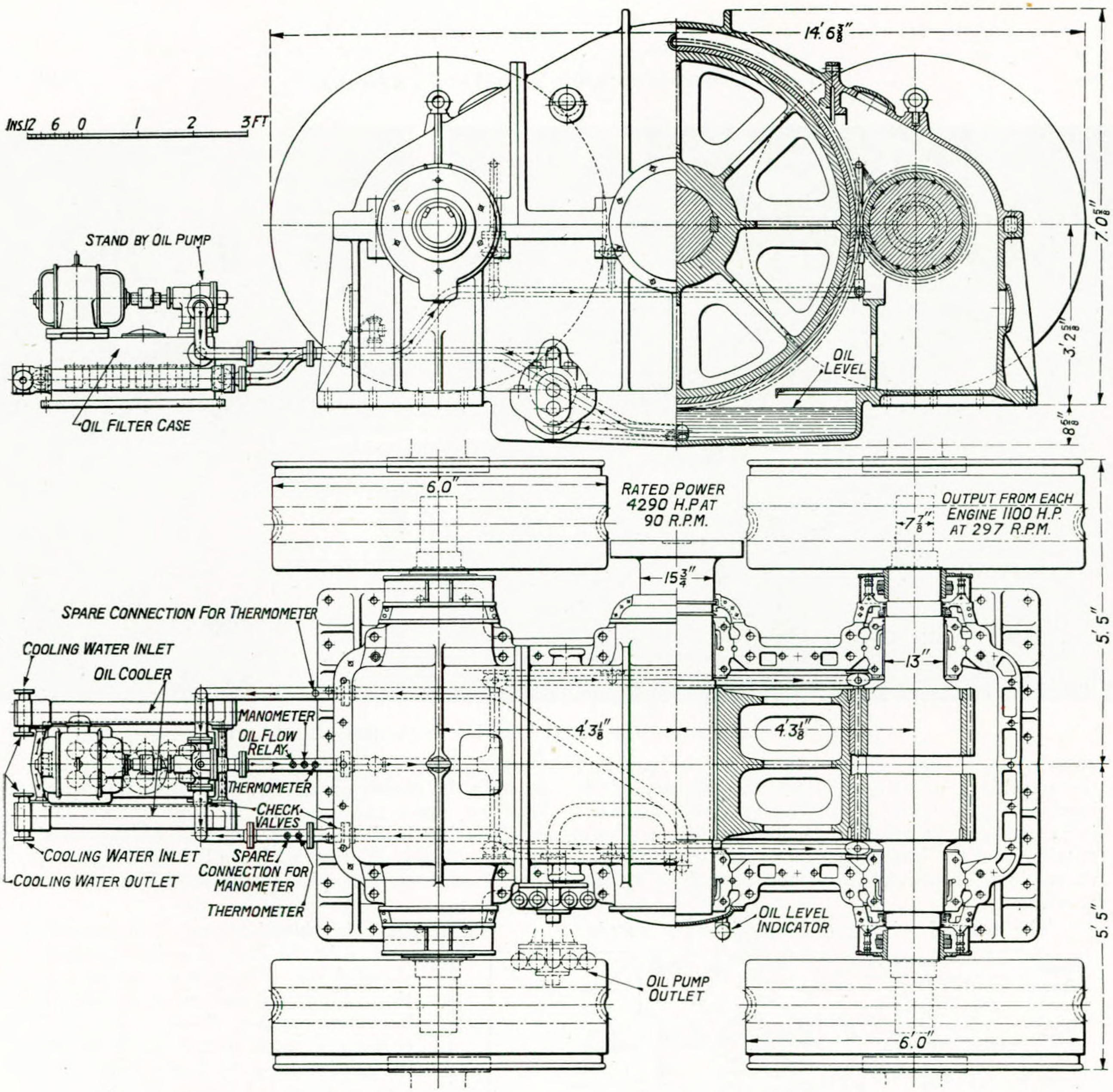
The control of the coupling is very simple; coupling and uncoupling is made by closing and opening the excitation circuit by means of a switch. In most cases the coupling is kept excited and manœuvring is done by the control of the ship's engines, which operate under all conditions as if they were flexibly coupled to the propeller.

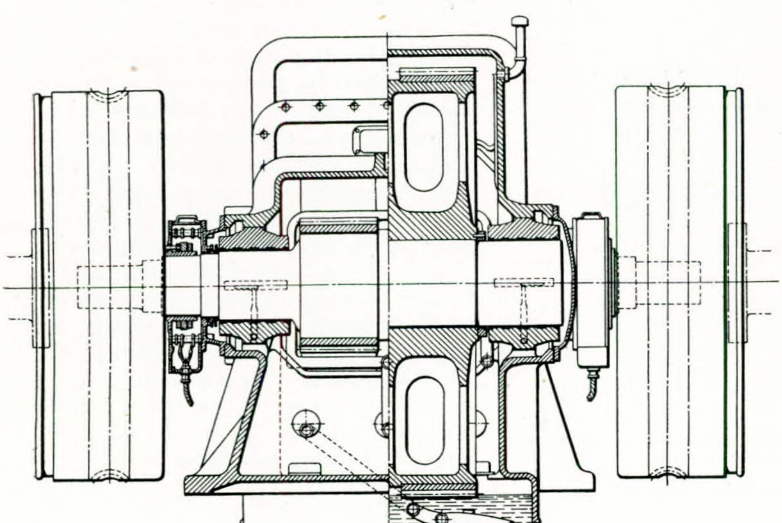


Arrangement of diesel engines and electro-magnetic couplings in the "Dagmar Salen".

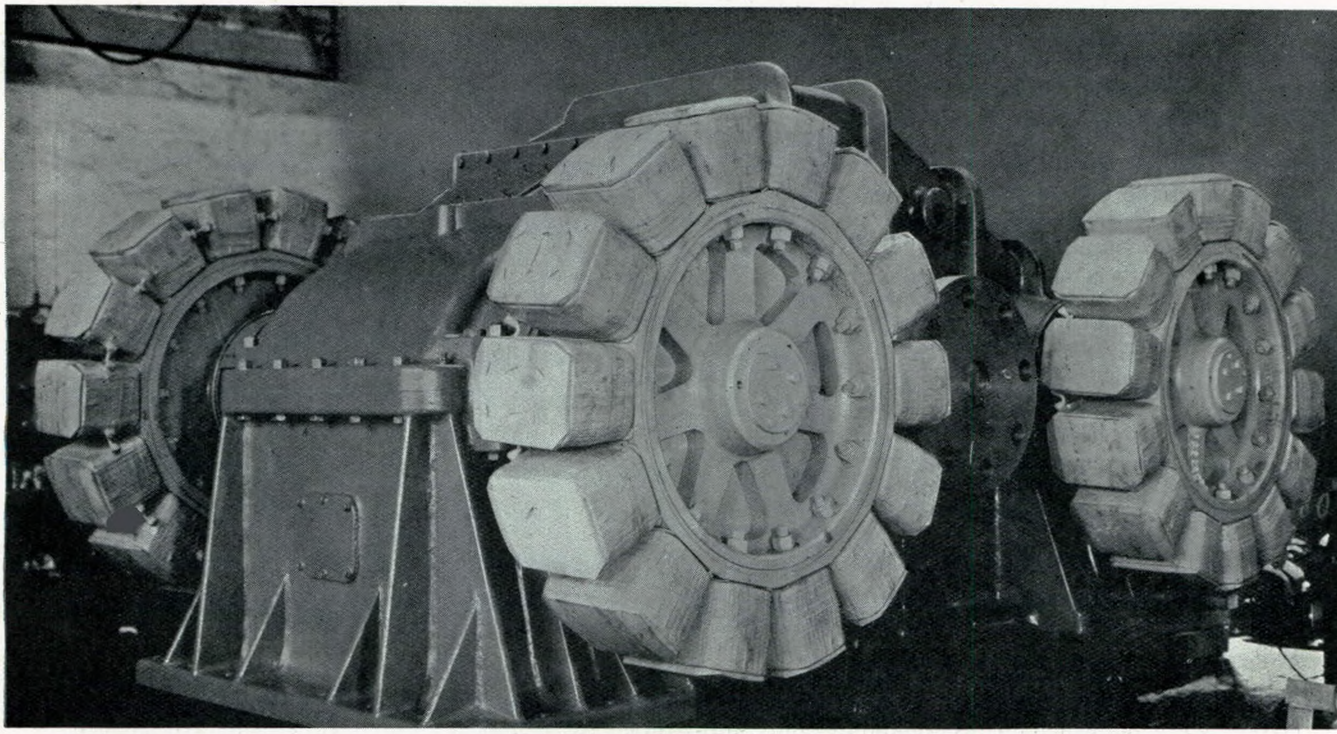
Manœuvring.

The propeller is, therefore, run and reversed just as in the case of a direct-coupled diesel drive. There is no lag between the engine and the screw, which follows the engine from moment to moment without any greater difference in speed than 1 to 2 per cent. This slip takes up all shock due to speed variations. When manœuvring and frequently starting and stopping, the engines can be run continuously and the screw can be run and stopped by switching the excitation on and off and using the coupling as a clutch. This simplifies manœuvring and economises starting air. It is even possible to keep one engine running ahead and a second engine running astern, so running the vessel forward or backward without reversing the engines. This method of control can be very useful when manœuvring in narrow channels. Operation of the coupling depends upon the maintenance of the ship's lighting service and to avoid putting the propeller out of action due to failure of supply, the





Part sectional elevations and plan of the Asea electro-magnetic slip couplings and reduction gearing installed in the "Dagmar Salen".

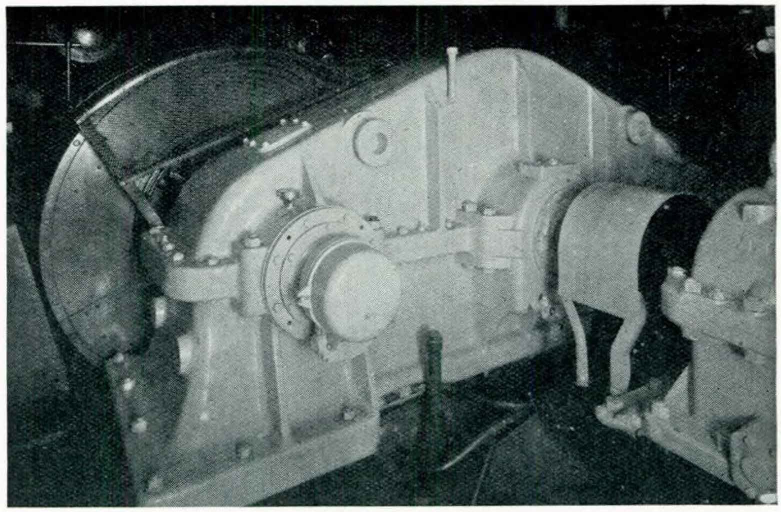


Asea electro-magnetic slip coupling and gearing installation for the "Dagmar Salen", showing three of the four multi-polar magnet rings which form the primary circuit.

In this illustration the gear casing has been removed, and the four couplings, pinions and main gear wheel are clearly shown.

coupling is designed so that it can be simply transformed into a flexible coupling of the ordinary type.

An interesting application of the Asea electric coupling is that installed in the 9,500-ton cargo motorship "Dagmar Salen", built by Oresundsvarvet A/B., Landskrona, to the order of Sven Salen, Stockholm. In this vessel, four 6-cylinder, two-stroke, single-acting Polar diesel engines, type M46M, each developing 1,100 h.p. at 300 r.p.m., are coupled to a single propeller shaft by means of four Asea slip couplings, type S.165, through reduction gearing. The couplings, a drawing of which appears on page 224, are arranged with an air gap of 10 mm., and operated by an excitation of 35 amps. at 220 volts.



"Astrid Thorden" gear casing and port engine drive.

Drawings of the vessel, together with a detailed arrangement of the engine room layout, were published in "Shipbuilding and Shipping Record" of 12th August, 1937. We reproduce on page 223 the main propelling machinery arrangement detail from that issue.

A total of approximately 4,400 h.p. at 296 r.p.m. is developed by the four engines and transmitted to the single reduction gearing which, in turn, transmits about 4,290 h.p. to the propeller shaft at 90 r.p.m. The pinions, manufactured of chrome-nickel steel, have 41 teeth, and the main gear wheel, constructed with a cast-iron hub with steel rim, has 135. Illustrations of the Asea couplings and gearing of the "Dagmar Salen" are shown on page 225.

The propelling machinery is designed for a speed of 14 knots.

We reproduce above an illustration of the Asea coupling fitted to the propelling machinery of the motorship "Astrid Thorden". This vessel, built by O. Y. Crichton-Vulcan, Abo, Finland, for Gustaf B. Thorden, Brando, is fitted with two Atlas diesel engines, type M46M, supplied by Atlas Diesel A/B, Stockholm. The engines, each developing 1,050 b.h.p. at 300 r.p.m., are direct coupled to a single propeller shaft through single reduction gearing and Asea magnetic couplings running at 130 r.p.m., the shaft horse-power being 2,040.

The principal particulars of the vessel are:—

Length overall	206ft. 0in.
Length between perpendiculars	285ft. 0in.
Breadth moulded	42ft. 0in.
Depth	27ft. 0in.
Deadweight	3,000 tons
Draught loaded	18ft. 7in.
Gross tonnage	1,816
Net register tonnage	766
Cubic capacity of holds	190,000 cub. ft.

Accommodation is arranged for 12 passengers. On ballast trials, a speed of 14·8 knots was attained.

Last week the "Astrid Thorden" was in London, and on her departure an interesting demonstration of the uses of the Asea coupling was given to technical experts on board. About half way down the river one engine was stopped and disconnected from the screw by merely opening the excitation circuit of its associated coupling. The vessel proceeded at slightly reduced speed on the second engine while the first engine was at standstill and available for any adjustments necessary.

The river is very congested at full tide and it was remarkable to see one of the engines brought to a standstill and then put back into service again merely by the operation of the controls and the coupling excitation switch.

A further application of the Asea electromagnetic slip coupling is the installation in the "Astri", built at the Lindholmens shipyard, which is described elsewhere in this issue. An illustration of the coupling appears on page 223.

Super-pressure Back-pressure Turbines.

Some details of the tandem set for Waterside No. 2 (New York).

"The Steam Engineer", October, 1937.

At the present time extensions are being carried out at the Waterside station of the New York Edison Co., which will be known as the "No. 2" station, the present plant in operation being the "No. 1".

Full details are not yet available, but essentially the new plant will consist of two large super-pressure boilers of "Combustion Engineering" make, each of 500,000lb. per hour normal evaporation, for 1,500lb. per sq. in. pressure and about 900° to 925° F. superheated steam temperature, with superheaters, air heaters, and economisers and a "Westinghouse" super-pressure tandem turbo-generator set of 53,000 kW. maximum capacity, 90 per cent. power factor, which has a number of highly interesting and unusual features.

Through the courtesy of the Westinghouse Electric and Manufacturing Co. (Pittsburgh and

Philadelphia) we are able to give a description, along with photographs and line drawings, of the set, which is now being erected at Waterside.

Essentially the arrangement consists of two turbines, that is a main back-pressure turbine and a small secondary back-pressure and bleeder feed heating turbine, connected in tandem, and driving a hydrogen-cooled generator of the latest type, a direct connected exciter, and a pilot exciter, all running at 3,600 r.p.m.

The main turbine is of the single-cylinder combination "Curtis" impulse and reaction make, with normal steam conditions of 1,200lb. per sq. in., and 900° F. at the stop valve, and exhausting at about 215lb. per sq. in. to a low-pressure header, which in turn will supply the secondary feed heating turbine. This is of the single-cylinder combination "Rateau" impulse and reaction type, taking steam from the header with conditions of about 195lb. per sq. in. pressure and 500° F. at the stop valve.

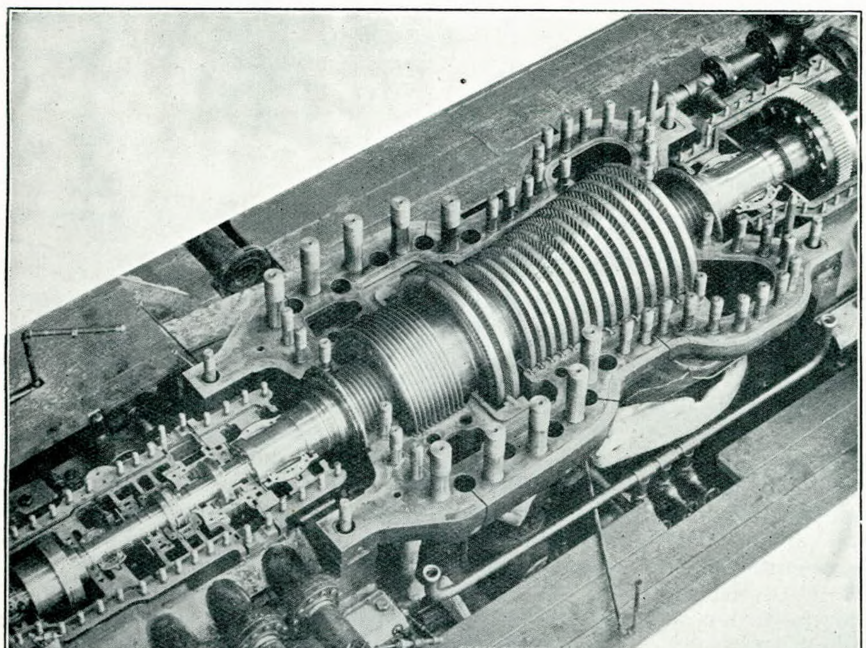
Bleeder steam is to be taken off at 60lb. per sq. in. and the back pressure is 5lb. per sq. in., both for feed heating for the new super-pressure boilers, the condensate at about 150° F. from the "No. 1" station being used, to be raised to 375° F. by the secondary turbine exhaust. Average performance also will be 49,500 kW. for the main turbine and 3,500 kW. for the secondary turbine under the above steam conditions.

The header (215lb.) is also supplied with steam direct from existing low-pressure boilers at the "No. 1" station, and operates an existing 35,000 kW. condensing turbine set. Further, the arrangement is such that when using the low-pressure boilers the main high-pressure turbine operates with a constant exhaust pressure, but if the low-pressure boilers should be out of action the high-pressure turbine will run either under constant exhaust pressure or with the pressure regulator shut off and the low-pressure condensing turbines acting as a cross-compound unit, with variable exhaust pressure from the main turbine.

This complicated but interesting arrangement, which in one sense can be regarded as a special variation of the "top" principle, has been rendered necessary because of the conditions at the present "No. 1" station, the condensing turbine of which is not provided with equipment for bleeder steam heating.

With regard to some of the constructional details, the main turbine cylinder at Waterside "No. 2" is of cast carbon-molybdenum steel, because of the high steam temperature, and is split in the horizontal centre line, forming a base and a cover. The blade ring elements also are cast integrally, and passages are provided for by-passing the "Curtis" stage at maximum load.

A most interesting feature is the annular steam jacket, which extends round the entire high-pressure cylinder, so as to equalise the temperature of the base and cover and reduce considerably the possibility of cylinder distortion. Further, this jacket forms a steam passage between the main inlet valve located in the cover and its nozzles at the base, and therefore is always completely filled with steam as soon as the valve is open.



Rotor and cylinder of the main turbine of the 53,000 kW. "Westinghouse" tandem set for Waterside No. 2.

Similarly the small 3,500 kW. feed heating back-pressure and bleeder turbine has the cylinder cast in two pieces, split horizontally to form a base and cover, but in this case ordinary carbon steel is used because of the relatively low temperature, that is about 500° F.

In order to allow of perfectly free expansion and contraction the main cylinder turbine is carried by four arms or lugs cast integrally at the bottom of the base, resting on separate pedestals on which they are free to slide, being secured only loosely by bolts. At each end also the cylinder is connected to the pedestal by a single vertical pin, so as to always maintain the correct axial and transverse position of the cylinder in relation to the pedestal. Further, the exhaust under the pedestal is anchored to the foundation seating blades and serves to anchor the entire unit, while the secondary feed heating turbine cylinder is supported on the same lines.

Each of the turbine rotors is machined from a solid forging, and in the case of the main turbine, chromium-nickel-molybdenum alloy steel is used, again because of the high inlet superheated steam temperature. A separate short stub shaft is bolted to the inlet end of the main turbine rotor to form a thrust bearing collar, and also to carry the oil impellers and the overspeed trip gear, and this thrust bearing is situated at the inlet end, whereas in the case of the small feed heating turbine the thrust bearing of the rotor is at the exhaust end, in such a manner that both turbines are connected together by a flexible coupling. Further, the main turbine rotor is connected to the generator by a rigid coupling and the complete rotating element is carried in seven bearings.

With regard to the blading, that of the main turbine consists of a "Curtis" stage followed by fourteen pairs of rows of reaction blades, while that of the small feed heating turbine comprises a single "Rateau" stage and 19 pairs of reaction blades.

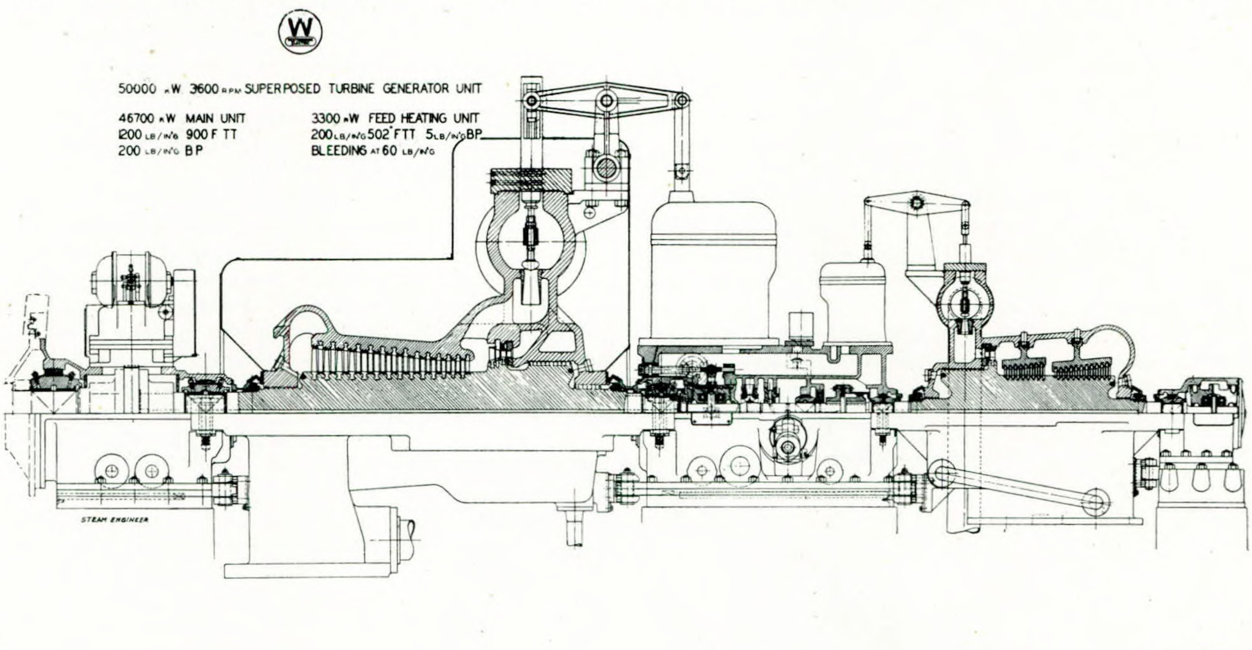
Steam is admitted to the turbine through an inverted, hydraulically-operated combination hand throttle and automatic trip control valve, situated below the floor level, but having the operating hand-wheel with a stand extending above to a convenient height. This valve is connected to the turbine by two pipes, so as to admit steam at both ends of the steam chest, while a cylindrical type of strainer is built in the main valve body. As usual the valve can be regarded as divided into two parts, that is the main steam valve and the valve mechanism, the valve itself being of the double plug type with two single-seated unbalanced valves, one placed within the other.

Each turbine also is controlled by a separate governor, both of the pressure transformer type with oil as the contro-operating medium, while each turbine has an exhaust pressure regulator, the entire control system comprising throttle valve, overspeed trip, measuring apparatus, emergency trip, exhaust pressure regulator, and auxiliary pumps and regulators.

In connection with the blades, the general arrangement of the impulse element consists of two rows of rotating blades attached to the rotor and one row of stationary blades attached to the cylinder. The rotating blades are secured to the rotor by what is known as the "Straddle Root" system of fastening, consisting of a T-root with lugs machined on the blade shank, which straddle and are held in the sides of the rotor groove against the top, to which the blades are held by half round steel sections caulked in place at the bottom.

Also, the stationary blades are secured in straight line grooves by a series of short keys which fit in auxiliary grooves cut in the blade shank and in the side of the main grooves, the blades also being shaped so as to form their own shroud.

To reduce leakage of steam round the blades to a minimum special seal strips are used, held in grooves by special steel locking segments, both the strips and the segments being fitted after the blades are installed. In the case of the reaction blading the ordinary T-root fastening is used, held against the



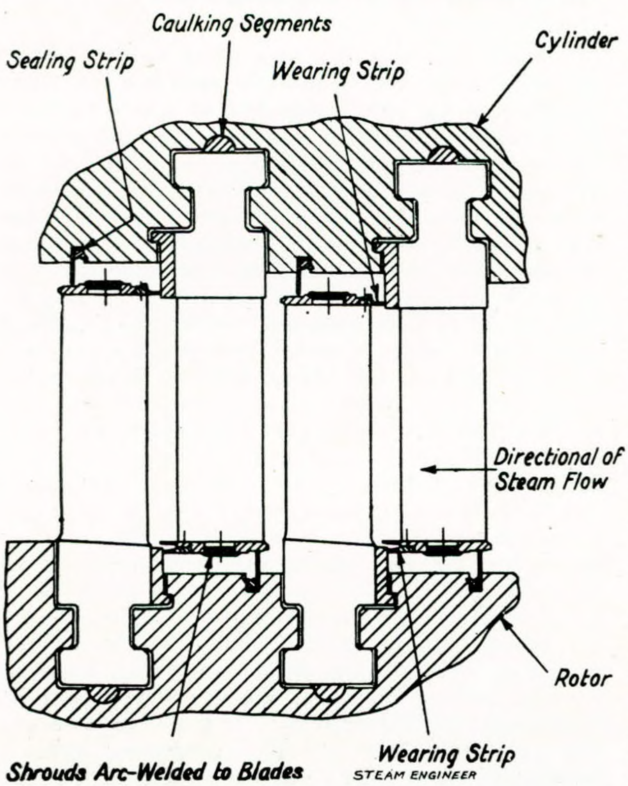
Vertical longitudinal section through the two turbines of the "Westinghouse" set for Waterside No. 2.

top of the grooves by caulked half-round segments, and each rotor blade is shrouded with a strip arch-welded in place. On each shroud also a thin wearing strip is riveted to minimise the leakage of steam round the ends of the blades, these strips being sharpened so that if a slight rub takes place there is no appreciable damage.

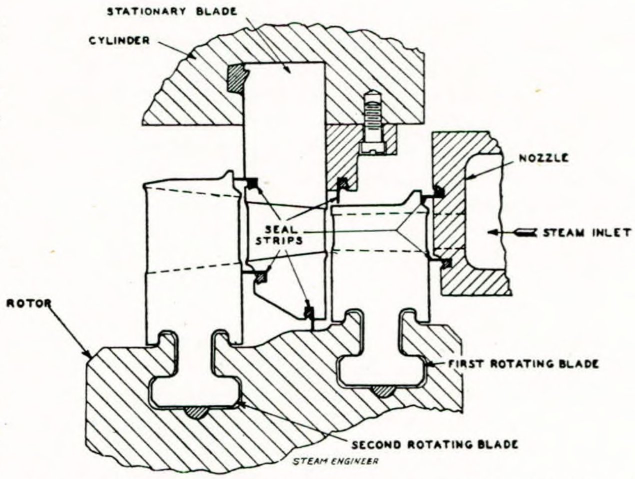
In addition to the actual clearance the blade shrouds are arranged to form very close clearances with steel strips, the latter being very thin and held in place in the cylinder or the rotor by soft steel strips, resulting in negligible leakage of steam, while causing no serious damage in the event of rub.

Mention must also be made of the type of glands used to prevent leakage at the point where the rotor shaft passes through the cylinder, the general principle adopted being the use of a small impeller pump operating within a casing, along with labyrinth seals with water as the only sealing medium.

The impeller or runner consists of four segments secured to the rotor by interlocking shoulders, and is capable of operating at a pressure of about 35lb. per sq. in. when supplied with water at the inner radius. The impeller pump case is split horizontally for easy dismantling and inspection, and there is provided a liner which protects the case against any erosive or corrosive action of the water in the runner cavity, while portions of the equipment, such as the liner and the runners, can be removed and replaced very easily.



Reaction blades of the 53,000 kW. set showing the axial and radial clearance type.



Impulse blades of the 53,000 kW. set at Waterside No. 2.

The Next Step in Engineering Education.

"The Steam Engineer", October, 1937.

There are definite signs of rumblings in the educational world, and our friends across the Atlantic are giving much thought to this department of engineering. The orthodox course which has done such excellent work for past generations now calls for extension in time and subjects. But it is the latter which particularly interests us, and we place on record here some extracts from an article in the September issue of "Mechanical Engineering", under the above title by Mr. E. D. Ayres (University of Wisconsin), in which the author proposes ways of broadening the education of engineering students so as to include more economic, social, and business courses by projecting instruction in the period beyond graduation following a four-year curriculum.

"About March, 1935, a careful study was begun to find what should be done at the University of Wisconsin in teaching business and economics to engineers. This study has, in approximately two years, produced some interesting conclusions, whose soundness and simplicity make them worthy of consideration for application on a national scale. Attention has been focused definitely upon the local problem. The college of engineering has always encouraged students enrolled there to avail themselves of the opportunities for broadening their vision and understanding in the humanities through elective work in the internationally eminent departments of economics and sociology of the University. She has, however, never established courses in engineering leading to degrees in administrative engineering, industrial engineering, business and engineering administration, or similar curricula. A department of engineering economics, until recently called the department of engineering administration, however, has sturdily attempted to bridge the gap between technical engineering and business by providing, in the senior year, surveys of the relations between engineering and commerce and guidance to the commercially minded student in making use of this free elective work. Although these facilities have recently been made available for the younger undergraduates, the status of the facilities and opportunities for providing the engineering student with work in business and humanities has not changed essentially in recent years.

"Close study of the situation at Wisconsin and a scrutiny of educational programs in engineering offered in general in the East and the Middle West against the background of increasing professionalism and the evident need for broader curricula suggests that the time is ripe nationally to project the education of the engineer beyond the end point of commencement day into the post-school period. The new goal, if it can be considered new, should be the achievement of a recognised professional level. The new feature, if it can be considered new, is the development of the idea that the university should take hold and provide educational paths through this post-school period to suit the individual. The idea appears as a responsibility which the colleges of engineering should grasp, because no other agency is so peculiarly fitted to attend to the birth struggles of professionalism for the engineer as is the university and to surround the young infant with comforts drawn out of its stores already developed for its resident instruction, adult education, and alumni and placement work.

"In considering a plan for providing education for the engineer in business and economics, at least four definite fundamental premises are immediately encountered:—

"(1) In the usual four years' college preparation, to expect the average engineering student to emerge with a degree in engineering and also a degree from a school of commerce is impossible.

"(2) Engineering schools are primarily interested in turning out men with the proper background for becoming successful engineers; hence, that the engineering student in college emerge at graduation with an adequate education in engineering fundamentals is of first importance.

"(3) The present trend toward professionalism in engineering is not likely to diminish in importance in the coming years, and the old importance of graduation from an engineering school as the end of one final stage in an engineer's preparation is overshadowed, or soon will be, by goals pushed forward to several years after graduation in the form of a state licence or recognition of an attainment of a professional level by engineering societies.

"(4) The engineer has a definite need for an education in business and economics, ranging from the needs of an ordinary citizen to those of a future executive or administrator in industry. In attempting to meet the needs of engineers within such a wide range, any plan for education in these fields must have sufficient variation in the way of optional paths to meet the particular demands and problems of the individual engineer.

"Many interviews with prominent engineers and engineering educators over the period given to this study have revealed a growing conviction that courses in engineering must be lengthened to five or even six years. Ultimately, so lengthening the period of resident instruction may be feasible. However, a definite drawback to such proposals exists. To-day, many capable engineering students are finding even the term of four years a severe drain upon their economic resources. That the idea of lengthening the curriculum can ever be universally adopted in the face of this one real obstacle does not seem possible. Careful development of post-graduate and post-scholastic work by the universities, however, can sidestep this obstacle, gain the lengthened curriculum in fact, and, moreover, provide the instruction at a time it can be thrown against a background of the junior engineer's work in industry. Thus, the work can be given to the engineer in the realistic atmosphere and environment of industry, which, for certain purposes, is likely to prove more stimulating and conducive to its appreciation than the college environment".

The Conditioning of a Bearing Face.

"The Motor Ship", October, 1937.

Much attention has been given to the subject of wear during running-in in the past few years and its effect on the subsequent life of a bearing face. The generally accepted view was that the process constituted a smoothing down of the high spots by abrasion. To-day, however, our knowledge inclines us to the view that when a bearing face is being run-in it undergoes certain fundamental changes at the immediate surface, which may be adapted to our benefit by suitable control in lubrication. Thus, the electron diffraction work of Professor G. I. Finch at Imperial College, London, indicates the presence of an amorphous and plastic skin of metal on the surface of the cylinder wall of an engine being run-in. Dr. Bowden, working at Cambridge, has, by a series of classical experiments, revealed that the temperature at the immediate surface of metal subject to friction, but inadequately lubricated, can rise to fusion point. Such a condition would occur in the earlier stages of running-in, when the high spots on a bearing face set up boundary conditions of lubrication or even metal-to-metal contact.

Some of these changes which occur in a metal face may account for the conditioning which a working surface undergoes when lubricated with oil containing colloidal graphite. It has been observed that such lubrication (during running-in) gives a bearing increased wear resistance and lower friction. Much evidence on this point has been collected, but space forbids a detailed description.

When colloidal graphite is used in the lubricating oil of an engine there is formed on the working faces a surface of sub-microscopic graphite particles. Some of these become fixed to the metal and have been described as a graphoid surface. A complete covering is thus provided for the underlying metal, which is protected from abrasive wear. Being resistant to corrosion, this surface isolates the faces of the cylinder wall or bearing from impurities which may be picked up by the oil in the course of its circulation, and which would attack the faces.

Providing, as it does, a high measure of efficiency in lubrication, particularly when an engine is new and bearing pressures are high, colloidal graphite reduces and controls running-in wear. That this is desirable is shown by the adoption of oil containing Acheson's colloidal graphite for assembly and running-in by many Diesel, gas and petrol-engine manufacturers. Mention might also be made of an interesting series of tests carried out on a ship's Diesel propulsion engine, reported in a paper to the Institute of Marine Engineers, in "The Transactions", September, 1934, in which colloidal graphite reduced cylinder wear on two successive voyages to the East from 0·012in. for plain oil to 0·008in. Preceding, as they did, some of the more fundamental research on this form of lubrication, the results of these tests can now be more readily understood in the light of newer knowledge.

Engine surfaces are conditioned, as already mentioned, to give a low friction value and a higher resistance to wear. The explanation for this may lie in the fact that the high spots are levelled carefully, and not at the expense of wear, to give the necessary structural changes in the immediate surface of the bearing metal. Whatever the explanation may be, it is apparent from practical experience that a bearing run-in with graphited oil has characteristic advantages from the bearing point of view.

Much research work has been carried out during the past few years on the subject of lubrication with colloidal graphite. Tests, for instance, made at the National Physical Laboratory as far back as 1928 showed that its presence in an oil increases the load-carrying capacity, raises the seizing temperature, permits reduced oil feed and lower starting energy in a bearing, and minimizes the possibility of seizure.

Recent work has shown that the particles of graphite formed an ultimate line of protection on a bearing face which cannot be removed except by direct abrasion. Already referred to as the graphoid surface, this has been shown to form on cast iron and steel and other metals. J. J. Trillat, of Besancon, using X-ray diffraction methods, has now shown that a surface treated with colloidal graphite encourages the orientation of polar molecules of a lubricant on a metal face, which in practice would mean better lubrication.

Interesting channels of research are being pursued, and not only is the value of colloidal graphite as a lubricant being more clearly understood, but interesting facts in the metallurgical side of bearing wear are being uncovered.

A short bibliography of references to the subject of this article is given below.

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Ships' Hatch Cover Failures.

"The Motor Ship", October, 1937.

Accidents to hatches at sea, followed by an inflow of water, have caused extensive damage to cargo and, more than once, have resulted in the foundering of a vessel.

The designs of ships' hatches reveal clearly that the naval architect is conscious of the danger of hatch covers being stove in by a sea; it is not so evident that he is apprehensive of the risk of the covers being forced upwards. A green sea falling upon a hatch seems a very probable cause of the former kind of accident, but there is also upward bursting to be considered.

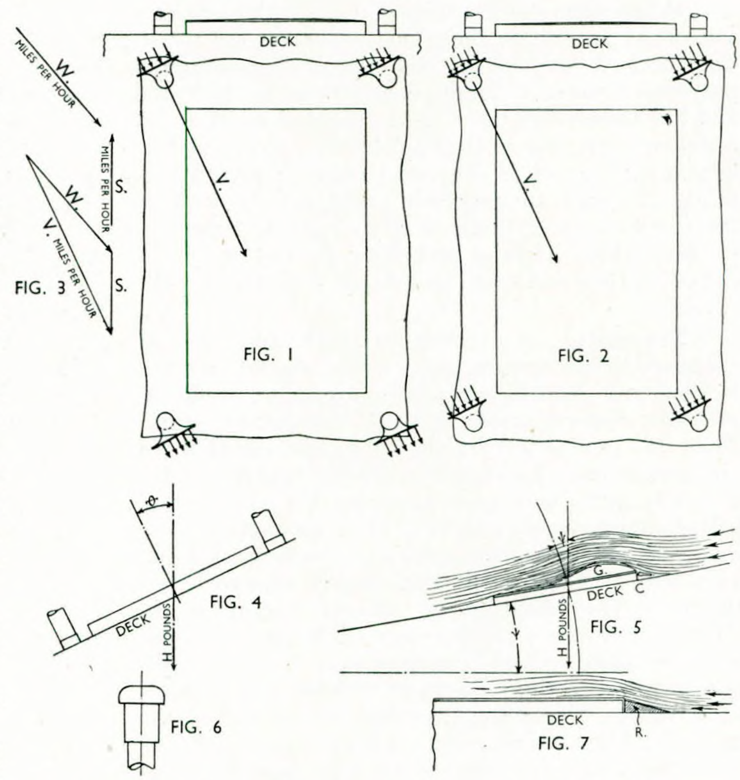
To account for the latter, it has been suggested by some ships' officers that wind entering the ventilators may be the cause; i.e., that the covers are literally lifted or blown up; it appears that such an explanation does not furnish the whole reason for accidents of this kind.

(1) To make the matter clearer, let us begin by considering the case of a hold that has no ventilators, although more or less directly in communication with the outer atmosphere. In these conditions we may take the pressure of air within the hold, and therefore on the underside of the hatch covers, to be the same as that of exterior atmosphere.

(2) In the case just considered, the pressure of air within the hold is practically static, but, if we now apply ventilators of, say, the cowl type to the hold and arrange them as shown in Fig. 1, it

will be seen that the total area provided for the ingress of air is practically equivalent to that permitting egress, and hence there will now be a current of air within the hold; notwithstanding, the internal pressure will still be almost the same as that of the external atmosphere.

(3) But, should all the cowls now be set to point more or less directly into the wind as in Fig. 2, there will be no provision for the egress of air from the hold and, in this case, a uniform aerostatic pressure of $0{\cdot}00265\ V^2$ above atmosphere* will be maintained below the hatch covers, where (V) is the resultant of the wind's actual velocity (W) and that of the vessel (S). See Fig. 3.



Now assume for a moment that the atmosphere above the hatch covers were wholly removed but that conditions within the hold remained as before, then there would be:—

Case (1) An upward thrust of 2,120lb. on each sq. ft. of the underside of the hatch cover; i.e., 14·7lb. per sq. in.

Case (2) Practically the same as in case (1).

Case (3) As in (1), but augmented by $0{\cdot}00265\ V^2$ lb. per sq. ft. Hence, if the area of the underside of the hatch covers is A sq. ft., and the total weight of the covers H lb., the net upward thrust is:—

Case (1) $(2{,}120\ A - H)$ lb.

Case (2) Practically the same as in case (1).

Case (3) $(2{,}120 + 0{\cdot}00265\ V^2)\ A - H$ lb.

Clearly this upward thrust must be sustained by the hatch fastenings reinforced by such resistance to tearing as the tarpaulins can offer.

These results are modified somewhat when the vessel is at any angle of roll (θ) or 'scending-pitching ψ (Figs. 4 and 5), for the component of the hatch cover's weight, opposing the interior air pressure, would then become less than (H) as follows:

Case (1) $(2{,}120\ A - H \cos\theta)$ lb.

Case (2) Practically the same as in case (1).

Case (3) $(2{,}120 + 0{\cdot}00265\ V^2)\ A - H \cos\theta$ lb.

Although the elimination of all air pressure from the outside of the hatch covers could not happen unless there was a very fortuitous combination of circumstances, nevertheless it can be shown that a certain sequence of seas coming on board would result in an appreciable diminution of the air pressure on the exterior of these covers. Taking, for example, the case of a vessel in a seaway, shipping a good deal of broken water and occasionally a green sea. Her hatch coamings are frequently buried in water, but, when she rises on the next wave, most of this water is thrown into the scuppers.

It is clear that, so long as the water is over the hatches, it displaces the atmospheric air which would otherwise be in contact with the hatch covers; and, should she ship a green sea before the covers have again become exposed to the atmosphere, this solid mass of water rushing along the deck will be obstructed by the hatch coamings as shown at C, Fig. 5, which it will now surmount and leap in the form of an arch across a larger or smaller area of the hatch covers.

Below a bridge of water formed in this way (i.e., in the space G) there would be a pressure of air very considerably less than that of the outer atmosphere, which state of affairs would continue for a few seconds before the bridge broke. Were this to happen concurrently with an increase of internal pressure* caused by the ventilators, as in case (3), then conditions contributing to upward bursting of the covers would be present in an aggravated form, and in a lesser degree for cases (1) and (2). An accident to hatches could therefore take the form, first of upward disruption of covers, followed in the second place by their downward collapse into the hold. It would appear that the type of ventilators applied to holds should be considered with more care, for the cowl or open-mouthed type

* Resultant wind velocities V, of 50 miles per hour are quite common on shipboard, a velocity which would augment the pressure within the hold (Fig. 2) by 6·5lb. per sq. ft. But hurricane gusts may rise to a resultant velocity V, of even 100 miles per hour, producing an augmented pressure in the hold (Fig. 2) of 26·5lb. per sq. ft. With only a small diminution of pressure in space G, such additional shock forces below the covers have considerable effect.

can contribute to the building up of an undesirable aerostatic pressure within the hold, whereas ventilators of the type indicated in Fig. 6 have not that disadvantage. Also, if the hatch coamings were provided with ramps R, as shown in Fig. 7, which could be shipped when at sea and unshipped when in port, the likelihood of a green sea arching the covers would be much diminished. T.W.M.

Fuel and the Diesel Engine.

"The Motor Ship", October, 1937.

Some forceful comments have recently appeared in the technical Press concerning the quality of the fuel supplied to Diesel-engined vessels. Little doubt exists that a considerable proportion of the running troubles experienced by the Diesel engine in the past were attributable to the use of unsuitable fuel oil. It may well be that other troubles exist also, where the connection is not so directly traceable. But it should be clearly understood that by the term "unsuitable fuel oil" is meant oil having characteristics which preclude its efficient utilization in the particular engine under consideraton. The same oil may meet the requirements of another engine admirably, or, alternatively, the first engine might burn it efficiently with suitable modifications to the combustion arrangements.

It would, no doubt, be an advantage if a chemical analysis of all oil bunkered were available. This, however, raises some interesting points. It is within the writer's experience that, without considering chemical constituents, even a consistent specific gravity is unobtainable from the same company, at the same port, over a period of time.

Apart from definitely refusing to bunker an obviously unsuitable oil, it is somewhat difficult to visualize in what other way the chief engineer of a vessel may best take advantage of such a specification. And, in the above case, what is he to do if the oil company concerned adopts a "take it or leave it" attitude? Is our knowledge of combustion processes sufficiently far advanced to be able to predict with certainty what should be done in the way of modifications with a change of fuel? And, if it were so, what would be the reaction of the master and owners of a vessel when told that the ship must be delayed for a lengthy period while the engineers make various alterations to suit the new fuel?

It is unfortunately a fact that, in many cases, even delays occasioned by totally unavoidable breakdowns are treated with a great deal of unnecessary impatience, especially when the vessel is on time schedule. It would, indeed, not be too much to say that a good many motor vessels are driven far too hard. Sufficient time is not then available to devote that skilled care and attention to detail which Diesel plant must have. The latter is in every way more economical and just as reliable as steam plant, but it requires more exacting attention and a higher order of skill to make it so. This is a fact which is frequently lost sight of in these days of hustle.

Effects of Changing Fuels.

Reverting to the consideration of combustion processes as they are affected by a change of fuel. Research on this subject is as yet far from complete, and the necessary alterations can, perhaps, only be arrived at by means of a process of trial and error in any particular engine. There is, of course, the comparatively simple alteration undertaken in a blast-injection engine, whereby a lighter or heavier oil demands the removal or insertion, respectively, of a pulverizer plate in the fuel valve atomising device.

The problem is very much more complex than this, however. For instance, the use of unsuitable fuel, or, rather, fuel which a particular engine is not designed to burn, may occasion uncontrolled pressure rises during the delay period, which cannot be detected by the usual means. These dangerous pressure rises may, in turn, produce impact loading of the engine structure, of a value far in excess of that calculated from the ordinary indicator diagram.

Even had we the full knowledge at our disposal, modifications with a change of fuel may quite possibly embrace such items as shape, size and number of spray holes in atomising devices, fuel-cam profile and valve timing. Compression and scavenging-air pressures are quite likely to require alteration, as, for instance, a fuel with a relatively high hydrogen content requires more air for efficient combustion. In some cases the actual shape of the combustion chamber itself may be open to reconsideration.

Removal of Pulverizer Plates.

It will be interesting to examine in rather more detail the simple alteration mentioned above, namely, the insertion or removal of a pulveriser plate. Suppose a vessel has bunkered a heavier grade of oil than that previously burnt in the engines. It has been decided that the insertion of an extra plate is necessary. Now, in a vessel with 12 fuel valves of moderate size, this is an operation which will take two or three hours at the very least, quite apart from any other work which may be in hand at the same time.

Whether the shipowner is aware of it or not, many of their captains are distinctly averse to such delays. How can a chief engineer be expected to explain to a non-technical man the importance of such alterations as he may wish to make? The human element plays an important part here, and, to save argument, the temptation to take the line of least resistance may be very great in such circumstances.

Following these remarks to their logical conclusion, it may be found that some, at least, of the apparently puzzling cases of damage to engines one hears from time to time are, after all, susceptible to a very simple explanation.

The problem of Diesel engine fuel is becoming more pressing, and, in the writer's opinion, a solution is a necessity. The first, and perhaps the most influential, step is to make the shipowner realise the position in so far as it affects his pocket by way of maintenance charges.

Having progressed thus far, the ordinary rules of business should suffice to produce some amelioration of the conditions whereby a customer may not be obtaining full value for his purchase price. After all, several oil companies exist and they are in competition with each other. In the search for a solution the chemist's skill should be utilised to blend various fuels to suit particular requirements, for once the most efficient fuel has been found for an engine, its quality should be departed from in the least degree possible. L. J. H.

Diesel-electric Alternating-current Propulsion.

A new B.T.H. development of technical importance is announced.

"The Marine Engineer", September, 1937.

A system of alternating current transmission has been evolved by The British Thomson-Houston Co., Ltd., for use between a group of comparatively high-speed diesel engines and a relatively slow running propeller, the scheme being particularly suitable for medium- and high-powered vessels of, say 3,000 s.h.p. per shaft and upwards. One advantage of this system is that it is possible for all the main electrical machines to be of the synchronous type, the alternator being a salient pole machine and the propeller motor of the synchronous induction class. It is well known that this type of electrical machinery is very robust and possesses high efficiency. The B.T.H. organisations and its associates have supplied 499,300 s.h.p. of this type of propeller motor in various vessels equipped with turbo-electric drive.

The advantages of alternating current transmission for high-powered ships may be summarized as follows:

(1) Great reliability.
(2) High efficiency.
(3) Low weight and compact construction of electrical machines.
(4) Large clearance between the rotating and standing parts of the electrical machinery, air gap clearance being of the order of 1¼in.
(5) Ease of repair. Even a major repair such as rewinding can be carried out within the space occupied by the machines themselves, deck openings or dismantling space around the machines being unnecessary.
(6) By the use of relatively high-speed diesel engines the headroom required is comparatively small and much valuable space, generally in the centre of the ship, can be saved.
(7) By using a number of fairly small engines many adjustments can be made on a faulty engine without causing even a momentary stoppage of the vessel at sea. Thus, on a vessel of 24,000 s.h.p. having four or five engines, removing one from service temporarily for adjustment will only reduce the full power speed by 1 to 1¾ knots, and quite possibly the normal service speed may not be reduced at all.
(8) By using relatively high-speed engines the moving parts are handled more easily when overhauling than is the case with the large slow-speed engine, and this enables labour charges, which form such a big portion of maintenance costs, to be kept to a minimum.

In principle, the control is the same as that used where the prime mover is a turbine; this form of control has given satisfactory service without any kind of trouble, and as mentioned above has been used for the control of propeller motors totalling 499,300 s.h.p.

The alternators are made self-synchronising, and where six or more engines are used an entirely automatic load equalising arrangement can be provided, if required. This arrangement automatically keeps the propelling load divided over all the engines, irrespective of the total propeller power or speed being developed at any time.

No paralleling difficulties.

The B.T.H. Co. has patented a method whereby all the alternators are kept in parallel under all conditions of speed and during reversing operations main power contactors open and close on a dead circuit. A further advantage of this system is that the power supply for engine auxiliaries whose duty varies with the speed of the engines, such as large scavenging blowers, lubricating oil pumps, etc., can be taken from the main propelling generators and maintained during manœuvring periods without having to transfer to another source of auxiliary power or specially transfer a main propulsion generator set to the auxiliary power circuit.

One very frequent source of trouble, and of particular annoyance to passengers, is the periodic vibration or beat due to hetrodyning of the engines. With the B.T.H. system all the engines can be synchronised in a predetermined relative crank position which gives the minimum vibration, and this relative crank position of all engines will be maintained during a stoppage or during a manœuvring period.

It is generally accepted that from a purely propulsive efficiency standpoint a single screw vessel has a propulsive efficiency of 7 to 12 per cent. better than a twin-screw ship of the same size and form, but this factor is frequently sacrificed owing to the fear of a complete stoppage due to engine breakdown at sea. It is also generally admitted that many vessels are fitted with direct coupled Diesel engines running at a higher propeller speed than that which is most efficient for the propeller.

The electrical losses vary with the size of machinery and not more than 6 per cent. loss would be incurred in a single-screw equipment of 10,000 s.h.p. and not more than 5 per cent. in a 30,000 s.h.p. twin screw equipment. The adoption of electrical transmission makes it possible for the engine builder to standardise engines, a factor which modern manufacturing methods have proved beyond doubt to be the best means for reducing first cost and maintenance costs with increased reliability.

Installation flexibility.

The B.T.H. electrical system can be used without limit to s.h.p. on any single propeller shaft or the number of engine-generator sets forming the power generating equipment, and, further, the generating sets can be distributed in different compartments over the vessel and the plant operated at maximum efficiency with a comparatively small number of operating engineers. Unlike mechanical geared transmission, which has the same object in view, namely, the use of standardised high-speed Diesel engines, the electrical transmission system allows the various items of machinery to be located almost anywhere in the vessel, and as pointed out above, the B.T.H. system permits of efficient operation of the plant with generator sets in different compartments. This feature the sponsors of this new development particularly direct to the attention of naval architects, who so frequently have to subordinate their wishes regarding passenger accommodation and location of public rooms to the requirements of the more orthodox propelling machinery.

"Dry Ice" for Extracting Large Shafts.

"The Engineer", 24th September, 1937.

"Dry ice" is now being used extensively for assembling and dismantling shrunk fits, and "Power Plant Engineering" describes a large job of this kind carried out at the Queenstown hydro-electric station at Niagara Falls. A 40-ton steel shaft was extracted from a 270-ton rotor by cooling the shaft with a mixture of dry ice and alcohol. The freezing mixture, consisting of 350 gallons of alcohol and 3 tons of dry ice, was placed in a tank and the mixture pumped through the hollow shaft. The shaft, which was some 30ft. long, was completely free of the rotor in about two hours, and the mixture reached a temperature of $-97°$ F.

A Huge Hydraulic Press.

"The Engineer", 1st October, 1937.

What is said to be the largest high-speed hydraulic press in the world has been supplied to the Douglas Aircraft Company by the Hydraulic Press Manufacturing Company. The press itself weighs 840,000lb., and the total pressing force of 10,000,000lb. is provided by means of a single 6ft. diameter hydraulic ram, which is actuated by oil under a pressure of 2,500lb. per sq. in. At each side the platen and bed is 8ft. by 6ft. and at the ends $5\frac{1}{2}$ft. by $15\frac{1}{2}$ft. Before this press was ordered the Douglas Company made a test of the possibilities of forming and punching a number of unrelated aircraft parts at a single setting with a 2,000-ton capacity press. Based on this experience the large press was purchased and now more than 3,000 parts are being formed on the two machines.

Dredging the Clyde.

"The Engineer", 17th September, 1937.

At a recent meeting at Glasgow of the Clyde Trust, the Chairman, Mr. G. Sloan, said that preparations were in hand for the dredging of the river in readiness for the passage of the new Cunard-White Star liner. He added that the Trustees had made application to the Board of Trade for permission to deposit upon an area in the Firth of Clyde during a period of five years a quantity not exceeding 500,000 barge tons of material which would be dredged. Consent has been given, subject to consent being granted by the Greenock Harbour Trust. The latter body has agreed, and there was no obstacle in the way.

Oil from Coal.

"The Engineer", 17th September, 1937.

Speaking at the annual general meeting of the North British Gas Managers at Edinburgh, Dr. J. G. King, of the Fuel Research Station, said that preliminary experiments have shown that 100 gallons of tar can be converted into 105 gallons of motor spirit and 25lb. of paraffin wax, or 36 gallons of spirit, 67 gallons of Diesel oil, and 57lb. of paraffin wax. Of the tar made to-day, other than in gasworks, more than one-half is produced in vertical retorts. If the whole of the tar were hydrogenated some 120,000,000 gallons of motor spirit, or 9 per cent. of the national consumption, could be manufactured by the gas industry.

A High-pressure Station in the U.S.

"The Engineer", 10th September, 1937.

An extension to the Twin Branch power station of the American Gas and Electric Company is to operate at a pressure of 2,500lb. per sq. in., and at a temperature of 940° F. A contract has been placed for a 22,500kW. turbo-generator to work at 2,400lb. per sq. in., and it will be cross-compounded with a 40,000kW., 400lb. per sq. in. turbo-generator. According to "Power", the pressure of 2,500lb. per sq. in. was selected as being the limit to which natural circulation boilers can be built, and any higher pressure would necessitate the forced circulation of the water in the boiler by means of pumps.

Accommodation for Ship's Crews.

"The Engineer", 10th September, 1937.

The Board of Trade has issued new instructions relating to the survey of masters' and crews' spaces in British ships. For several years the new instructions have represented the basic minimum requirements laid down by many shipowners, although they are an advance on the previous requirements. The main improvements are: The accommodation is to be amidships or aft, instead of forward, as has hitherto been usual; a hospital is to be provided in all ships over 2,500 tons; beds are generally to be in single tier; there are to be separate mess-rooms, separate sleeping accommodation for different watches, better washing and bathing facilities, proper drying rooms, provision for hanging oilskins and dirty clothes, better ventilation, and the accommodation is to be of greater height.

The Icebreaker "Joseph Stalin".

"The Engineer", 3rd September, 1937.

On Friday, 13th August, the Soviet icebreaker "Joseph Stalin" was launched from the Orjonikidze yard at Leningrad. The ship is said to be the largest vessel of its kind in the world, and is 106m. long, 23·2m. broad, and has a displacement of 11,000 tons. She is propelled by three 3,350 h.p. steam engines and will have a speed of 15½ knots.

Ships That Made History.

IV—The Allan Liner "Victorian".

"Shipbuilding and Shipping Record", 2nd September, 1937.

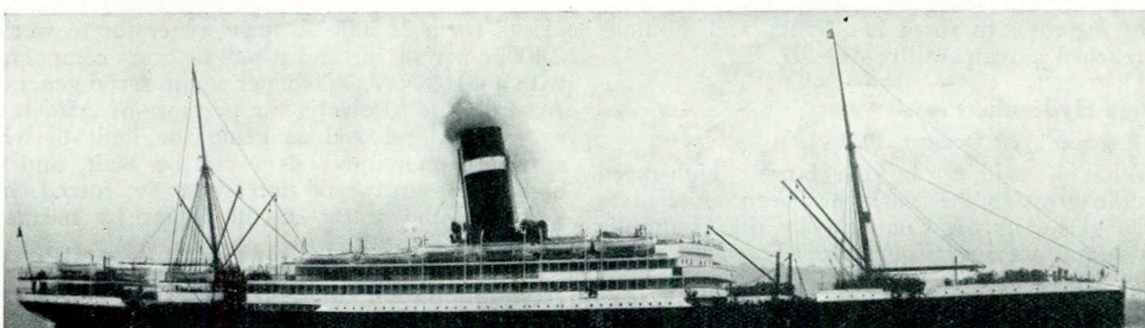
When the Allan Line, whose historic service to Canada was being threatened by the purchase of Elder Dempster's Beaver Line by the go-ahead and wealthy Canadian Pacific Company, ordered two steamers at the end of 1903, they were intended to be twin-screw ships of ordinary design, but bigger and faster than any others which had been considered for the Canadian run. Before their construction had proceeded very far, however, the directors of the company had been impressed by the claims of Parsons' turbine engine and they were altered to triple-screw turbine ships, the first liners in the world to be given that form of propulsion. The "Virginian", which finally became the Swedish-American liner "Drottningholm", was built on the Clyde, and her sister, the "Victorian", by Workman, Clark & Co., of Belfast.

In spite of the change in the system of propulsion, involving the complete reconstruction of the stern, the "Victorian" was launched in April, 1904, only ten months after the laying of the keel, and so won the title of being the first turbine-driven Atlantic liner.

To outward appearance the "Victorian" was merely an improvement on the accepted Canadian liner of that time, with considerable passenger accommodation amidships and a single funnel between two masts, but it was remarked by shipping men before she was launched that her lines were unusually sweet and that she ought to prove a very fast vessel, in spite of the fact that most of the authorities were doubtful as to the wisdom of fitting the turbine engine, which was not yet proved in such a large size, into an expensive passenger ship. She was 520ft. long between perpendiculars with a beam of 60ft. The gross tonnage was 10,629, and in addition to an extensive passenger accommodation she had stowage for over 8,000 tons of cargo, including a proportion refrigerated for the carriage of Canadian fruit and dairy produce.

Mr. C. E. Allan, of the family which had controlled the Allan Line since its commencement, was particularly interested in the engineering side, and he watched the construction of the engines by Workman, Clark under licence from the Parsons Company, with the greatest care. The high-pressure turbine drove the centre shaft and the two low-pressure ones, with which the astern turbines were incorporated, the two wing shafts. Three-bladed propellers were fitted instead of the four-bladed which then were usual, and the innovation was a successful one. The shaft horse-power was fixed at 12,000, which was estimated to be sufficient for a sea speed of 18 knots, but when on trials in the Irish Sea in March, 1905, the ship averaged 19½ knots with little more power, the engines running at 260 r.p.m. The ship was immediately commissioned for the Canadian mail and passenger business.

She arrived in Canada on her maiden voyage



The Allan liner "Victorian", later known as the "Marloch".

in April, 1905, but in view of the novel design of the machinery, the owners were careful not to press her unduly. In September of the same year she had her first accident when stranded in the St. Lawrence owing to the smoke of forest fires at Cape St. Charles blowing across the river and temporarily blinding the people on the bridge. Curiously enough, her sister, the "Virginian", had a similar accident in precisely the same circumstances almost at the same time, but in neither case was the result serious and they were soon refloated.

As was to be expected, the turbines gave a certain amount of preliminary trouble owing to their novelty, but remarkably little considering the circumstances, and when they had been carefully nursed into condition she proved herself a remarkably fast ship. In May, 1906, she began to break records, and in the following month made a passage of five days five hours from Rimouski to Moville, which stood for a long time. Towards the end of that year, however, she was laid up at Liverpool for four months for a general overhaul, during which the opportunity was taken to effect a number of alterations in her machinery, none of them of great importance, but combining to overcome practically all the initial difficulties. She then returned to the Canadian service and ran most successfully, in spite of the fact that her record had been beaten by the Canadian Pacific Company's "Empresses" until war broke out.

Within a few days of the outbreak she was taken up as an auxiliary cruiser, all the alterations being completed and the ship ready for commissioning, by 14th August, 1914. To begin with she was armed only with ancient 4·7in. guns which had been taken out of worn-out cruisers built under the Naval Defence Act of 1889, and considering that there were, at that time, a number of German cruisers at sea armed with the most modern 4·1in. gun, it was, perhaps, lucky that she did not meet an enemy. She was attached to the Ninth Cruiser Squadron, patrolling in the area of the Canary Islands and escorting suspected ships into Gibraltar for examination. The ship also worked along the West African coast, which was one of the areas which gave the Admiralty most anxiety.

In March, 1915, she was sent back to Liverpool, refitted and armed with eight fairly modern 6in. guns, to which two 6-pounder anti-aircraft guns were later added, and transferred to the Tenth Cruiser Squadron which operated the distant blockade in the North Atlantic. Later, when the need of the distant blockade was considered to be secondary to the carriage of troops and foodstuffs, she was put on ocean escort duty, not only protecting other merchantmen, but carrying large numbers of troops and big quantities of cargo herself. During war service she steamed nearly a quarter of a million miles, and the excellent coal stowage, and habitability, made her exceptionally useful as an auxiliary cruiser.

While she was on this work the Allan Line was taken over by its old rival, the Canadian Pacific, and, owing to the important Canadian trade being so very short of tonnage, she was one of the first auxiliary cruisers to be released, leaving Liverpool for the Clyde, to be reconditioned before Christmas, 1918, although the shipyards were so congested at that time that the vessel was not ready for service again until the spring of 1920.

From then onwards the vessel resumed her place on the Liverpool-Canadian service, running to St. John's in the winter, but in 1921 was taken up for a trooping trip to Bombay, and at its conclusion was sent to the Fairfield yard to have single-reduction geared turbines substituted for the original engines. She returned to the Liverpool service in 1922, was relegated to the cabin class, and soon afterwards renamed "Marloch". In 1923 the vessel acted as a floating hotel at a big Baptist conference at Stockholm, and after 1925, newer cabin tonnage having been built, spent a good deal of her time laid up, although she was very useful as a reserve ship, and was constantly being brought out for service. In the spring of 1929, when the post-war ships could cover all the trade that was offering on the Canadian route, she was sold to shipbreakers for £32,750. F. C. B.

Ships That Made History.

V—The "John Bowes".

"Shipbuilding and Shipping Record", 30th September, 1937.

The collier "John Bowes" deserves a special place in the history of British shipping, for she was the first practical steamer to be built for the regular coal trade between the North-East Coast and London, and if it had not been for her success there is little doubt that the railways, as their economy improved, would have obtained a position in the coal trade from which coastal shipping could never have displaced them. Before she was built the only steam collier to London had been an auxiliary of very poor economy, the first full-powered steamer had been employed on the North-East Coast only, and she was built against the advice of all the economists who prophesied that she could never pay.

Charles Palmer, who had recently founded Palmer's yard on the Tyne, was a man of extraordinary moral courage—his contemporaries often described it as rashness—and he was quite convinced that a full-powered steam collier would pay. Among his many other interests was a share in the coal firm of John Bowes & Partners and he persuaded his co-directors to join him in the venture and to form the Iron Screw Collier Company for the purpose of building and running this ship. She was an iron screw steamer with a gross tonnage of 437 on dimensions 150 by 25·7 by 15·6ft. depth of hold and was built in Palmer's yard, with machinery by R. Stephenson & Company designed for a speed of nine knots. This machinery consisted of two compact engines of 35 nominal horsepower each geared to a single screw and the small space that they occupied permitted her a deadweight tonnage of 650.

Among other features of the design was a 60ft. hatch which permitted much more economical and efficient loading than the small hatches of the ordinary collier.

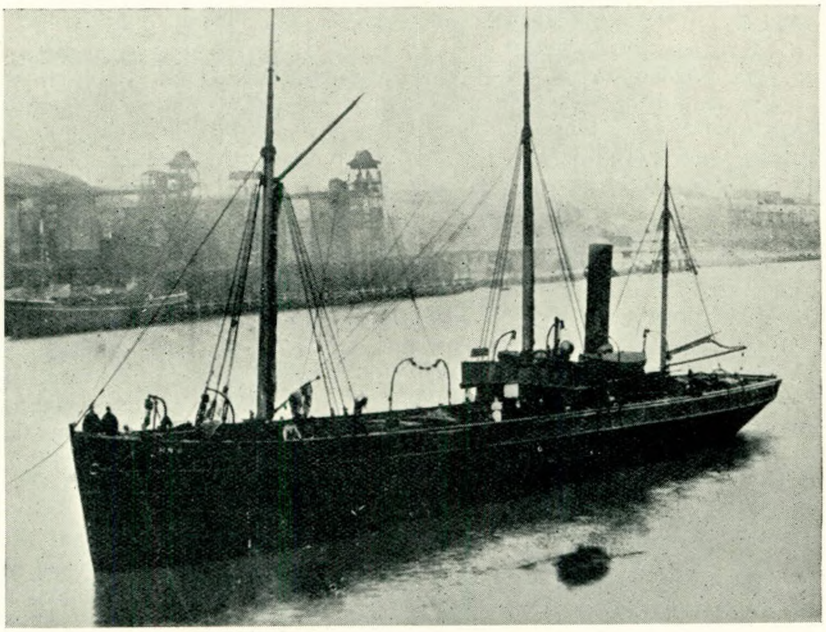
Launched at the beginning of July, 1852, the vessel was ready for her maiden voyage before the end of the month and arrived at London 48 hours after leaving the Tyne. She was discharged in 24 hours and returned in another 48, doing the complete voyage in five days and carrying as much cargo as two sailing colliers could have taken in a month.

The first voyage was a triumphant success, but before long it became obvious that if she continued with the ordinary collier routine, which meant delay to take in chalk ballast under the terms of the Coal Turn Act, she could not possibly cover overhead expenses, which were naturally much higher than those of an ordinary sailing collier. That was the trouble which had been foretold, but the owners were determined not to be beaten. After she was held up at the ballast wharves during the first few trips the owners decided to ballast her with a number of empty barrels placed in her hold and then filled with water. As she approached the loading berths on the Tyne these barrels were started and the water ran into the bilges, whence it was easily pumped out by the donkey engine without transgressing the regulations of the Tyne, where the authorities were naturally anxious that the port should not be spoiled by solid ballast being dumped overboard which every sailing collier did whenever there was an opportunity. At the same time, the procedure was very expensive in barrels, for the only way to get rid of the water was to destroy them. It was John McIntyre, the manager of Palmer's yard who solved the difficulty by fitting water ballast tanks forward of the stokehold and in the after peak, and connecting these with the pumps in the engine room by pipes.

That system proved a success from the very first and, with the coal freights then ruling, the "John Bowes" had no difficulty in earning large sums. Naturally the ship was copied by many collier owners, although the majority of the contracts went to Palmer's yard until other shipbuilders on the coast developed similar types.

As a general rule she was employed on the coal trade, but was such a handy little vessel that she picked up a number of miscellaneous and profitable charters, including the laying of the Dover-Ostend telegraph cable in 1853.

The rapid improvement of collier types indicated that the engines which were originally fitted were no longer economical and in 1864, at the sacrifice of a certain amount of hold space, she was given a new two-cylinder simple engine of the same



"John Bowes", the first practical steam collier.

power, with cylinders 34½in. in diameter by 26in. stroke. Nine years later she was sold to Mr. B. G. Barnett of London, later of Barnett Brothers, and in 1883 was sent round to Dumbarton to receive new compound engines and boilers.

She continued on the London trade until 1896, when transferred to John Mackenzie of Dublin, for general tramping work round the coast. She came back to London in 1897 and in 1898 was sold to Norwegian owners who renamed her "Spec". In 1900 she was transferred to the Swedish flag and renamed "Transit", but a few years afterwards returned to the Tyne for complete reconstruction which so thoroughly altered her appearance that it was difficult to distinguish her from a coasting collier of recent date. In 1908, she was transferred to the Spanish flag and renamed "Carolina", principally for the coasting trade, although she made quite long voyages during the war and earned high freights. In 1919, the owners were shrewd enough to see the end of the war boom and transferred her to other Spanish owners who renamed her "*Valentin Fierro*". After that she changed hands several times in Spain and in the late summer of 1932 was again renamed "Villa Selgas".

In November, 1933, while carrying iron ore from Bilbao to San Esteban Pravia, the ship was in a gale as she had been so many times before, but on this occasion it proved too much for the eighty-year old hull and she sprank a leak forward which was sufficiently serious to make the crew abandon her in a hurry, the famous old ship foundering almost immediately afterwards. There is little doubt that but for the exceptional weather encountered on that voyage she would have been good for many more years of service. The long service of the "John Bowes", which started life as a collier, was one of the finest tributes that could be paid to Tyneside shipbuilding in the middle of the last century. F. C. B.

The Effect of Water Depth on Speed.

"The Motor Ship", October, 1937.

Although it is well known that the depth of water has an effect on the speed of a ship, the magnitude of this influence is not generally realized by those who are concerned mainly with vessels of moderate speed. It was found, for instance, during the trials of the "Prins Albert" last month that, although she maintained over 25 knots in deep water, when the trials were made 300 yards nearer the shore the speed fell by 2 knots, the depth of the water being there in the neighbourhood of 50ft. It would appear that when the speed did not exceed 16 knots the depth of the water within reasonable limits was immaterial.

Naturally, builders prefer to carry out their trials over measured miles where the depth of water is ample. But the case of vessels of the Belgian State Railways' Dover-Ostend service (for which the "Prins Albert" is intended) is peculiar. For nearly half the distance on the run between Ostend and Dover the ship is in fairly shallow water, whereas the remaining part of the journey is made in deep water. Hence, it is of commercial importance to the owners to know the speed of the ship for given engine revolutions when operating in water of moderate depth.

Higher Speeds for Auxiliary Engines.

"The Motor Ship", October, 1937.

One of the many useful purposes that an exhibition, like that which closes practically at the outset of this month at Olympia, serves is to indicate the trend of events. There has always been a certain amount of difficulty in persuading shipowners and their superintendent engineers to accept higher speeds for auxiliary Diesel engines, and it is fairly conclusive that matters are being brought to a head. However much it may be preferred to run a generating set at 250 r.p.m., or possibly 350 r.p.m., there may be excellent reasons why such a conservative practice is bound to cease. Price alone may determine the question, for with shipbuilding and engine constructional costs as they are now (and are likely to remain for an appreciable period) anything that can be done to effect economies, however small, will merit such approval as has been difficult to secure when the position was less acute than it is to-day.

Cylinder liner wear and vibration, two of the objections to high-speed auxiliary engines raised formerly in certain—in fact, most—quarters, are now of almost negligible importance, if advantage be taken of improvements which are approaching a degree of standardization for land installations. However, shipowners move cautiously, and we foresee some time elapsing before a large vessel is fitted with a complete set of auxiliary diesel engines (of which two outstanding examples are in evidence), running at 1,500 r.p.m. Nevertheless, the latest emergency oil-engined dynamo for the biggest liner under construction runs at 900 r.p.m. Of the largest auxiliary engines in the Show to which we refer, at least three run at about 600 r.p.m.

It is our own conviction that the time is not very far distant when 500 r.p.m. will be a relatively slow speed for a ship's diesel generating set, and when this question of first cost is realized, as it must be in the present circumstances, there will be taken by many owners steps towards a complete change of front. They have no longer to fear many of the technical difficulties that they were warned against formerly.

The Metric System in Shipbuilding.

"The Motor Ship", October, 1937.

A new campaign has been inaugurated with the object of securing the adoption of a Metric system of weights and measures in the United Kingdom. The advocacy of the system is nothing new; 40 years ago the President of the North-East Coast Institution of Engineers and Shipbuilders is reported to have stated that the members of that body were unanimously in favour of the change. Since the development of the motor ship the Metric system has almost wholly replaced measurements in feet and inches so far as propelling machinery is concerned, and it is very seldom that marine diesel engines are built in this country based on inch measurements.

Some years ago, even after the Metric system had become widespread on the Continent, ships' dimensions were always given in feet and inches. Latterly, there has been a very definite tendency in the other direction. For instance, a few years ago we received information of Japanese ships in feet and inches, but now we have them in metres. In Germany the Metric system is frequently adopted for ship dimensions, and in Scandinavia it is being more generally employed.

It may not be many years before we shall be alone in building ships on the British system of measurement. Ultimately the Metric system must prevail, and it might be as well for British shipbuilding if we took the plunge. But it would be a very gentle plunge, since any change-over would naturally take a considerable time to be completely operative and a good deal might, of course, depend on individual enthusiasm and co-operation. It would be desirable to suppress the practice of "conversion" from one system to the other as a principal part of the scheme.

In one direction, however, there is no advocacy of the Metric system. There is little likelihood of any abolition of the nautical mile or knot, since these units are based upon the subdivision of the arc of the Meridian. The land mile, on the other hand, is a purely arbitrary unit imposed in the Elizabethan reign, and may well give way to the kilometre.

BOARD OF TRADE EXAMINATIONS.

List of Candidates who are reported as having passed examinations for certificates of competency as Sea-Going Engineers under the provisions of the Merchant Shipping Acts.

Name.	Grade.	Port of Examination.
For week ended 16th September, 1937 :—		
Williams, John	2.C.	Cardiff
Cooper, Arthur W.	2.C.	Glasgow
Docherty, William	2.C.	,,
Mackie, James E. T. ...	2.C.	,,
Rowan, Alexander	2.C.	,,
Sharp, John F.	2.C.	,,
Stewart, John	2.C.	,,
Cowley, Norman	2.C.	Liverpool
Hazlehurst, John J. ...	2.C.M.	,,
Turner, Gordon	2.C.M.	,,
Broomfield, Leslie A. ...	2.C.	London
Hunt, Allen H.	2.C.	,,
Jones, Geoffrey L.	2.C.	,,
Batey, John R.	2.C.	Newcastle
Smith, William H.	2.C.	,,
Burns, William W. ...	2.C.M.	,,
Edwards, William A. ...	2.C.M.	,,
Gibson, Henry E.	2.C.M.	,,
Givens, Wallace	2.C.M.	,,
Peterson, Eric T.	2.C.M.	,,
Walsh, Patrick	2.C.M.	,,
For week ended 23rd September, 1937 :—		
McLean, John A.	1.C.M.E.	Glasgow
Russell, Charles S.... ...	2.C.M.E.	,,
Begg, James M.	1.C.S.E.	,,
Urwin, Thomas	1.C.M.E.	Newcastle
Macfarlane, Kenneth ...	1.C.M.E.	London
Langer, Frederick E. ...	1.C.M.E.	Glasgow
Hibbs, Ronald G.	1.C.M.E.	,,
Duncan, John	1.C.M.E.	Liverpool
Graham, Robert N. B. ...	1.C.M.E.	,,
Herriot, James C.	1.C.M.E.	Liverpool
Jones, William J. L.... ...	1.C.M.E.	,,
Walker, Philip H. G. ...	1.C.M.E.	,,
Barker, John	1.C.	Newcastle
Chambers, Norman	1.C.M.	,,
Huntley, John F.	1.C.M.	,,
Willis, Arthur L.	1.C.M.	,,
Anderson, John C. B. ...	1.C.	London
Rankin, Stuart M.	1.C.	,,
Bell, Donald McA.	1.C.	Glasgow
Lansberry, Archibald J. ...	1.C.	,,
Todd, Thomas W.	1.C.	,,
Alexander, William R. ...	1.C.M.	,,
McIntyre, Andrew	1.C.M.	,,
McLeish, James B.	1.C.M.	,,
Coulthard, William W. ...	1.C.	Liverpool
Evanson, Austin E.	1.C.	,,
Lee, John L.	1.C.	,,
Smith, Charles H.	1.C.	,,
Wheeliker, George H. ...	1.C.	,,
Wright, Cecil	1.C.M.E.	Newcastle
Crowthers, Arthur ...	1.C.M.E.	,,
Coulson, Robert	1.C.M.E.	,,
Ross, Edwin W.	1.C.M.E.	London
Hunt, Arthur R.	1.C.M.E.	,,
Howieson, Nicol McC. ...	1.C.M.E.	,,
Berry, Albert	1.C.M.E.	,,
Urquhart, Francis	1.C.M.E.	Glasgow
Allison, William B.	1.C.M.E.	,,
King, Norris W.	1.C.M.E.	,,
For week ended 30th September, 1937 :—		
Brown, George	2.C.	Glasgow
Bruce, Robert D.	2.C.	,,
Robertson, Alexander S. ...	2.C.	,,
Turnbull, Peter K.	2.C.	,,
Clark, John	2.C.M.	,,
Crawford, Cameron J. ...	2.C.M.	,,
Ewing, William S.	2.C.	London
Grieve, William	2.C.	,,
Robertson, Ian C.	2.C.	,,
Swan, Frank D.	2.C.	,,
Armstrong, Stanley G. ...	2.C.	Liverpool
Boothroyd, Joe	2.C.	,,
Forbes, John A.	2.C.	,,
Nuttall, Percy E.	2.C.	,,
Scholes, John	2.C.	,,
Wilson, Joseph J.	2.C.	,,
Wootton, John A.	2.C.	,,
Heaton, Thomas D.	2.C.M.	,,
Starkey, William D. ...	2.C.M.	,,
Masters, Jamshed N. ...	2.C.	Newcastle-on-Tyne
Stephenson, George ...	2.C.	,,
Bailey, Ernest	2.C.M.	,,
Dixon, Thomas	2.C.M.	,,
Noble, Percy F.	2.C.M.	,,
Richardson, William ...	2.C.M.	,,
Sutherland, Gilbert ...	2.C.M.E.	,,