INSTITUTE OF MARINE ENGINEERS

INCORPORATED.

SESSION 1913-14

President: THOMAS L. DEVITT, Esq.

Visit to the Power Station of the City of London Electric Lighting Co., Ltd., Southwark.

Saturday, May 3, 1913.

ON Saturday, May 3, a visit was paid to the Power Station of the City of London Electric Lighting Company, Ltd., Bankside, S.E.

The main engine room, which was first visited, is a building 520 ft. long by 50 ft. wide, with a gallery containing switch gear, meters and controlling gear of various descriptions, extending the length of the room on either side. The total capacity of the plant is about 26,000 kilowatts, or about 42,000 indicated horse power, about one-third of the electricity generated being high tension alternating current with a periodicity of 100 per second, supplied to transformer stations; the other two-thirds is for the supply of continuous current.

The oldest type of machinery remaining in the works is the Ferranti alternating current generator, of which there are two sets each of 2,500 I.H.P. giving 1,500 kilowatts, but these are not now used and will shortly be scrapped. The engines are compound of the inverted vertical type, with two cylinders of 38 in. and 68 in. diameter, and 30 in. stroke, one on either side of the alternator armature. The engines run at 150 revolutions per minute, the steam pressure being 160 lbs.

The latest additions to the plant are three Parsons high speed turbo-alternators, single phase, each of 3,000 kilowatts, the revolutions being 1,500 per minute. For the generation of continuous current a similar turbine of 2,500 kilowatts capacity has been installed, and in addition there are six Musgrave-Westinghouse slow speed 2,000 kilowatt generating sets, and three Allis Chalmers-Westinghouse 1,000 kilowatt sets. The Musgrave engines are of 4,000 I.H.P., the cylinder diameters being $38\frac{1}{2}$ in. and 76 in. by 54 in. stroke, running at 75 revolutions per minute; and the Allis Chalmer engines are of 2,000 I.H.P., the cylinders being 26 in. and 60 in. diameters by 48 in. stroke, running at 90 revolutions per minute. The Westinghouse generators are multipolar, the armatures being provided with compensating windings.

In the boiler house, which was next visited, there are 46 Babcock and Wilcox boilers of the land type and 12 Fraser Dry Back Marine type. Each of the Babcock boilers has a heating surface of 4,400 square ft., and is composed of twenty sections, each consisting of 19 solid-drawn mild steel tubes, 3 in. diameter by 15 ft. long. There are two steam and water drums, each 48 in. diameter by 21 ft. long, made of steel plate $\frac{1}{2}$ in. thick. These drums are surmounted by a cross drum, 24 in. in diameter by 8 ft. long, provided with a steam nozzle of 7 in. in diameter. Most of the boilers are fitted with mechanical stokers, and induced draught is used. A main flue receives the waste gases, which pass through fuel economisers situated at the end of the flue.

The river frontage provides a convenient and economical means of obtaining the necessary coal supply, the coal afterwards being transported from the wharf bunker to the store above the boiler house, which has a capacity of about 10,000 tons, and from which the coal is conveyed to the automatic stokers through chutes. The ashes and clinker are similarly conveyed to the wharf or roadway, whence they may be removed at once into barges or carts.

Another advantage of the proximity to the river is that the water for condensing purposes can be easily obtained. For this purpose three sets of Allen's steam-driven and two sets of motor-driven, centrifugal pumps are installed, the maximum lift at lowest tide being nearly 20 ft.

Through the courtesy of Mr. Frank Bailey, Chief Engineer to the Company, a large number of members of the Institute were privileged to make this interesting visit.

The thanks of the Institute for the kindness shown were conveyed by the Hon. Secretary.

Visit to the New Reservoirs of the Metropolitan Water Board at Chingford.

Saturday, May 24, 1913.

On Saturday, May 24, a large party assembled at the new Chingford Reservoirs and Pumping Station of the Metropolitan Water Board, on the occasion of a combined visit of three Societies, the Institute of Marine Engineers, the Junior Institution of Engineers, and the Association of Engineers in Charge.

The chief objects of interest were the five large Humphrey pumps on the internal combustion principle, the first of their kind which have been recently installed, and the visitors were favoured with the presence of Mr. H. A. Humphrey, the designer of the pumps, who, in the course of the afternoon, gave a brief description of them to a large audience in the pump house.

The whole series of pumps will only be required to work when there is sufficient surplus water in the River Lea available, and on the occasion of the visit only one of the pumps was shown at work. The combined capacity of the pumps is 180 million gallons per day, four of them having a capacity of 40 million gallons per day each, and one of 20 million gallons. The type of pump used at Chingford is designed to work advantageously with a low lift, the lift in this instance being about 25 to 30 ft. The pumps work on the four cycle principle. On the mixture of gas and air being exploded in the combustion chamber, the column of water in the pipe is forced along, with the result that the air is expanded and the pressure falls to below that of the atmosphere, and a further supply of water is automatically admitted to the pump. The exhaust gases are driven out on the return stroke. A second out-stroke follows, in which a fresh charge is admitted, and the cycle is completed with a return stroke which compresses and fires this charge. The cylinders of the larger pumps are 7 ft. in diameter, and develop 250 to 350 horse power. The explosion chamber heads are composed of cast steel; below these are the water suction valve boxes, connected by a bend and a 6 ft. pipe to vertical steel towers in an adjoining building. From these water towers, 4 ft. pipes convey the water to the reservoir, into which it flows in a steady continuous stream over a granite terrace. The water towers receive 15 to 20 tons at a time from each pipe at each explosion, and the rise and fall of water in the towers enables the intermittent delivery to be converted to a continuous delivery.

The enormous reservoir, which has a capacity of 3,000 million gallons of water, and an area of 416 acres, impressed the visitors with its magnitude.

A cordial vote of thanks was accorded to Mr. Humphrey on the proposal of Mr. M. A. Tookey (Junior Institution of Engineers).

The thanks of the party were also accorded to Mr .W. B. Bryan, Chief Engineer to the Board, through whose courtesy the visit was arranged, and to Mr. Deveral, the Resident Engineer, on the proposal of Mr. A. H. Mather (Institute of Marine Engineers), seconded by Mr. A. E. Penn (Association of Engineers in Charge).

Visit to the General Steam Navigation Co.'s S.S. "Fauvette."

Friday, June 5, 1913.

Through the courtesy of the General Steam Navigation Company, a party of members, on Friday evening, June 5, made a visit of inspection to the Company's Steamer "*Fauvette*," at present engaged in the London-Bordeaux service. The vessel, which is the latest addition to the Company's fleet, has been constructed and fitted throughout on a generous scale, and with commendable forethought for the comfort of passengers and the expeditious handling of cargo.

Built by Messrs. Sir Raylton Dixon and Company, Ltd., of Middlesborough, and engined by Messrs. The North Eastern Marine Engineering Company, Ltd., of Wallsend, the "*Fauvette*" is a single-screw steamer of 315 ft. length, 44 ft. breadth, and 18 ft. 6 in. depth, and a gross registered tonnage of 2,670 tons. She is classed at 100 A1, with shelter deck, above which amidships are bridge and boat decks respectively. The cellular double bottoms, which extend nearly the whole length of the ship, also a large fore peak tank, are used for water ballast. Sub-division is effected by means of five transverse watertight doors.

The triple expansion engines are of 3,300 I.H.P., with cylinders of 28 in., 46 in. and 76 in. diameter, and 48 in. stroke, and a speed of over 15 knots was attained on the trial trip in August last. A Contraflo condenser, Edwards' air pump, Hall's CO_2 refrigerating machine, and two 100 kilowatt machines for the electrical gear, with switchboards, form part of the engine room equipment. Steam is supplied by three single-ended boilers.

One of the most interesting features in the vessel is the complete installation of electrically operated windlass, cranes, winches, capstans, etc., supplied by Messrs. Clarke, Chapman and Company, Ltd.

The windlass has two cast iron cable holders, each suitable for working two 1-15/16 in. diameter cables. The cable holders have a positive clutch action for hauling, by which the whole of the power is transmitted direct to the cables. The gearing is of the worm and spur type.

The six cranes, each with a lift of $1\frac{1}{2}$ tons at 120 ft. per minute, or 3 tons at 60 ft., are of the two-motor type, the hoisting and slewing motions each being operated by a separate motor. These also are fitted with the worm and spur gear.

There are two capstans, and each barrel has two diameters, the larger diameter at the bottom being necessary to give room for the gear case; this also gives a quick speed necessary for hauling in slack rope. They give a pull of 3 tons at 40 ft. per minute. There are two winches, one with a lift of 5 tons at 60 ft. per minute, or $2\frac{1}{2}$ tons at 120 ft., and the other of 3 tons at 60 ft. per minute, or $1\frac{1}{2}$ tons at 120 ft.

The pressure of supply from the 100 kilowatt power generating plants is 220 volts, and from the lighting plant 110 volts. The power installation is quite separate from the lighting installation, both as regards wiring and machines.

The absence of deck steam pipes is a noticeable feature, and the silent running and absence of vibration are distinct advantages in a passenger vessel of this description.

The masthead, stern, anchor and side lights are all electrically operated, and are connected to an electric ship log in the captain's room. The vessel is equipped with a wireless telegraphy outfit, and in many other directions bears witness to the thoroughness with which modern improvements have been adopted.

The party was hospitably entertained to tea in the spacious dining saloon, and at the conclusion of the visit a vote of thanks was heartily accorded to the Company on the proposal of Mr. W .T. Seaton, seconded by Mr. A. H. Mather; also to Mr G. L. Florence, Engineer-in-Chief to the Company, under whose guidance the inspection was made.

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Visit to the Works of Messrs. R. Gay & Co., and Robt. Ingham Clark & Co., Stratford.

Saturday, June 6, 1913.

On Saturday, June 6, a visit of inspection was paid to the Paint and Varnish Works of Messrs. R. Gay and Company, Ltd., and Robert Ingham Clark and Company, Ltd., Stratford.

The works are situated on the site of the old abbey of Langthorne, and a portion of the old abbey wall, dating from the year 1134, forms a small part of the surrounding wall of the works.

The firm of Robert Ingham Clark and Company, Ltd. enjoys a high reputation for the quality of varnish produced, and it was this part of the works which proved of especial interest. It consists of about 25 buildings of moderate dimensions, so constructed that the windows of one building do not face those of another. This formation is adopted in order that any building may be readily isolated in case of fire, and a very efficient and well equipped works fire brigade is a further precaution against such an event.

Previous to the inspection of the works, the visitors were shown various specimens of the fossilised gum, which forms the basis of the varnish. These gums are in a fossil form up to 2,000 and 3,000 years old, and require a temperature of about 600° F. to melt.

After visiting the gum stores, containing supplies of varying qualities and colours, the running or boiling room was inspected. Large copper cauldrons containing the gum are placed over sunken fires at a high temperature. About 25 per cent. of the material is given off in fumes, which are drawn through pipes by means of electrically driven fans. These fumes are condensed, and the residue sold for commercial purposes. The remaining liquid, after a process of filtering and straining, is conveyed to the maturing warehouses, which have a total tank capacity of 500,000 gallons, where it is left for a period of from 9 to 12 months, to settle and mature. The total output of varnish from the factory is about 500,000 gallons per annum, and of this a large quantity is exported, the Colonial and Continental warehouses showing the extent of the business done apart from the home trade.

The manufacture of the "Pearline" enamel was then shown, the mixing, grinding, and other machines being electrically operated. The preparation of linseed oil was also a process which excited much interest.

The paint factory of Messrs. R. Gay and Company, Ltd., in which 250,000 gallons are produced annually, was next visited, and an opportunity was given of seeing the various processes of manufacture. A speciality in this department is the orange red lead made by the firm, which, in addition to having special preservative qualities, retains its original colour for long periods under exposure to the weather. The firm also specialises in the manufacture of zinc white paint for decorative purposes, and this also was shown in process of manufacture.

In the handsome exhibition room were seen beautiful specimens of the work accomplished with materials manufactured by the firm, also specimens of the raw materials, etc.

A photograph of the party was taken, after which refreshments were generously provided. A vote of thanks to the Company, and to Mr .R. S. Clark, Mr. T. W. Bamford, and other gentlemen, under whose guidance the visit was made, was heartily accorded on the proposal of Mr. Jas. Adamson (Hon. Secretary), seconded by Mr. Jas. Shanks.

Visit to the Marconi Co.'s Works at Chelmsford.

Saturday, June 14, 1913.

On Saturday, June 14, a large party from the Institute of Marine Engineers visited the Chelmsford Works of Messrs. Marconi's Wireless Telegraph Company, Ltd.

The Works were originally established in 1893, but the rapid increase in business necessitated extensions, until, ultimately, a new site comprising about 10 acres was secured, on part of which were erected, in the early part of 1912, workshops to accommodate the 700 persons employed, and of dimensions which give an idea of the extent to which this new industry has been developed.

The workshops occupy a space about 460 ft. long by 150 ft. wide. They are lofty and well-lighted ; a large number of wooden shafts in the roof form a very efficient means of natural ventilation; and the heating is very adequately effected by means of low pressure hot water radiators. For protection against fire, water sprinklers are fitted throughout, and by an ingenious arrangement the doors connecting the various departments are automatically closed through the rise in temperature.

The water supply is obtained from a 450 ft. borehole, and is conveyed to a water tower, in which is a tank of 8,000 gallons capacity.

The first department visited was the mounting room, where coils of various sizes were seen in course of construction; also various field sets for military work. In another section were seen condensers in various stages of progress. These are in the form of a number of sheets of tinfoil, separated by waxed paper, the alternate sheets of tinfoil being connected so as to form two separate areas.

Most of the fittings required are made in the works, and the machine shop, which contains a large number of machines of various descriptions, is roomy and well laid out, with a view to facility in turning out the work. All the machines are electrically driven, the power being obtained from the works power station, which is equipped with De Laval turbines.

The two steel masts for the aerials, 470 ft. in height, are a conspicuous feature of the works. They are 4 ft. 6 in. in diameter up to a height of 450 ft., and are made of $\frac{1}{2}$ in. pressed steel in sections of 15 ft., the distance between them being 700 ft.

After looking through the carpenters' shop, mounting shop and stores, some time was spent in the testing room, which is very completely equipped. The generating plant in this section includes two 30 kilowatt motor generators, a 50 horse power motor, 2 kilowatt converter, giving 100 volts at 50 periods; a 3 kilowatt motor generator, giving 300 volts; a $\frac{1}{2}$ kilowatt motor, coupled to a Duddell high periodicity generator, giving from 500 to 2,000 periods, with a maximum speed of 9,000 revolutions per minute; an alternating current generator of 10,000 volts, and 2 direct current machines, giving 3,000 volts.

There are six alternating current testing panels, for $1\frac{1}{2}$, 3, 5, 15, 30 and 60 kilowatts respectively; also six direct current distribution boards for up to 3,000 volts circuits, and six high tension 3 terminal boards, for connecting to a voltmeter, reading up to 30,000 volts.

A series of 36 tin plates hung on porcelain insulators in the roof of the building form an artificial aerial of variable capacity, resistance and inductance; and four large oil baths, containing galvanised steel plates, form another artificial aerial for measuring energy losses. An apparatus which will dissipate 20 kilowatts and will stand a pressure of 100,000 volts, is installed to represent the energy lost by radiation in aerials. A Duddell oscillograph shows voltage and current-wave forms and the distorting effect of sparking; and a large number of other instruments are used for tests of various kinds, the majority of which are of a special nature, and are designed by the Marconi Company's staff.

Demonstrations and explanations were given of the various instruments under working conditions, including a $\frac{1}{2}$ kilowatt set as used on cargo vessels. Ships' installations are supplied up to the 15 kilowatt sets used on the large passenger liners.

In one of the silence boxes in the instrument room, a number of the party had an opportunity of hearing messages transmitted from vessels at sea and from other stations.

The office buildings, which are constructed of brick, with stone facings, are well designed and well equipped. In one of the rooms the visitors were hospitably entertained to tea, and afterwards a very hearty vote of thanks was accorded to the Company and to the various assistants whose explanations had assisted in making the visit of such an interesting nature.

Mr. John McLaren (Member of Council) proposed the vote of thanks, which was seconded by Mr. J. E. Elmslie (Member), and responded to on behalf of the Company by Mr. Eddington.

Visit to the Gerrard Telephone Exchange.

Saturday, September 6, 1913.

On Saturday, September 6, members of the Institute of Marine Engineers paid a visit to the Gerrard Telephone Exchange, Shaftesbury Avenue, London, W.C.

The Exchange is worked on the Central Battery system, the main features of which are that, signalling the Exchange is done automatically by the act of lifting or replacing the telephone receiver; glow lamps are used on the switchboard instead of the old form of indicators; and the current for working these and all subscribers' instruments is supplied by the power plant in the Exchange.

All lines enter the Exchange by means of lead covered dry core cables, which terminate on the vertical side of a main distributing frame. As the lines do not necessarily appear in numerical order, they are arranged in proper order according to subscribers' numbers by being cross-connected to the opposite side of the main frame, called the horizontal side. By means of other cables the lines are thence connected to an intermediate frame for the purpose of so distributing the subscribers' lines among the various operators' positions as to equalise the work.

In another part of this room are the relay racks. When the telephone receiver is lifted off the rest, a connection from the central battery is completed through a relay. This relay is thereby actuated, and completes a circuit through which the current flows to the little glow lamp in front of the operator, which acts as a calling signal. Directly the operator sees the lamp light up, she connects to the corresponding line and asks the caller what number is required. The act of plugging on to the line brings another relay into operation which extinguishes the calling lamp. Other relays control the lamps, known as the supervisory signals, which, by glowing, indicate to the operator when the subscriber has hung up the receiver.

Registers consisting of an electro-magnet operating a train of gearing, and dials are used for recording effective calls. Each operator has at her command seventeen pairs of cords, each of which can be used for making a connection. Corresponding to each pair of cords is a button which is pressed on the completion of the telephone conversation.

In a section at the end of the apparatus room is the central battery, the current being obtained from one or other of the two dynamos installed, and these are coupled direct to motors which obtain their energy from the electric power supply mains.

Some 12,000 lines, comprising subscribers' exchange circuits, junctions and private lines, pass through the test room. A staff of specially trained and skilled men is employed to anticipate trouble, as far as possible, on this mass of wires, and to do all the necessary testing when trouble occurs. With the aid of the very delicate testing instruments employed, the test clerks are enabled to say exactly what the nature of the trouble on the circuit is, and in most cases to direct the faultsman to the exact spot where the breakdown has occurred.

In the operating room is a switchboard consisting of eighty-eight operators' positions, on each of which is a large number of small lamps to indicate the calls. Adjacent to each lamp is a "jack" connected with the same subscriber's line, and on each position are seventeen pairs of cords, terminating in plugs, with which the desired connection is made. Above the subscribers' "jacks" and lamps is the "multiple," a most important feature of the Exchange, consisting of 10,000 "jacks" connected to the different subscribers on Gerrard Exchange, and another 1,000 in connection with the junctions to other exchanges in the Metropolitan area, all being repeated or multiplied round the switchboard, so that each operator has before her and within her reach every subscriber's line connected to her own exchange and every junction line to all other exchanges.

Supervisors are employed to maintain discipline and to see that operators perform their duties properly, and, if necessary, to assist them in this.

The visit was conducted under the guidance of Messrs. Gregory and Oldham, whose explanations and demonstrations of the various instruments were much appreciated.

The thanks of the party were expressed by Mr. Jas. Adamson (Hon. Secretary).

The following extracts from the paper read by Prof. Hopkinson to the Institution of Mechanical Engineers are printed by the kind permission of the author and of the Institution. This paper bears upon, and amplifies by description of the process, the reference made by Dr. Dugald Clerk in his lecture, extracts from which were given in our previous issue:—J.A.

A New Method of Cooling Gas Engines.

A paper was read by Professor Bertram Hopkinson, F.R.S., Member, of the University of Cambridge, before the Institution of Mechanical Engineers, at Cambridge, 29 July, 1913, on the above subject.

Starting with the problem of cooling, the following extracts indicate some of the chief points:—Hitherto (except the small air-cooled engines) the removal of the heat due to the heat-flow from the hot gases into the cylinder walls has been effected by the circulation of water round the cylinder and (in large engines) in the substance of the piston and exhaust valve. About 30 per cent. of the heating value of the fuel passes into the metal of the engine in this way.

In order that the heat may be caused to flow from the inner surface of the metal where it enters, to the outer surface where it is removed, there must be a difference of temperature between these surfaces proportionate to the thickness, the necessary difference being of the order of 50° Cent. per inch thickness of metal. In consequence of the dangers of overheating it has been found impossible to work gas engines, especially of large size, continuously, at the maximum power which they can develop; it it were possible the cost per horse-power would be reduced by from 20 per cent. to 40 per cent. By applying the cooling medium on the inside of the cylinder instead of to the outer surface it seems fairly obvious the difficulties can be overcome. If water can be injected internally against the surfaces to be cooled the heat is removed on that side of the metal on which it is generated, and therefore there is no heat-flow through the metal. The water may be distributed by means of jets, and the engine can be maintained at substantially the same temperature all over. A simple single walled casting can be used for the cylinder, and the arrangements for cooling the piston can be dispensed with. Finally, pre-ignitions are entirely prevented, for even a thick deposit of carbon being cooled by the projection of water against the vessel into which the heat flows is kept at a temperature much below that full red heat which is necessary to fire the charge.

The most important condition to be satisfied, if the injected water is to act as an effective cooling agent, is that it must be projected in comparatively coarse drops or jets directly against the surfaces to be cooled, so that it reaches these surfaces in the liquid form without much loss by evaporation on the way. Further, it must be distributed properly so that each portion of the metal receives water in proportion in which it receives heat. It is of no use to inject the water in a fine spray produced by an atomiser or to introduce it into the gas or air pipe. It is necessary to project the water positively and directly against the metal surfaces by means of properly arranged nozzles in a rose projecting into the combustion chamber.

Most producer-gas contains a certain proportion of sulphur dioxide which readily dissolves in cold water forming sulphurous acid, which would rapidly destroy the cylinder walls by corrosion if these are allowed to become and remain wet, even if the gas does not contain sulphur dioxide, liquid water spoils the working of the engine by washing away the lubricant.

When the author first began to consider the use of internal injection as a means of cooling, these difficulties of corrosion and lubrication seemed to be an insuperable bar, until it occurred to him that they could probably be overcome by the simple device of regulating the amount of water injected in such a way that the temperature of the whole of the engine is kept well above 100° Cent. That corrosion may be completely prevented in this way has been proved by actual trials, of which particulars are given in the paper. From experiments it seemed likely that for practical purposes the heat-flow into the barrel of the cylinder during the last three-fourths of the expansion stroke might be so small compared with that in the first period that direct cooling of this portion of the cylinder could be dispensed with altogether. This anticipation has been found to be correct. It is sufficient to inject water on to the surface of the combustion-chamber and the head of the piston only. There is no jet on to the exhaust valve, as it has been found that the drip from the rose is sufficient to keep this cool.

A section of a cylinder with water injection rose is given. Then follows a description and trials of a 50 B.H.P. Crossley engine.

This experimental engine has been worked for some thousands of hours, no trouble has arisen, and the absence of pre-ignition is noteworthy. The water used is very hard, containing $25\frac{1}{2}$ grains to the gallon, so that the surface of the combustion-chamber and the face of the piston have become thickly encrusted with salts.

Cambridge coal-gas was used, and the engine used 15 cubic feet per B.H.P. per hour, being practically the same as it burnt when developing the same power when jacketed.

The engine was run continuously for 120 hours and developed during this period 43 B.H.P. on the average. When jacketed it would not develop more than 40 B.H.P. continuously without overheating.

The quantity of water used was on the average 2·4 lb. per B.H.P. hour, and when the engine was stopped at the end of the trial the inside of the combustion-chamber was found to be perfectly dry. When the engine was jacketed and giving the same power for short periods, the water jacket removed about 67,000 B.T.U. per hour, which would be sufficient to evaporate 108 lbs. of water at a temperature of 20° Cent. under atmospheric pressure against 102 lbs. per hour with water injection. After the trial the engine was put to drive a factory dynamo. Its speed was increased from 180 to 195 revs. per minute. At times it developed 50 B.H.P. with coal-gas for several hours together, being an increase of 25 per cent. on the maximum continuous load which it could safely carry when jacketed. Since then it has been employed at Cambridge with a suction producer, and has been in regular work for two years, the total running time being 5,000 hours. Anthracite coal is used in the producer, and although there has been no corrosion in the engine the nozzles were at first found to corrode away rapidly. After many trials a suitable material has been found which lasts very well. Lubrication has been entirely satisfactory, and the combined wear on cylinder and piston together in the course of 4,000 hours has nowhere exceeded 1-100th inch.

The ordinary working temperature of the cylinder is about 160° Cent., but it will work satisfactorily between 120° and 200° Cent., chiefly in order to minimise the inconvenience of a stoppage, because even in a 36in. cylinder it has been found that no serious harm has been done by shutting off the water supply—the engine is provided with a fusible plug, screwed into the wall of the combustion-chamber, which melts if the temperature rises above about 200° Cent. and the escaping gases warns the attendant.

Trials were also made with this new system of cooling on large engines—one an engine of 18½in. bore giving from 105 B.H.P., the other a 1,000 horse-power Oechelhauser engine of 36in. bore. In each case the water was simply run out of the jackets, the injection rose fitted, and the engine put again to ordinary duty. With no water in the jackets or piston of the large engine the temperature of every part when on full load could be kept between 100° and 200° Cent. The engine was taking full load within a few hours of fitting the apparatus, and ran for 30 hours without a stop. After stopping for a short time for adjustments, it ran continuously for 70 hours taking the ordinary working load, which would fluctuate about an average of 800 B.H.P. The quantity of water used was about 2·4lb. brake horse-power per hour, and it is interesting to note that this quantity seems almost independent of the size of the engine.

The trials of this large engine proved that the largest cylinders now built can be cooled entirely by water injection if applied in accordance with the principles enunciated. The whole apparatus cost about £20, and within a few hours of fitting it on the engine it was doing all the work of complicated and costly plant—cooling tower, centrifugal pumps, 8in. water mains necessary for the cooling service of an engine of this size when jacketed.

A new engine which embodies all the experience gained is now undergoing trials. It is a 2-cycle single acting engine, 18in. diameter by 24in. stroke with separate gas and air pumps, and is cooled entirely by water injection.

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SESSION 1913-14.

President: THOMAS L. DEVITT, Esq.

"Titanic" Engineering Staff Memorial.

*This Fund now amounts to £2,566 5s. 0d., the interest of which will form the nucleus of a benevolent fund, to which donations are invited yearly for the purpose of assisting the widows and orphans of members of the Engineering Staff who may be left unprovided for, and by whom help is required in respect to placing children in an orphanage or otherwise.—J.A.

The full list of steamers from which subscriptions have been received to date, is given below.

Abangarez
Afghanistan
Alert
Amarapoora
Anglian
Anhui
Arabia
Arabistan
Arawa
Argu
Armanistan
Ascot
Atenas
Ava
Ayrshire
Bahadur
Bankura
Barala
Bargora
Baroda
Baron Garioch
Barrow
Beacon Grange
Beckenham
Bellona
Beltana
Berbera
Beryl
Bhamo
Blackheath
Blackrock
Borderer
Buteshire
Cadillac
Cairngorm
Caledonia
Cambria
Camio
Canadian Government Steamers:
- Aberdeen
- Curlew
- Druid
- Earl Grey
- Governor Cobb
- Lansdowne
- Lady Laurier
- Montcalm
- Stanley

Caradoc
Carpentaria
Cartago
Castor
Ceiba
Centipede
Cervona
Ceylon

* £300 having been used towards the erection of a Memorial at Southampton. A Memorial will also be placed in the premises of the Institute.

Champion
Chanda
Changsha
Chihli
China
Chindwin
Chinhua
Chinkiang
Chiswick
Chupra
Chyebassa
City of Corinth
City of Edinburgh
City of Poona
City of Vienna
Cobra
Colaba
Colonia
Commonwealth
Cornelian
Crane
Culna
Cumbria
Dargai
Delaware
Demosthenes
Devon
Devona
Durham
Eden Hall
Emerald
Empire
Envoy
Epsom
Essex
Estrellano
Euphrosyne
Excelsior
Falls of Monero
Fatshan
Fengtien
Fingal

Fooshing
Frankmere
Fremona
Garesfield
Geelong
G.E.R. Steamers
Gibel Dersa
Gibel Kebra
Gibel Tavik
Gibel Zedid
Girasol
Glenlogan
Glenroy
Golconda
Gordonia
Guelph
Gwendolen
Haiyang
Hampstead
Hangchow
Henzada
Heredia
Heungshan
H.M.S. Amethyst
H.M.S. Bacchante
H.M.S. Bellerophon
H.M.S. Black Prince
H.M.S. Canopus
H.M.S. Dartmouth
H.M.S. Defence
H.M.S. Derwent
H.M.S. Electra
H.M.S. Fervent
H.M.S. Garry
H.M.S. Gloucester
H.M.S. Implacable
H.M.S. Kestrel
H.M.S. Lightning
H.M.S. Majestic
H.M.S. Ness
H.M.S. Rattlesnake
H.M.S. Recruit

H.M.S. Renard
H.M.S. Ringdove
H.M.S. Sphinx
H.M.S. Torch
H.M.S. Zebra
H.M.T.B.D. Brazen
H.M.T.B.D. Coquette
H.M.T.B.D. Cynthia
H.M.T.B.D. Porcupine
H.M.T.B.D. Vulture
H.M.T.B.D. Zephyr
H.M.T. Boats Nos. 071, 079, 3, 6, 7, 8, 9, 10, 11, 12, 17, 18, 19, 20, 23, 30, 112, 113, 114, 115
Highland Brae
Highland Pride
Highland Warrior
Himalaya
Hindu
Henley
Hoihow
Hoisang
Honam
Horlington
Hsin Pekin
Huichow
Hunan
Hupeh
Hurona
Hurunui
Hydra
Ichang
Ilford
Inanda
India
Ingeli
Inkosi
Insizwa
Intaba

Iona
Irene
Iroquois
Irrawaddy
Islanda
Jacona
Jaffa
Jelunga
Joseph Vaccaro
Kadett
Kaifong
Kaikoura
Kaipara
Karamea
Karanja
Kariba
Karma
Karonga
Karuma
Katuna
Khartoum
Kia Ora
Kian
Kinling
Kinshan
Kioto
Kistna
Kola
Kueichow
Kumara
Kurrachee
Kutsang
Kyanite
Lady McCallum
Lake Erie
Lake Michigan
Laura
Leversons
Lewisham
Lhassa
Liangchow
Linan
Lindula
Linga
Lintan
Lord Cromer
Luen Yi
Lunka
Mackinaw
Magnet
Makarini
Malda
Maloja
Malta
Mamari
Mandalay
Manitou
Mantua
Marmora
Martaban
Massapequa
Matatua
Matiana
Mazagon
Media
Mermaid
Milleped
Miltiades
Milwaukee
Mimiro
Min
Minneapolis
Minnehaha
Minnewaska
Moldavia
Mombassa
Monmouth
Montcalm
Montezuma
Montfort
Montreal
Montrose
Mooltan
Morayshire
Morion
Mount Royal
Mount Temple
Muttra
Namur
Nanning
Narragansett
Nephrite
Ngan Kin
Nile
Ningpo
Nore
Norfolk
Nubia
Nyanza
Nyasaland
Omrah
Opawa
Ophia
Orama
Orari
Orontes
Orvieto
Osterley
Otaki
Otranto
Ottawa
Otway
Pakeha
Palamcotta
Palawan
Palermo
Palma
Parisima
Patrol
Pera
Persia
Perthshire
Peshawur
Plasma
Plassy
Ploussa

Poona	Shantung	Themistocles
Poyang	Shasi	Thongwa
Prase	Shenandoah	Tongariro
Prince Rupert	Shropshire	Triton
Prometheus	Shuntien	Trocas
Pundua	Siangtan	Tung-ting
Purnea	Sicilian	Twickenham
Putiala	Simla	Ula
Pyrope	Singan	Umballa
Queda	Siren	Umta
Rakaia	Socotra	Umtali
Rangatira	Somali	Usworth
Ready	Soudan	Vadala
Recorder	Star of Scotland	Vestal
Remuera	St. Albans	Volute
Rhesus	Stella	Wai Shing
Rio Squassa	Sumatra	Waimana
Rosina	Sunda	Waimate
Rotorua	Sungkiang	Waipara
Royal Edward	Sui-An	Waiwera
Royal Scot	Sui-Tai	Wallaroo
Ruby	Suwanee	Walter Dammayer
Sagenite	Swarka	Warden
Sanui	Szechuan	Warwickshire
Sard	Tainui	Willesden
Sardinia	Taiyuan	Wiltshire
Satellite	Talavera	Wing How
Seistan	Taming	Winlaton
Seldanha	Tamsui	Woodford
Sentinel	Tean	Yoro
Servian	Tenasserim	Zaida

———o———

If the candidate has not served at all as apprentice Engineer or as journeyman, he will be required to have served at sea, in lieu thereof, as Engineer on regular watch on the main engines or boilers, six years in a foreign-going steamer of not less than 66 nominal horse-power, or nine years in a home-trade steamer of not less than 66 nominal horse-power.

(*b*) (i.) In addition to the apprenticeship as above described, or the alternative sea service, the applicant must have served one year at sea as engineer on regular watch on the main engines or boilers of a foreign-going steamer of not less than 66 nominal horse-power; or eighteen months in a home-trade steamer of not less than 66 nominal horse-power.

(ii.) On and after January 1st, 1915, the applicant will be required, in addition to the apprenticeship above described or the alternative sea service, to have served eighteen months at sea as Engineer on regular watch on the main engines or boilers of a foreign-going steamer of not less than 66 nominal horse-power; or twenty-seven months in a home-trade steamer of not less than 66 nominal horse-power.

(*c*.) He must be able to give a satisfactory description of boilers, and the methods of staying them, together with the use and management of the different valves, cocks, pipes, and connexions.

(*d*.) He must understand how to correct defects from accident, decay, &c., and the means of repairing such defects.

(*e*.) He must understand the use of the water gauge, pressure gauge, barometer, thermometer, and salinometer, and the principles on which they are constructed.

(*f*.) He must be able to state the causes, effects, and usual remedies for incrustation and corrosion.

(*g*.) He must be able to explain the methods of testing and altering the setting of the slide valves, and method of testing the fairness of shafts and adjusting them.

(*h*.) He must be able to calculate the suitable working pressure for a steam boiler of given dimensions, and the stress per square inch on crank and tunnel shafts when the necessary data are furnished.

(*i*.) He must understand the construction of steering engines, evaporators, feed filters, and feed heaters.

(*j*.) He must understand the construction of centrifugal, bucket, and plunger pumps, and the principle on which they act.

(*k*.) He must be able to state how a temporary or permanent repair could be effected in case of derangement of a part of the machinery, or total break down.

(*l*.) He must write a legible hand, and have a good knowledge of arithmetic up to and including vulgar and decimal fractions and square root. He must also understand the application of these rules to questions about safety valves, coal consumption, consumption of stores, capacities of tanks, bunkers, &c.

(*m*) He must be able to pass a creditable examination as to the various constructions of paddle and screw engines in general use; as to the details of the different working parts, external and internal, and the use of each part.

(*n*.) He must possess a creditable knowledge of the prominent facts relating to combustion, heat and steam.

27. First-Class Engineer.—A candidate for a First-class Engineer's Certificate must be not less than 22 years of age.

In addition to the qualifications required for a Second-class Engineer,

(*a*.) (i.) He must:—

(1) have served at sea for 12 months, with a Second-class Certificate of competency or service, on regular watch on the main engines or boilers of a foreign-going steamship of not less than 99 nominal horse-power, as senior engineer in charge of the whole watch; or

(2) have served at sea for 18 months, with a Second-class Certificate of competency or service, as First Engineer of a home-trade steamer of not less than 99 nominal horse-power; or two years with a Second-class Certificate of competency or service as Second Engineer of a home-trade steamer of not less than 99 nominal horse-power; or

(3) have served two-and-a-half years with a Second-class Certificate of competency or service as Third Engineer of a home-trade steamer of not less than 99 nominal horse-power, if, during the whole of

that period, he has been the senior engineer in charge of the whole of a watch on the main engines and boilers; or

(4) possess, or be entitled to, a First-class Certificate of service.

(ii.) On and after January 1st, 1915, the candidate will be required, in addition to the qualifications required for a Second-class Engineer.

(1) to have served at sea for 18 months, with a Second-class Certificate of competency or service, on regular watch on the main engines or boilers of a foreign-going steamship of not less than 99 nominal horse-power, as senior engineer in charge of the whole watch; or,

(2) to have served at sea for 27 months with a Second-class Certificate of competency or service as First Engineer of a home-trade steamer of not less than 99 nominal horse-power; or three years with a Second-class Certificate of competency or service as Second Engineer of a home-trade steamer of not less than 99 nominal horse-power; or

(3) to have served three years nine months with a Second-class Certificate of competency or service as Third Engineer of a home-trade steamer of not less than 99 nominal horse-power, if, during the entire period, he has been the senior engineer in charge of the whole of a watch on the main engines and boilers; or

(4) to possess, or be entitled to, a First-class Certificate of service.

The service described in paragraphs 47, 48, 49, and 50 of the regulations may as heretofore be accepted as qualifying for examination in accordance with the conditions specified in those paragraphs.

(*b.*) He will be required to make an intelligible hand sketch, or a working drawing of some one or more of the principal parts of a steam-engine, and to mark in, without a copy, all the necessary dimensions in figures, so that the sketch or drawing could be worked from.

(*c.*) He must be able to take off and calculate indicator diagrams.

(*d.*) He must be able to calculate safety-valve pressures and the strength of the boiler shell, stays, and riveting.

(*e*.) He must be able to state the general proportions borne by the principal parts of the machinery to each other, and to calculate the direct stress, the torsional stress, and the bending stress in round bars, and the direct stress and the bending stress in rectangular bars with given loads.

(*f*.) He must be able to explain the method of testing and altering the setting of the slide valves, and to sketch about what difference any alteration in the slide valve will make in the indicator diagram, and also the method of testing the fairness of shafts, and of adjusting them.

(*g*.) He must be conversant with surface condensation, superheating, and the working of steam expansively.

(*h*.) His knowledge of arithmetic must include the mensuration of superficies and solids and the extraction of the square and cube roots, and the application of these rules to questions relating to the power, duty, and economy of engines and boilers, and to the stresses in rods, shafts, and levers of the engine. He should also be able to calculate the effect of the application of the lever, pulley, inclined plane, and other mechanical powers.

(*i*.) He must understand the construction of, and be able to maintain in working condition the auxiliary machinery which is placed under his charge, viz.: refrigerating machinery, electric light engines and dynamos, electric motors fitted to ships' boats, hydraulic machinery, and the various descriptions of steering engines, &c.

28. First-Class Certificates without Second.—The Board of Trade may see fit to allow an applicant who, in consequence of service abroad, has had no opportunity to obtain a Second-class Certificate, to be examined for a First-class Certificate, although he does not possess a Certificate of the lower grade, provided he is able to satisfy them as to the satisfactory character of his services, but these should be ample both as regards length and experience.

If any candidate, who has not got a Second-class Certificate of Competency, fails to pass the examination for the First-class Certificate, but passes that for the lower grade, he may be given a Second-class Certificate of Competency, but no part of the fee will be returned. A candidate who has been permitted to be examined for a First-class Certificate without first obtaining a Second-class Certificate of Competency or a Certificate of Service, and who fails in his examination in practical knowledge, may not be re-examined for a Certificate of the higher grade until he has served three months as watchkeeper with a Second-class Engineer's Certificate of Competency or Service as required by the regulations. If the candidate fails in practical knowledge, both for the lower as well as for the higher grade of Certificate, he may be re-examined for a Second-class Certificate only, subject to the usual regulations relating to failure.

29. Extra First-Class Engineer.—This examination is voluntary, and is intended for such persons as wish to prove their superior qualifications, and are desirous of having Certificates for the highest grade granted by the Board of Trade.

30. Extra Examinations, when held.—The extra examinations are held once in every three months, and at ports where examinations of Engineers are ordinarily conducted. The examination extends over several days. According to present arrangements these examinations will begin on the second Tuesday in January, April, July, and October in each year.

31. Notice Required.—Notice must be given by the candidate at least one week before the day on which the examination begins, and these notices must be *immediately* reported by the Examiners to the Chief Examiner in London.

32. Qualifications Required.—A candidate for an Extra First-class Engineer's Certificate must possess a First-class Engineer's Certificate and have served an apprenticeship of five years at least or, as an equivalent, three years' apprenticeship and three years at an approved technical school; or he must have served for one year at sea on regular watch on the main engines or boilers as senior engineer in charge of the whole of the watch while holding a First-class Engineer's Certificate.

(*a.*) He must be able to write good English.

(*b.*) He must possess a thorough knowledge of the construction and working of the different forms of marine engines and propellers in all their parts, and be so far acquainted with the fundamental principles of theoretical and applied mechanics as to comprehend the general principles on which the machine works, and to illustrate his knowledge of these principles by numerical examples.

(*c.*) He must possess a knowledge of the theory of strain and stress sufficient to be able to deduce the ordinary rules for the bending of rectangular bars and for the twisting and bending of round bars.

(*d.*) He must be acquainted with the principles of expansion and the modern theory of heat, and be able to solve, with the assistance of his own books or without books, according as the examination papers may be set, questions in economy and duty in connexion with engines and boilers.

(*e.*) He must understand how to apply the indicator, and to draw the proper conclusions from the diagrams, and to construct the approximate diagrams for any given data.

(*f.*) He must be able to produce, without a copy, a fair working drawing of any part of the machinery with figured dimensions fit to work from.

(*g.*) He must understand the principles of the action of the screw propeller and the paddle-wheel, and must be able to estimate numerically the effect in speed of ship and consumption of fuel due to any alteration in pitch, diameter, revolutions, &c., &c.

(*h.*) He must be able to give a description of boilers and the methods of staying them, and must show that he possesses a knowledge of the theoretical principles which regulate their construction, and that he is able to calculate the strength of the boiler shell, stays, and riveting.

(*i.*) He must understand the general nature of the strains and stresses produced by the steam pressure, and by the expansions due to unequal temperatures in boiler shells.

(*k.*) He must have a knowledge of safety-valve construction, and the principles involved in determining the size of a safety-valve, and the construction of spring-loaded and dead-weight valves.

(*l.*) He must possess a thorough knowledge of the theory of combustion; the chemical composition of fuels; the evaporative duty of fuels of given composition; the production of draught; the effect in regard to economy, safety, and wear and tear, of increasing or of diminishing the proportion of heating surface, of grate bar surface, of area of section of air passages, of area of water surface, of steam space capacity and water capacity.

(*m.*) He must be able to explain the formation of scale and the precipitation of salt, and the precautionary means adopted in respect thereto, with jet condensers, and with surface condensers.

(*n.*) He must understand the general principles involved in the construction of the barometer, thermometer, salinometer, and steam and vacuum gauges.

(*o.*) He must be familiar with the general results obtained from past experience in relation to corrosion, pitting, and galvanic action in boilers, and the use of zinc and of soda in boilers.

(*p.*) He must be able to give a variety of illustrations of how defects have arisen from accident, imperfect construction, or deterioration, and how these defects might have been prevented, and the best way of repairing such defects.

(*q.*) He must be familiar with the properties and processes of manufacturing and testing the ordinary materials used in the construction of machinery and must possess an intelligent knowledge of the properties of the lubricants, boiler cements, and india-rubber in general use in steamers.

(*r.*) He must understand the causes of spontaneous combustion and the formation of explosive gases in coal holds, and the precautionary measures proper to prevent accidents from these causes.

(*s.*) He must be acquainted with the principles and practice of the generation and application of electricity to various purposes on board ship.

(*t.*) He must be able to explain the construction and working of the refrigerating machinery in use on board ship, the electric lighting plant, the steering engines, hydraulic and pneumatic engines, the pumps, and all other auxiliary machinery placed under the Chief Engineer's control.

(*u.*) In order to deal intelligently with ballast tanks, the cocks, valves, and pumps of which are under the Chief Engineer's control, and to co-operate the more readily with the Master in keeping the vessel in a safe condition, especially when she is light, and when coaling operations are proceeding, candidates are expected to possess an elementary knowledge of the stability of floating bodies.

(*v.*) He must possess a practical knowledge of ship construction, and understand the elementary principles involved, so as to be able to deal with engine and boiler seatings and to supervise and direct any repairs that may be required to an iron or steel ship.

If the candidate does not obtain 67 per cent. of the total number of marks allotted for the papers he will be declared to have failed. The papers will be founded chiefly on the foregoing sub-paragraphs.

33. On and after January 1st, 1915, a candidate for either a Second-class or a First-class Certificate who within two years from the date of application to be examined has attended an approved course comprising general mathematical and scientific instruction at a technical school recognised by the Board of Trade as suitable for the training of Marine Engineers, will be allowed to count time so spent as equivalent to sea service in the ratio of three months at the Technical School to two months at sea. Time so spent cannot be accepted as equivalent to more than one-sixth of the total sea service required for either Certificate, but a candidate who has been allowed to count such time on examination for a Second-class Certificate, will not be debarred from counting similar subsequent time on examination for a First-class Certificate.

Time spent in an approved Marine Technical School subsequent to obtaining a First-class Certificate and within two years from the date of application to be examined, may also be accepted as forming part of the qualifying service required under paragraph 32, in the case of candidates for Extra First-class Engineer's Certificates, but if such time is substituted for sea service, it will only count as equivalent thereto in the ratio of three months at the school to two months at sea.

In every case in which an allowance is made for time spent at a Marine Technical School, the candidate will be required to produce the Principal's Certificate for continuous and regular attendance at all the approved classes and for satisfactory progress.

Certificates for Engineers of Home-trade Passenger Ships propelled by Oil Engines.

34. Oil Engine Certificates.—Candidates may be examined for Second-class Certificates of competency as Engineer of vessels propelled by oil engines.

These Certificates will entitle the holders to go to sea as Second-class Engineers of home-trade passenger ships propelled by oil engines but will not entitle them to go to sea as Second-class Engineers of foreign-going ships or of home-trade passenger steamships.

35. Second-Class Engineer (Oil Engines).—A candidate for a Second-class Oil Engine Certificate must be at least 21 years of age.

(*a.*) He must prove:—

(1) four years' experience at the making or repairing of machinery, of which at least six months must be at the making or repairing of oil engines, or

(2) three and a half years' experience in charge of engines and boilers at sea or an equivalent suitable experience on shore.

and, in addition to either (1) or (2):—

(3) six months' experience with oil engines at sea.

Note.—Alternative service to the above may be considered, but it is essential that the candidate should have experience with oil engines, and have spent at least six months at sea in the engine-room of a sea-going vessel.

(*b.*) He must write a legible hand, and have a good knowledge of arithmetic up to and including vulgar and decimal fractions and square root. He must also understand the application of these and other rules to problems relating to spring and lever-loaded relief valves, and be able to solve questions about the relative speeds of a vessel at different revolutions, the capacity of oil tanks, &c.

(*c.*) He must be able to give a clear explanation of the principle on which an oil engine works, and to shew by means of illustrative sketches and otherwise that he understands the construction of those in general use.

(*d.*) He must be able to describe the chief causes which may make the engine difficult to start, and to explain how he would proceed to remedy any defects.

(*e.*) He must be able to show that he understands the mechanism of the starting and reversing arrangement, and is competent to deal with defects which may lead to failure in the prompt handling or reversing of the engine.

(*f.*) He must have sufficient mechanical ability to be able to overhaul the engine, to adjust the working parts, and to put the engine together again in good working condition.

(*g.*) He must be able to give satisfactory answers to the elementary questions numbered 305 to 310 inclusive in Appendix C.

305. Name the principal parts of an oil-motor, and briefly state their functions. Give the name of the makers of the motor.

306. What kind of oil is usually employed in oil-motors? What is its flash-point? What is its specific gravity? What is its calorific power? What precautions are taken in its storage to guard the public against casualty by fire or explosion?

307. How many cylinders are generally used in oil-motors? What kind of pistons are fitted? How frequently (measured in revolutions) is explosion per cylinder effected? How is explosion in the cylinder carried out?

308. Describe how an oil-motor is started. If starting prove difficult, where would you chiefly look for defects? How is piston speed modified? How is the speed of vessel varied? How is reversing effected?

309. Before examining an oil-motor with a naked light, what steps should be taken for safety's sake?

310. How frequently should an oil-motor, working 12 hours a day, be opened up for examination, cleaned, and its parts re-adjusted? What difficulty arises when the internal parts become foul with carbonized oil?

NOTE.—Questions should be read in the light of their context. Thus the "sparking" referred to in question 283 relates to the sparking in an electric lighting circuit on board ship.

(*h.*) He must be able to prove (by actual trial if practicable) that he is competent to manipulate an oil engine when under way by starting, running the engine, stopping, reversing or slowing down.

(*i.*) He must understand what is meant by the flash point, and have a knowledge of the explosive properties of the oil generally used in oil engines when exposed in the open air, and the danger of exposing any vapour from the oil to a light or of allowing any leak from the oil tanks, particularly into the vessel's bilges.

(*j.*) He must understand the action of wire gauze diaphragms when placed in pipes and connections to oil tanks, &c., for the purpose of preventing the explosion or ignition of oil vapour therein.

(*k.*) He must be able to take the necessary precautions to guard against the escape of inflammable vapour from the vaporiser when the engines are stopped.

(*l.*) He must be able to explain the principle and construction of a dynamo and the construction and arrangement of primary and secondary batteries and induction coils, so far as is necessary for the efficient management of an oil engine.

36. WORKSHOP SERVICE.—Workshop service must have been performed in works where steam engines, boilers, &c., are made or repaired, but no time served before the age of 15 will be counted.

Not less than two years of the apprentice time must have been spent at fitting, erecting, or repairing engines and machinery either in the works or outside. The remaining two years may be made up of time spent in engine works at fitting, erecting, or repairing engines and machinery or at one of the other branches of the trade given below, or at an approved technical school (*see* Appendix K); the time so spent to count as follows:—

Fitting, erecting, repairing, or turning	Full time.
Working in drawing office ...	Full time up to one year, and beyond one year one-half time.
Patternmaking	One-half time with a maximum allowance of one year.
Planing, slotting, shaping, and milling.	One-third time.
Boiler-making or repairing	One-half time.
Smith work	One-half time with a maximum allowance of one year.
Coppersmith work	One-third time with a maximum allowance of six months.

In the event of the apprentice time being extended to five years or more, four years at turning *followed* by one year at fitting or erecting may be accepted as qualifying.

37. WORKSHOP SERVICE OTHER THAN THE ABOVE.—When the workshop service has been performed in a place where engines are made, but not in the manner specified in paragraph 36, the case must be referred to the Board of Trade with a report upon the service performed. If the service be such as is useful training for an Engineer, the Board may accept the service; but in every such case the applicant must prove additional engine room or marine engine workshop service as required in the succeeding paragraph.

38. Workshop Service where Engines are not made.—When the workshop service has been performed in a place where steam engines are not made or repaired, and the class of work done is similar to that required in engine making, the service may be accepted with an additional year of qualifying service; that is, four years' workshop service and either two years at sea on regular watch, or one year at engine fitting in a suitable marine engine workshop and one year at sea in the engine room. The approval of the Board of Trade must be obtained in every such case before the candidate is examined.

39. Technical Schools.—Time spent after the age of 15 at a Technical Day School (recognised by the Board of Trade as suitable) where there is an engineering laboratory, may be taken into account and accepted as equivalent to artisan service, usually at the ratio of three years in the Technical School to two in artisan service, provided that the applicant has taken the full engineering course and can produce the Principal's Certificate for regular attendance at all the approved classes and for satisfactory progress; and provided also that the remaining portion of the time has been spent in works where steam engines, boilers, &c., are made or repaired, in accordance with the scale of values indicated above.

For list of Approved Technical Schools and time allowed for attendance at each, *see* Appendix K.

40. Sea-service.—The sea-service required by these regulations is, unless otherwise stated, service performed in foreign-going ships of at least the nominal horse-power specified for the respective grades of Certificate. The nominal horse-power, as given on the vessel's Certificate of Registry, may in all cases be accepted by the Examiners.

41. Qualifying Service defined.—In the case of candidates for First-class Certificates, qualifying service means, as a rule, service on regular watch on the main engines or boilers as Senior Engineer in charge of the whole watch. When, however, three or four Engineers are on watch at the same time the service of the two seniors may be allowed to count, and when not less than six Engineers are on watch together that of the three seniors, provided a certificate from the Superintending Engineer is produced stating the number of Engineers on watch, the rank held by the applicant and that he was in full charge of a watch on a definite section of the main engines or boilers. During the whole of the period claimed, candidates must have been in possession of Second-class Certificates.

In the case of candidates for Second-class Certificates qualifying service means service as Engineer on regular watch on the main engines or boilers. In no case will time spent in clerical work be allowed to count.

42. FURTHER AS TO QUALIFYING SERVICE.—Only such service as gives the experience required to make a man thoroughly competent as a sea-going Engineer is accepted as qualifying service. Even for a Second-class Certificate the candidate must prove to the satisfaction of the Examiner that he is qualified by experience and knowledge to act as Chief Engineer in an under-powered steamer of 99 nominal horsepower on a voyage, say, from England to Egypt, taking full responsibility for engines and boiler.

43. FOREIGN ENGINEERS.—Foreign Engineers cannot be examined for a First-class or Extra First-class Certificate unless they have performed the sea-service stated in paragraphs 27 and 32 respectively, with the requisite British Certificate. The service may have been performed in foreign vessels if the candidate can produce satisfactory testimonials as to conduct and character, and is able to prove that the service has been in the required capacities, and that during the period of service he has held a British Certificate of Competency of the rank required by the Regulations.

44. NAMES ON ARTICLES.—In all cases the candidates' names must have been duly entered on the ship's Articles as Engineers in their proper ratings.

45. REGULAR WATCH.—Being on regular watch means being on watch for at least eight hours a day.

46. HOME-TRADE SERVICE.—Service in the home or coasting trade is regarded as being equivalent to two-thirds of the same period of time served in the foreign trade except where other allowances are specified. *See* paragraphs 27 (*a*) (2) and (3), 47, 49, and 50.

47. LAKE OR RIVER SERVICE.—Service as watchkeeper on a lake or river steamer of not less than 66 nominal horsepower may be accepted under the following conditions:—

(*a*) the service will only count half as much as sea service; *i.e.*, every two months of lake or river service is only equivalent to one month's foreign-going sea service;

(*b*) candidates for Second-class Certificates must prove, in addition to the lake or river service, at least three months' qualifying service at sea in a foreign-going steamship of not less than 66 nominal horse-power, or four and a half months' similar service in the home trade;

(c) candidates for First-class Certificates must prove, in addition to lake or river service in vessels of not less than 99 nominal horse-power, at least six months' qualifying service at sea, with a Second-class Engineer's Certificate, in foreign-going vessels of not less than 99 nominal horse-power or nine months' similar service in the home trade.

48. SERVICE IN AUXILIARY SCREW STEAMSHIPS.—Service performed on board auxiliary screw whalers and other vessels with auxiliary steam power of not less than 66 nominal horse-power, in the capacity of Engineer may be allowed to count towards qualifying candidates for examination for Second-class Engineers' Certificates of Competency to the extent of one-half of the time the vessel is actually at sea. If the candidate is able to prove a larger amount of time under steam, he will be allowed to count the whole of such extended time.

49. SERVICE IN DREDGERS, FISHING-BOATS, TUG-BOATS, OR PILOT-VESSELS.—Service in sea-going steam dredgers, fishing-boats, or tug-boats, and in sea-going pilot-vessels when on their station or when going to or returning from the same, may be accepted under the following conditions:—Two months of such service is only equivalent to one month's qualifying service in a foreign-going steamer. Candidates for Second-class Certificates may perform all their sea service in sea-going steam dredgers, fishing-boats, tug-boats, or pilot-vessels, but they must have been on regular watch on the main engines or boilers, and the vessels must not be less than 66 nominal horse-power. Candidates for First-class Certificates must, while in possession of a Second-class Certificate, have served in vessels of at least 99 nominal horse-power, and have been in charge of a watch on the main engines or boilers. They must, in addition, have served in a qualifying capacity for at least six months in a foreign-going cargo or passenger steamship, or nine months in a home-trade cargo or passenger steamship.

50. SERVICE IN YACHTS.—Service performed in steam yachts, either within or beyond home-trade limits, may be accepted as equivalent to two-thirds of the time performed in foreign-going trading vessels, provided that the candidate's name is entered on the vessel's Articles, and that he can prove, to the satisfaction of the Examiner, that the time claimed was actually served at sea.

Candidates for Second-class Certificates may perform all their service in yachts, but the candidate must have been on regular watch on the main engines or boilers, and the vessel must be of not less than 66 nominal horse-power.

Candidates for First-class Certificates must have served on vessels of not less than 99 nominal horse-power, and must have been in regular charge of the main engines or boilers. In addition they must have served for at least three months in a qualifying capacity on board a foreign-going cargo or passenger steamship. This additional service will, however, not be required in the case of a candidate who has served for 18 months as First Engineer, or for two years as Second Engineer, of a steam yacht of the requisite power.

51. CERTIFICATES OF SERVICE.—An officer who has attained the rank of Engineer Lieutenant or Engineer Sub-Lieutenant in His Majesty's Navy or the rank of Engineer or Assistant Engineer in the Indian Marine Service, is entitled without examination, if an Engineer Lieutenant or Engineer, to a Certificate of Service as First-class Engineer, and if an Engineer Sub-Lieutenant or Assistant Engineer, to a Certificate of Service as Second-class Engineer. These officers may be examined for a Certificate of Competency on the same conditions as Engineers of the Mercantile Marine.

An officer who has attained the rank of Chief Artificer Engineer in His Majesty's Navy is also entitled without examination to a Certificate of Service as Second-class Engineer.

52. EXAMINATION OF ENGINE ROOM ARTIFICERS.—Artificer Engineers, Chief Engine Room Artificers, Engine Room Artificers, and Mechanicians in the Royal Navy may be examined for Certificates of Competency on the same conditions as Engineers of the Mercantile Marine.

53. APPLICATION BY NAVAL OFFICERS.—The Lords Commissioners of the Admiralty have directed that applications from officers of the Navy for Certificates of Service or for permission to be examined for Certificates of Competency must, in the case of officers on the active list, be made through the Commanding Officer to the Secretary to the Admiralty, and in the case of officers who are on half-pay or who have retired, direct to the Secretary to the Admiralty, who in either case will forward the applications to the Board of Trade.

54. MASTERS' AND MATES' EXAMINATION IN STEAM.—Particulars of the examination of Masters and Mates in steam will be found in Appendix G of the full text of the Regulations.

55. CERTIFICATES.—The term "Certificate" in these regulations means a Certificate issued by the Board of Trade, or by a British Possession under Order in Council in accordance with Sec. 102 of the Merchant Shipping Act, 1894. A list of

the Colonial Certificates issued under Order in Council is given in Appendix H; and the holder of a Certificate so issued must not be examined in the United Kingdom for a Certificate of the grade already held.

56. Colonial Local Certificates.—The holder of a Colonial Certificate of Competency not granted under the Merchant Shipping Act, or of a Certificate of Competency granted after examination on board one of His Majesty's Ships, who wishes to be examined for a Board of Trade Certificate of the same grade, must prove that he has performed the amount of service required by these regulations for that grade, and complied with the conditions laid down as to testimonials. No fee will be demanded for the first attempt, but if the candidate fails the usual fee will be demanded on any subsequent attempt.

All Colonial Certificates for marine purposes, whether local or issued under Order in Council, must be given up before a further Certificate is issued by the Board of Trade.

APPENDIX F.

Dangers attending the Existence of a Vacuum in Boilers.

The attention of the Examiners of Engineers is called to the following report relating to a fatal accident to an engineer on board a British ship, and they are requested to see that all candidates for Engineers' Certificates realise the danger of removing a manhole door without taking the necessary precautions.

The *Elderslie* is a screw steamer, built in 1884, of 2,761 tons gross and 1,801 tons net register. The engines are compound, direct-acting, and there are two double-ended boilers of the usual marine type, each boiler having six furnaces, three at each end, W.P. 90 lbs. Mr. E. Marshall, the Third Engineer, was found dead in one of the boilers under circumstances which are not readily understood.

The Chief Engineer, Mr. Bishop, repeated to us a statement which he had previously made, and he was corroborated, so far as his personal knowledge went, by the Second Engineer, and also by a Greek fireman, Spiloni, and the other firemen in the engine room and stokehold at the time. It is clear that on the vessel's arrival at Smyrna on the 14th October, after the fires had died out, the boilers were blown down between 5 and 6 p.m., and by the instructions of the Chief Engineer, the Third

Engineer proceeded at 7 a.m. on the following morning to take the manhole doors off. (The manholes are $16\frac{1}{4}$ inches by $12\frac{1}{4}$ inches, and are in the end plate at the after end of the boiler.) He was assisted by Spiloni, who was usually detailed to work with him, and who says that one nut and one dog or cross-bar had been taken off the door, and the other nut started, when the Third Engineer sent him to prepare to take the door off the manhole of the other boiler. Spiloni left the Third Engineer, went down a ladder into the stokehold, across the stokehold, up another ladder to the starboard boiler, and immediately afterwards, hearing a loud report, went back to the port boiler where he had left the Third Engineer, and saw nothing but that the door was off and not in sight. What happened in the interval between this fireman leaving the Third Engineer and his return in a few minutes can only be reasoned out from the conditions and circumstances of the case, as there is nothing definitely known.

The Engineers and Engineers' crew were at this time engaged as follows:—

Chief Engineer on deck.

Second Engineer in engine room at H.P. cylinder; one fireman with Second Engineer; one fireman with Third Engineer; four firemen cleaning engines, and two trimmers cleaning tubes in boilers.

The Second Engineer in the engine room heard the report—he says, about 7.15 a.m.—and describes it as being like the sound caused by coal falling in the bunkers. The Chief Engineer knew nothing until informed that the Third was missing. Spiloni and others had been looking about and inquiring for him. The Chief joined in the search and finally went to the manhole, when he noticed that the door was off, and not to be seen. He states that the boiler was so hot inside that he could not keep his hand in, and that on trying to put his head in the manhole he found it impossible to do so. Hot vapour was coming out of the manhole. His first thought was that the Third Engineer had allowed the door to drop into the boiler, and, attempting to get it out, had gone into the boiler, and been overcome by the heat. He tried to look in with lamps, &c., but could not see anything. He then got the bottom doors off, first the after bottom door and then the forward one. He could not see anything through the after door, but on looking in the forward bottom door he saw blood on the sides of the furnaces—that is, he explains there was some fresh blood as if running down on the side of the centre and wing furnace near to the forward end of the boiler. This was at 7.45. The boiler was allowed to cool down and in about four hours the body of the Third Engineer was got out. It was found lying on two of the longitudinal stays close to the forward end plate, and opposite the manhole. The door was found on the top of the tubes almost underneath the body, and one of the dogs beside it,—both of the studs in the door were bent and a small piece of rope was fastened to one of the studs. A spanner was found on the top of the combustion box girders—that is half-way between the manhole and the position of the body, and a lamp, hammer, and chisel and broom-head or brush were found in the bottom of the boiler. When the body was got out it was found that the skull was fractured, and that the skin where exposed peeled off when rubbed. A surgeon certified that the skull was fractured but does not appear to have examined the whole body, contenting himself with seeing sufficient cause for the man's death. The Master, however, says that the arms and shoulders looked to him as if seriously injured or broken, and that there was a deep mark on the forehead and the clothing torn in places.

The foregoing statement contains the important points of the case so far as we can gather them. We both have entered the boiler, examined the manhole and door, had the exact position where the body was found pointed out, and also that of the door, &c., and spanner. The whole story appears straightforward and is easily realised, but the causes which brought the body of the Third Engineer to the position where it was found are not so readily explained. Accepting the statements of the Master, engineers, and firemen (and we have no reason for doubting them), it is clear that the Third Engineer either (1) got into the boiler of his own accord, (2) was put in by others, or (3) met his death accidently by causes unforeseen and unnoticed, and which no one contributed to, except himself, and that unknowingly. The first two causes must, it appears to us, be dismissed—the position of the body and the statement as to the high temperature of the boiler and other reasons rendering them absolutely inadmissible; and after considering the whole circumstances of the case, we are of opinion that the death of the Third Engineer was brought about in the following manner:—

The boilers were blown down and left, neither safety-valves nor cocks were opened (the Chief Engineer says he gave instructions to open the gauge cocks, but found them shut) so that when the steam condensed there would be a vacuum in the boilers. The manhole is in the after end plate, there is a small platform almost in a line with the door. The deceased took off both the nuts without starting the door, one dog was taken off, the other turned partly round, a piece of small rope (which the Second Engineer says was very weak stuff) was fastened to one of the studs of the door and to the gauge glass stand. He then, stooped down in almost a lying position, probably holding the door by one of the studs, or by the rope, with one hand, and perhaps tapping it with the spanner in the other hand, when the door started, was suddenly driven inwards by the pressure of the atmosphere with great force, the rope broke, and the deceased, involuntarily tightening his grip on the stud or rope, was drawn into the boiler—the inrush of air assisting this movement, as his body became near to or partly filled the hole—and he was propelled with such violence as to fracture his skull on the other end of the boiler, or it may be by striking the plate at the manhole as his head was entering it.

This explanation which, from its singularity may at first appear somewhat doubtful, is the only one which we think fits all the known facts of the case, such as:—the short interval which elapsed between the time when the fireman Spiloni left the Third Engineer and his return to the manhole; the short time from starting work at 7 a.m. until the report was heard 15 minutes later; the sudden disappearance of the Third Engineer; the condition and position of the body when found, the position of the door, spanner, &c.; and also the high temperature of the boiler.

It certainly appears extraordinary that a man could be drawn into a boiler through a manhole with such force as to fracture his skull on the end plate, 16 feet from the hole, and in a direct line with it, but the stays would form a sort of guide to keep the door and body travelling in a horizontal and direct line, and it may be added that the deceased was not a big man. He is said to have been about 10 stone in weight and 5 feet 5 inches high. It can be seen by examination of the small platform at the manhole that the occurrence is at least quite possible. At any rate, unless the whole story is disbelieved, a manhole door weighing 85 lbs. was found along with the body of the Third Engineer, close to the end plate furthest from the manhole, and had been in that position for some hours and from a time when the condition of the boiler was such that no one would have entered it, or could have lived therein.

We wish to add that, although death under the above circumstances is probably unprecedented, the violent inrush of a manhole door due to vacuum in the boiler has been frequently experienced. A case somewhat analogous occurred in one of the steamers of the ——— Line, which hearing about, we inquired as to the facts from the Superintendent who kindly sent a letter describing the case, a copy of which is given below.*

We have inquired in reference to the circumstances of this case of the Master, First and Second Engineers, Spiloni, and the other men. The firemen are Greeks, and understand very little English. The present Third Engineer, who is a native of Smyrna, and can speak English and Greek acted as interpreter.

The area of the manhole, $16\frac{1}{4}$ in. by $12\frac{1}{4}$ in. is about 156 square inches, and assuming a temperature of about 180 degrees in the boiler, there might exist an external pressure of 7 lbs. per square inch, which, if suddenly applied, would exert a force of 1,092 lbs.,—at any rate sufficient force would be exerted to set up a high velocity on the door when suddenly relieved.

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*The vessel arrived on a Saturday evening, and it being necessary to get the men in the boiler at the earliest possible moment for cleaning purposes, one of the junior Engineers was ordered to the ship on Sunday morning. His instructions were to pump the remaining water out of the boiler, and he did this without admitting air. So far as we were able to gather at the time, it seems that the Engineer, together with a Chinese fireman, went to take off the lower manhole door. This door was some few inches above the stokehole floor, and, as is the usual practice of Chinamen, the fireman assumed the "squating" attitude. He was left to himself to remove the nuts and dogs of the door, and when he had done so he started the door and was instantaneously drawn in towards the boiler, his stomach practically closing the aperture, and the door swinging to the back of the boiler with a loud report.

Hearing the fireman's cries, the Engineer opened the gauge cocks in order to admit air to the boiler, whilst the fireman in the meantime suffered great agony, being pinned in this position until the vacuum was destroyed.

When the matter was reported to me the next morning, I saw the fireman, who complained of internal injuries. These, however, do not appear to have been of a severe nature, as the man was able to resume his work in a few days.

APPENDIX H.

List of Colonial Certificates issued under Order in Council, which are of the same force as those granted by the Board of Trade.

Colony.	Certificates.		Date of orginal Order in Council.	Date from which Order in Council takes effect.
	By whom granted in Colony.	Description.		
Victoria ...	* Marine Board ...	Master; 1st Mate; Only Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer	30 Mar. 1871	4 Jan. 1870
Canada ...	The Minister of Marine and Fisheries	Master; Mate† ... ... 1st Class Engineer; 2nd Class Engineer	19 Aug. 1871 10 Nov. 1886	19 Aug. 1871 1 Jan. 1887
New Zealand	Marine Department	Master; 1st Mate; Only Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer	9 Aug. 1872	1 May 1872
New South Wales	‡ Department of Navigation	Master; 1st Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer	30 Aug. 1873	18 June 1872
Malta... ...	The Head of the Government	Master; 1st Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer	12 May 1874	12 May 1874
South Australia	Marine Board ...	Master; 1st Mate; Only Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer	12 May 1874	12 May 1874
Tasmania ...	The Governor ...	Master; 1st Mate; Only Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer	12 Feb. 1876	1 April 1876
Bengal ...	Lieutenant-Governor	Master; 1st Mate; Only Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer	27 June 1876	27 June 1876
Newfoundland	Governor	Master; 1st Mate; Only Mate; 2nd Mate 1st Class Engineer; 2nd Class Engineer	14 May 1877 19 July 1910	14 May 1877 19 July 1910
Bombay ...	Governor	Master; 1st Mate; Only Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer	11 July 1877	11 July 1877

* The Steam Navigation Board was superseded by the Marine Board on the 21st December, 1888. *See* Order in Council of 23rd November, 1893.

† Equivalent to First Mate.

‡ The Marine Board was superseded by the Department of Navigation on the 17th March, 1900.

Colony.	Certificates.		Date of original Order in Council.	Date from which Order in Council takes effect.
	By whom granted in Colony.	Description.		
Queensland..	Marine Board ...	Master; 1st Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer	26 Mar. 1878	1 Oct. 1877
Hong Kong...	Governor	Master; 1st Mate; Only Mate; 2nd Mate; 1st Class Engineer; 2nd Class Engineer	31 Dec. 1883	1 Jan. 1884
Straits Settlements	Governor	Master; 1st Mate; 2nd Mate	1 May 1890	1 June 1890
		1st Class Engineer; 2nd Class Engineer	do. do.	1 Aug. 1888
* Mauritius...	Governor	Master; 1st Mate; 2nd Mate	22 Nov. 1890	1 Jan. 1891

* Mauritius does not issue Engineer Certificates under the Order in Council.

APPENDIX K.

Technical Schools recognised by the Board of Trade.

When nothing is stated to the contrary, time spent in a recognised technical school is accepted as equivalent to artisan service, at the ratio of three years of the former to two of the latter, provided the applicant was over 15 years of age and can produce the Principal's Certificate for continuous and regular attendance at all the approved classes and for satisfactory progress. Such time cannot be accepted as equivalent to more than two years artisan service. This recognition applies to day classes only, not to evening classes.

Name of School or Institution.

Armstrong College, late Durham College of Science, Newcastle.
Battersea Polytechnic, London, S.W.
Birmingham University.
Bradford Municipal Technical College.
Brighton Municipal Technical College.
Bristol University College.
Cardiff University College.
Central Technical College, London, S.W.
City and Guilds Technical College, Finsbury, London, N.

Electrical Standardising, Testing and Training Institution, Southampton Row, London, W.C.*
Glasgow and West of Scotland Technical College, Glasgow.†
Hartley College, Southampton.
Huddersfield Technical College.
Hull Municipal Technical School
James Watt Engineering Laboratories, Glasgow University.†
King's College, Strand, W.C.‡
London County Council School of Marine Engineering, Poplar, London, E.
Manchester Municipal School of Technology.
Merchant Venturers' Technical College, Bristol.
Municipal Technical Institute, Belfast.
Municipal Technical Institute, West Ham.
Northampton Polytechnic Institute, Clerkenwell, London, E.C.¶
Oundle School, Northants, Engineering Department.§
Owen's Technical College, Manchester.
Pembroke Day Trades Preparatory School, Ringsend, Dublin.§
Polytechnic School of Engineering, Regent Street, London, W.
Royal Naval Engineering College, Devonport.‖
Royal Technical Institute, Salford.
St. Olave's Grammar School, London, S.E.§
South Western Polytechnic, Manresa Road, Chelsea, London, S.W.
Sunderland Technical College.
University College, Gower Street, London.
University College, Liverpool (Walker Engineering Laboratories).
University of Sheffield.

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* Half the time only to be counted.

† A complete session to count as six months.

‡ Two-thirds of time to count, with a maximum of two years for three-year students, and two years and eight months for four-year students who have spent three summer sessions in the works of a maker of steam engines, for which no separate allowance is claimed.

§ One-third of the time only to be counted with a maximum of one year.

‖ Time to count in full up to three years; or in the case of students who were in training in or before September, 1908, up to four years under the following conditions:—

(a) A certificate of practical workmanship and good conduct must be produced.
(b) A student must have been at least 20 on completion of his training.
(c) Any deficiency in workshop service to be made good by service as engine fitter in shops where steam engines are made or repaired.

¶ Two-thirds of time to count, with maximum of two years and eight months.

A circular No. 1540, issued in September, 1913, contains additions to the list of Technical Schools as follows:—

Name of School or Institution.

Belfast.—Municipal Technical Institute, Belfast.
*Birmingham.—University of Birmingham.
†Birmingham.—City of Birmingham Municipal Technical School, Suffolk Street, Birmingham. (Afternoon Classes.)
Bradford.—Municipal Technical College, Bradford.
Brighton.—Municipal Technical College, Brighton.
Bristol.—Merchant Venturers' Technical College, Bristol.
Bristol.—University College, Bristol.
‡Cardiff.—City of Cardiff Day Preparatory Technical School, Cardiff.
Cardiff.—University College, Cardiff.
§Devonport.—Royal Naval Engineering College, Devonport.
‖Dublin.—Pembroke Day Trades Preparatory School, Ringsend, County Dublin.
Edinburgh.—Heriott-Watt College, Edinburgh.
¶Glasgow.—Royal (late Glasgow and West of Scotland) Technical College, Glasgow.
¶Glasgow.—James Watt Engineering Laboratories, Glasgow University.
Huddersfield.—Huddersfield Technical College, Huddersfield.
Hull.—Municipal Technical School, Hull.
Leeds.—The University of Leeds.
Liverpool.—The Faculty of Engineering, The University of Liverpool, Liverpool.
London.—Battersea Polytechnic, London, S.W.
London.—Central Technical College, London, S.W.
London.—City and Guilds Technical College, Finsbury, London, E.C.

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* Time spent by students of the Electrical Engineering Department on work similar to that in the Mechanical Engineering Department to count as equivalent.

† Time spent at afternoon classes to count as equivalent to two-thirds of the same period of workshop service, five hours in the classes being reckoned as equivalent to one day.

‡ One-sixth of the time only to be counted.

§ Time to count in full up to three years, or in the case of students who were in training in or before September, 1908, up to four years under the following conditions:—

(*a*) A certificate of practical workmanship and good conduct must be produced.

(*b*) A student must have been at least 20 on completion of his training.

(*c*) Any deficiency in workshop service to be made good by service as engine fitter in shops where steam engines are made or repaired.

‖ One-third of time to count with a maximum of one year.

¶ A complete session to count as six months.

London.—East London College (University of London), Mile End Road, London, E.

**London.—Day Technical School for Boys, Borough Polytechnic Institute, 103, Borough Road, London, S.E.

*London.—Electrical Standardising Testing and Training Institution, Southampton Row, London, W.C.

†London.—King's College, Strand, London, W.C.

London.—London County Council School of Engineering and Navigation, Poplar, London, E.

‡London.—Day Technical School for Boys of London County Council School of Engineering and Navigation, Poplar, London, E.

§London.—Northampton Polytechnic Institute, Clerkenwell, London, E.C.

London.—Polytechnic School of Engineering, Regent Street, London, W.

London.—South Western Polytechnic, Manresa Road, Chelsea, London, S.W.

London.—University College, Gower Street, London.

‡Londonderry.—Municipal Day Trades Preparatory School, Londonderry.

Manchester.—Manchester Municipal School of Technology, Manchester.

Manchester.—Owen's Technical College, Manchester.

Newcastle-on-Tyne.—Armstrong College, Newcastle-on-Tyne.

||Newcastle-on-Tyne.—Rutherford Technical College, Newcastle-on-Tyne.

¶Oundle.—Engineering Department of Oundle School, Northants.

Portsmouth.—Portsmouth Municipal College, Portsmouth.

Salford.—Royal Technical Institute, Salford.

Sheffield.—University of Sheffield, Sheffield.

Southampton.—Hartley University College, Southampton.

Sunderland.—Sunderland Technical College, Sunderland.

Swansea.—Swansea Technical College, Swansea.

West Ham.—Municipal Technical Institute, West Ham.

** One-third of the time only to be counted.

* Half the time only to be counted.

† Two-thirds of time to count, with a maximum of two years for three year students, and two years and eight months for four year students who have spent three summer sessions in the works of a maker of steam engines, for which no separate allowance is claimed.

‡ One-third of time only to be counted.

§ Two-thirds to count with a maximum of two years eight months.

|| A complete session to count as four months.

¶ One-third of time to count with a maximum of one year.

(II.) EVENING CLASSES.

Time spent in attending Evening Classes in Engineering at approved Technical Schools is accepted as equivalent to workshop service, five hours in the classes being reckoned as equivalent to one day, and two-thirds of the number of days so obtained counting as workshop service, subject to the provisions laid down in Handbill 300.*

Name of School or Institution.

Belfast.—Municipal Technical Institute, Belfast.

†Birmingham.—City of Birmingham Municipal Technical School, Suffolk Street, Birmingham.

Brighton.—Municipal Technical College, Brighton.

Bristol.—Merchant Venturers' Technical College, Bristol.

‡Cardiff.—City of Cardiff Technical Schools.

Dundee.—Dundee Technical College, Dundee.

Edinburgh.—Heriott-Watt College, Edinburgh.

Greenock.—Greenock Technical School, Greenock.

Glasgow.—Royal (late Glasgow and West of Scotland) Technical College, Glasgow.

Huddersfield.—Huddersfield Technical College, Huddersfield.

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* *Handbill* 300.—The Board of Trade have decided to accept time spent by candidates for certificates of competency as Engineer in attending evening classes in Engineering at approved Technical Schools in lieu of a portion of the period of workshop service required by the Board's Regulations for the Examination of Engineers. Such time will be allowed to count under the following conditions:—

1. Each candidate claiming an allowance for time spent in attending evening classes at a Technical School must produce a certificate signed by the Principal of the School to the effect that he has attended regularly at a definite class or classes, which should be specified, and has made satisfactory progress. This certificate must also state the total number of hours spent by the candidate in attending each class.
2. Time spent by the candidate in attending such classes as have a direct bearing on the training of a Marine Engineer will be reckoned at the rate of five hours to one day. The total number of days so obtained will then be accepted in lieu of a certain fraction of the same period of workshop service. This fraction will be fixed for each School at the time of approval, and will generally be two-thirds.
3. A candidate who has attended a Technical School in the evening, while being employed as an apprentice or journeyman Engineer during the day, must, in order that the School time may be accepted, produce satisfactory proof that he has spent the full working day in the works, at which he is employed, before attending the School. Such proof will usually take the form of a statement in the testimonial as to workshop service given by the employer.
4. Allowance will only be given for classes attended after the candidate has reached the age of 15.

Applications for the approval of the evening classes of Technical Schools desiring recognition (including those whose day classes are already approved) should be made to the Assistant Secretary, Marine Department, Board of Trade.

† Afternoon classes also count in the same proportion.

‡ Time spent by students of the Electrical Engineering Department on work similar to that in the Mechanical Engineering Department to count as equivalent.

Leeds.—University of Leeds.

Leith.—Leith Technical College, Leith.

London.—Battersea Polytechnic, London, S.W.

London.—Borough Polytechnic Institute, 103, Borough Road, London, S.E.

London.—London County Council School of Engineering and Navigation, Poplar, E.

London.—Northampton Polytechnic Institute, Clerkenwell, E.C.

London.—The Polytechnic School of Engineering, 307, 309 and 311, Regent Street, London, W.

London.—South Western Polytechnic Institution, Manresa Road, Chelsea, S.W.

Londonderry.—Municipal Technical School, Londonderry.

Manchester.—The Manchester Municipal School of Technology, Manchester.

Newcastle-on-Tyne.—Armstrong College, Newcastle-on-Tyne.

Newcastle-on-Tyne.—Rutherford Technical College, Newcastle-on-Tyne.

Preston.—Harris Institute, Preston.

Salford.—Salford Royal Technical Institute, Salford.

Sheffield.—Department of Applied Science, University of Sheffield, St. George's Square, Sheffield.

Southampton.—Hartley University College, Southampton.

South Shields.—The Marine School, South Shields.

Swansea.—Swansea Technical College, Swansea.

(III.) *Marine Technical Schools.*

When nothing is stated to the contrary, time spent at a Technical School recognised as suitable for the training of Marine Engineers will, subject to the provisions laid down in paragraph 33* of the Regulations, be allowed to count as sea service in the ratio of three months at the Technical School to

* *Para.* 33.—On and after January 1st, 1915, a candidate for either a Second class or a First class Certificate who within two years from the date of application to be examined has attended an approved course comprising general mathematical and scientific instruction at a Technical School recognised by the Board of Trade as suitable for the training of Marine Engineers, will be allowed to count time so spent as equivalent to sea service in the ratio of three months at the Technical School to two months at sea. Time so spent cannot be accepted as equivalent to more than one-sixth of the total sea service required for either certificate, but a candidate who has been allowed to count such time on examination for a Second class Certificate, will not be debarred from counting similar subsequent time on examination for a First class Certificate . . . . . In every case in which an allowance is made for time spent at a Marine Technical School, the candidate will be required to produce the Principal's Certificate for continuous and regular attendance at all the approved classes and for satisfactory progress.

two months at sea, time so spent not to be accepted as equivalent to more than one-sixth of the total sea service required for a certificate.

Name of School or Institution.

Greenock.—Watt Memorial School, Greenock.
South Shields.—The Marine School, South Shields.