both under natural and forced draught, all the machinery working smoothly and satisfactorily. We append the detailed results of the trials of the first of the three vessels. The machinery on the occasion, it

Results of Trials of H.M.S. "Indefatigable" off Isle of Wight.

—		Natural Draught.		Forced Draught.	
Draught of water..		Forward, 15 ft. Aft, 18 ft. 6 in.		Forward, 15 ft. Aft, 18 ft. 6 in.	
Steam in boilers ..		134.7 lb. per square inch.		135.9 lb.	
		Starboard Engine.	Port Engine.	Starboard Engine.	Port Engine.
Vacuum		27	26.9	25.46	26
Revolution per minute ..		126.3	127.5	136.9	138.1
Mean pressure ..	High	43.78	44.7	49.66	50.27
	Intermediate	27.05	26.79	31.73	31.73
	Low	12.82	12.6	14.65	14.45
Indicated Horse Power ..	High	1019	989	1181	1192
	Intermediate	1370	1390	1614	1678
	Low	1373	1361	1690	1692
Total indicated horse-power		3702	3 19	4484	4552
Collective indicated horse-power		7321		9046	
Mean air pressure ..		.47 in.		.92	
Speed of vessel		18.74 knots		19.75 by patent log	

may be stated, was under the charge of Mr. William Morison, manager of the engine works of the London and Glasgow Company.

ELECTRICITY IN THE NAVY.*

On the Applications of Electricity in the Royal Dockyards and Navy.

By Mr. HENRY E. DEADMAN, Chief Constructor, Portsmouth Dockyard.

THIS is an age of electricity; and the fact is well exemplified on board a modern battle-ship of the Royal Navy. Some of the applications of electricity in the naval service do not come within the scope of ordinary mercantile practice; and in the case of those which do, the naval experience is of a special kind, and may be of some value to those outside the service. A statement, therefore, of naval methods and practice up to date may not be without interest and instruction to the members of this Institution. At the present time visitors to Portsmouth Dockyard will probably be surprised, if not disappointed, at the somewhat primitive character of the workshops devoted to the electrical testing and construction. This branch of work was commenced in a very small way about seventeen years ago, and found a temporary home in a small shed which had been previously used for a different purpose. As the work from time to time has grown, this shed has been enlarged as far as available space would permit. Designs have been prepared for a more substantial and suitable building, in the hope that in time the Admiralty will be able to devote sufficient money to providing a proper habitation for this important branch of dockyard work.

The larger proportion of the plant required for electric installations in the Navy is not made in the dockyard. Formerly all dynamos and their engines were obtained entirely by contract; but recently five sets of these have been designed and constructed in the dockyard. After patterns of the smaller fittings have been fixed, the supply of these also in bulk has generally been obtained by contract. There is, however, a great deal of work left to be done in the dockyard, in testing and installing these fittings in the ships, in carrying out repairs, and in devising and preparing patterns of new fittings to meet the constantly growing requirements of the Navy. There is also some work which, for obvious reasons, is confined to the royal workshops.

The applications of electricity in the Navy may be dealt with under the following heads: (1) search lights: (2) internal lighting of ships, including temporary installations in ships building and repairing; (3) torpedo and gun circuits; (4) electric communication; (5) other applications.

1.—SEARCH LIGHTS.

The introduction of the search light, without which no modern warship or torpedo boat would be considered complete, dates from 1876; and the first vessel in the Navy fitted with a search-light apparatus was the Minotaur. Some experiments had been carried out in the

and several other vessels were fitted with the same class of apparatus.

In 1878 direct driving was first introduced. In this year Messrs. Wilde and Co. coupled their machines to engines made by Brotherhood and by Chadwick, of Manchester. The dynamo was also improved, so as to be able to maintain two arc search lights at one time. In the same year also the Triumph was fitted by Messrs. Siemens Brothers with a search-light installation. The dynamos were four in number, of horizontal type, arranged in two pairs, and each connected in parallel to one circuit. A switchboard was fitted, for enabling any two of these dynamos to be coupled up together on any circuit. It consisted of a wood base with two sets of bars at right angles to each other, one set on the top of the base, and the other underneath. One set of bars was connected to the dynamos and the other to the circuits. At their intersections these bars could be connected as required by means of suitable plugs. The projector used was a Siemens holophote, which was heavy and clumsy, being made largely of cast iron. It was fitted with diverging and dioptric lenses; of these the latter was composed of concentric glass rings of triangular section, held in a metal frame. It had also a flashing arrangement. The lamp used was one of the Siemens self-regulating type, and had a small mirror fixed to it. It was complicated, and frequently got out of order. The carbons were apt to stick together, and the lamp was sensitive to any slight variation in speed of dynamos. This lamp did not come into general use.

Subsequently the Gramme dynamo was introduced for search lighting by Messrs. Sautter Lemonnier, of Paris; and in 1881 the Inflexible was fitted with this dynamo. In this installation the Mangin projector was used, with a Mangin mirror instead of the dioptric lens. The lamp was hand regulated and inclined. The Gramme dynamo has since been superseded by others of later make; but the Mangin mirror and the inclined hand-lamp survived, and became the standard service fittings.

Naval Service Projector.—Out of these earlier attempts the modern naval service projector has gradually been evolved, which has now become familiar to most persons. It consists of a cylindrical lantern made of very thin steel, with a silvered glass parabolic mirror at the back end, in the focus of which an arc light is produced between two carbon sticks, held in what is known as an inclined hand lamp, the carbons standing at an angle of about 70 deg. to the axis of the mirror. The feeding of the carbons is not automatic, but is accomplished by hand; and the lantern is so suspended that it has motion on its pedestal through the whole circle in azimuth and through about 60 deg. in altitude. During its motion the electrical connections are kept up by suitable rubbing contacts. A switch is fitted in the pedestal for switching the current on and off. The circuit wires, main and return, are brought from the main switchboard to the switch on the pedestal, thence to the rubbing contacts, and finally pass close together up one of the hollow arms of the lantern support, and through the trunnion bearing to two springs at the bottom of the lamp box. The lamp when put in makes contact with these springs, and completes the circuit through the carbons. Two sizes of these projectors are used in the naval service, a larger with a 24-in. mirror for ships, and a smaller with a 20-in. mirror for torpedo boats. The parabolic mirror in these projectors converges the rays into a powerful and penetrating cylindrical beam of light. At the front end of the lantern diverging lenses can be attached, for spreading the beam over a larger surface when desired, or a flashing screen can be affixed for signalling purposes.

The two most important parts of these projectors for the production of a good and steady beam are, of course, the reflecting mirror and the carbons. For the supply of these articles the naval service was, until recently, dependent entirely upon French manufacturing firms. The Admiralty, fully alive to the dilemma in which this country might under certain circumstances be placed, have sought to induce English manufacturers to enter into competition with the French firms for the supply of these articles; and everything of this kind which has been offered with the slightest promise of success has been fully and carefully tested at Portsmouth. The English manufacturers have no doubt had no easy task to accomplish; for, disregarding cost, the French mirrors and carbons left nothing to be desired, and are still the standards to which all others are referred.

Mirrors.—As regards mirrors the qualities required are three: First, that they shall project a cylindrical, sharply

point on the negative; and that the waste shall be steady and uniform, without cracking or crumbling. A certain amount of success has already crowned the persevering efforts of English manufacturers. Although the English carbons are not even yet fully equal to those previously obtained from France, it is hoped they will soon come sufficiently near that standard to make them acceptable for use in the Navy.

Projector Requirements.—The present service projector requires at least one man close to it, to direct the beam of light in any desired direction, and also to feed and adjust the carbons as necessary. This is a disadvantage, because the position of a search light is evidently one affording a good mark for an enemy's fire, and is a bad position for observing the object illuminated; and it would be an advantage if the projector could be entirely manipulated from a protected position at some distance—for instance, from the ordinary conning tower. For this purpose two requisites are necessary: First, a good automatic lamp; and, second, an efficient motor for giving the necessary movements to the projector. It is to these two improvements that attention is now being given.

A good practical automatic lamp is the first necessity; without this a man must be stationed at the projector to feed the carbons, and being there he can also direct the beam of light. Several automatic lamps have been tested, but none have as yet been adopted for general use. One lamp, in which the carbons are regulated by a small electric motor in a shunt circuit is promising; but in its final form it has not yet been returned from the makers. The field, however, is still open for invention in this direction.

Experiments have also been made with an electric motor attached to the service projector, by which the movements of the latter can be directed and controlled from a distance. The results are highly satisfactory, but as already stated the invention is not likely to be brought largely into use until it can be combined with a satisfactory automatic lamp. Recently a wheeled carriage has been introduced for using a ship's projector on shore.

2. INCANDESCENT OR GLOW LAMP LIGHTING.

Electricity is at the present day largely resorted to for the purpose of lighting internally the vessels of the Navy; all the larger vessels, such as battle-ships and first and second-class cruisers, are now so lighted. Moreover this mode of lighting is not restricted to the habitable portions of the ship, but is carried out to the complete exclusion of other modes, although the latter may be fitted as a reserve. Thus the electric lighting is extended to machinery spaces, coal bunkers, magazines, shell-rooms, store-rooms, gun quarters, &c., as well as to the illumination of compass cards, telegraph dials, bow and masthead and signal lanterns, semaphores, &c. Clusters of glow lamps beneath an enamelled metal reflector are also employed for lighting the upper deck, when coaling or other operations are being carried on at night. In a large battle-ship like the Royal Sovereign there would be about 800 of these glow lamps, necessitating for this system alone about eight miles of electric leads, which are equivalent to something like 155 miles of copper wire of varying sizes, principally No. 20 legal standard wire-gauge or 0.036 in. in diameter.

Progress.—The first installation of internal lighting in the Navy was carried out on board the Inflexible in 1881 by the Anglo-American Brush Company. It was a combined system of arc and glow lamps. The dynamos used were of the Brush type, of which the first specimen brought to this country was purchased by the Admiralty, and is still in use in Portsmouth Dockyard. Each machine was capable of maintaining sixteen Brush arc lamps of 2000 candle-power each. The lamps had double sets of carbons, each pair burning eight hours. These arc lamps were switched on and off by a switch opening and closing a shunt circuit of small resistance. With this plan it is evident that a lamp could not be safely handled while the current was on, even if the light was switched off, because the lamp itself still formed a part of the circuit. A switch was accordingly devised in the dockyard, by means of which the lamp could be cut completely out of the circuit. The Swan glow-lamps were fitted in sets of 18 in series, each set being placed in parallel between the main circuits of the arc lamps. Each glow-lamp was fitted with an automatic cut-out, bringing into the circuit a resistance equal to about that of the lamp, in case the latter failed. This system now no longer exists in the Inflexible, an installation on modern methods having been substituted for it.

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1.—Search Lights.

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* Paper read before the Institution of Mechanical Engineers.

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The two most important parts of these projectors for the production of a good and steady beam are, of course, the reflecting mirror and the carbons. For the supply of these articles the naval service was, until recently, dependent entirely upon French manufacturing firms. The Admiralty, fully alike to the dilemma in which this country might under certain circumstances be placed, have sought to induce English manufacturers to enter into competition with the French firms for the supply of these articles; and everything of this kind which has been offered with the slightest promise of success has been fully and carefully tested at Portsmouth. The English manufacturers have no doubt had no easy task to accomplish; for, disregarding cost, the French mirrors and carbons left nothing to be desired, and are still the standards to which all others are referred.

Mirrors.—As regards mirrors the qualities required are three: First, that they shall project a cylindrical, sharply defined, and homogeneous beam of light of great intensity and penetrative power; second, that when in operation they shall not be liable to crack by contact with water, in the form either of rain or of sea-water spray, or by a blast of cold air; third, that they shall resist the concussion caused by the discharge of heavy guns. These qualities should be combined at a moderate cost if possible, although efficiency is the primary consideration. Thus far mirrors have been submitted for trial by six different English makers, and by others specimens are being prepared for future trial. From among these at least one successful English specimen has been obtained, which compares in all points favourably with the French production; and one-half of the supply for the Navy will this year be ordered from the firm producing this specimen.

Carbons.—With regard to English carbons, the results were for a long time disheartening; even after several attempts by the same firm, none of the specimens submitted for test approached in efficiency those of French make. The three qualities required in good carbons are that they shall maintain a steady arc without flaming or excessive hissing; that they shall be perfectly pure and homogeneous in structure, and shall preserve a well-formed crater on the positive carbon and a well-formed

head and signal lanterns, semaphores, &c. Clusters of glow lamps beneath an enamelled metal reflector are also employed for lighting the upper deck, when coaling or other operations are being carried on at night. In a large battle-ship like the Royal Sovereign there would be about 800 of these glow lamps, necessitating for this system alone about eight miles of electric leads, which are equivalent to something like 155 miles of copper wire of varying sizes, principally No. 20 legal standard wire-gauge or 0.036 in. in diameter.

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The five Indian troopships were next fitted throughout with glow-lamps by the Edison Company, who used the Edison Hopkinson type of dynamo giving a current of 180 ampères at 110 volts. The Polyphemus was also entirely fitted by Messrs. Siemens, and the Colossus by the Brush Company, the dynamos in the latter being of the Victoria Brush type. The Polyphemus was the only ship in the Navy fitted on the single wire system. Afterwards the adoption of internal lighting became general; all new vessels except the smaller cruisers were fitted, as were also the previous vessels, on the first opportunity of their coming in for repairs and refit. There are now in the Navy about 300 vessels either fitted or being fitted with electric lighting, for search lights or internal lighting or both.

(*To be continued.*)

The Corinth Canal.—The aggregate extraction effected upon the Corinth Canal from the resumption of working operations to April 30 this year was 1,886,385 cubic metres. The number of workmen employed to the close of April was 1600, and there were also three steam navvies and one dredger at work.