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THE ELECTRICAL FITTINGS OF THE COAST-DEFENCE SHIP "BOUVINES."

By E. PRAT, Lieutenant de Vaisseau.

Translated from "*Revue Maritime et Coloniale*" for December, 1895,
by Staff-Engineer T. J. HADDY, R.N.

General Installation.—The battle-ship "Bouvines" was put into commission for her first trials at Toulon, on 15th October, 1894, under the command of Captain P. Fauque de Jonquières. The electric installation is by the Compagnie des Forges et Chantiers de la Méditerranée, and therefore of recent date. The details present some peculiarities which may interest the officers called on to manage the electrical apparatus on board other ships. From the special point of view with which we are concerned, the duties of the different installations may be enumerated as follows:—

1. For illumination complete.
2. For control of steering engines, and helm indicator.
3. Working eleven winches for ammunition hoists.
4. Eight ventilators for ventilating bunkers and forward and after compartments; and
5. Five 60-centimetre projectors, each fitted to control at a distance.

Electrical Machinery.—The electrical power for working the above is furnished by four dynamos, type *H.*, by the firm of Sautter, Harlé and Co.

Each of these machines can furnish on continuous service a current of 400 ampères, with a difference of potential of 80 volts at the terminals. From experiments made at the trials the self-regulation of these machines was very satisfactory, a constant potential at the terminals being maintained with a variation in the external circuit from 0 to 400 ampères.

The four machines are placed in the same compartment under the protective deck, and ventilated directly by a large air trunk; the temperature at the least ventilated part of this compartment was never excessive. After the four dynamos had been at work uninterruptedly for twenty-four hours the temperature rose to 35° C. or 20° C. above that of the external air. Thanks to some modifications in details made after the preliminary trials, these machines are now in good working order.

From a naval point of view we might criticise this installation of four machines in one compartment. On ships having important electrical installations we have, in fact, up till now taken care to separate the dynamos into groups, forward and aft. Such an arrangement does not appear to us to be necessary in the "Bouvines." The dynamo compartment is situated at the upper part of the large water-tight compartment enclosing the propelling machinery. If the water level should rise to the

height of the dynamos from any cause, the propelling machinery would have been already put out of action, and the four electrical ammunition hoists for this department would also have been rendered useless; in fact from the large volume of water which had entered, the safety of the ship herself would have been endangered. Under these conditions, the want of electricity would not be of very much importance.

On the other hand, by the arrangement of the dynamos in one compartment satisfactory ventilation was assured, great facility was obtained for dividing the work of the different circuits between the machines, also a reduction in the technical *personnel*, and a simpler grouping of the circuits, making the detection and localisation of defects particularly easy. These advantages, together with greatly decreased first-cost, appear to us to fully compensate for any inconvenience which could possibly result from the grouping of four machines in one compartment.

Distribution.—The electricity produced by these four dynamos is transmitted to the various apparatus on board by means of four switch-boards, viz.:—

1. For the distributing mains.
2. Electric lighting, incandescent.
3. Motors.
4. Projectors.

Fig. 1 shows this part of the installation (see also note on the same).

Distributing Mains.—The main switch-board is the only one in direct communication with the collectors of the machines, Figs. 1 and 2. It consists of four bipolar commutators, having the following denominations: Incandescent lighting, Motors *A*, Motors *B*, Projectors. Each of these commutators allows of the connection of these different mains to one of the four machines. As under normal conditions the whole of the motors would absorb a current of over 400 ampères (maximum output of each machine) the motor switches have been duplicated so that the work can be divided between two machines. By the arrangement of the commutators themselves it is always impossible to connect two dynamos to the same circuit by mistake. In the distributing mains, as elsewhere in the electric installation of the "Bouvines," the closing and opening of important circuits is always effected simultaneously on both poles. Common return leads always adopted up to now have been very properly suppressed. The switch-board is completed by four pilot lamps in shunt with the principal circuits of each machine and by four ampèremeters showing the total output of each of them respectively. The single voltmeter and the two pilot lamps of insulation can be put in shunt with the different circuits by means of a little commutator of four directions. Another supplementary commutator, added by the staff on board after acceptance, permits of measuring directly by the help of the voltmeter the insulation of each of the circuits with respect to the hull of the ship. We shall describe each of the switch-boards in detail, and at the same time the part of the installation which it directly commands.

Incandescent Circuit.—The lighting installation is governed by a

switch-board close to the main, to which it is directly connected. It comprises (Fig. 3) one voltmeter; one ampèremeter, a pilot lamp, and eight bipolar interrupters, having the following significations :—

Helm, signals, night, starboard and port, day, starboard and port, external lighting, indicating and head-lights.

As the only ampèremeter fitted is graduated to 100 ampères, it would be insufficient for the total current, and the positive lead is therefore duplicated, so that by means of a special commutator either of the circuits may pass through the meter or outside it. Thus on Fig. 3 it is easy to see that the "signal" circuit passes through the ampèremeter, and the circuits, "day starboard" and "helm," do not. In the third position of the commutator the circuit is cut out. The three distributing leads are placed at the bottom of the board; one of the positive and the negative lead are in direct communication by two large cables with the "incandescent" commutator of the main switch-board. Two other cables put the same leads in communication with the motor switch-board, thus allowing a portion of the motors to be supplied from the same dynamo as the incandescent circuit.

Internal Lighting.—Is effected by four circuits starboard day, port day, starboard night, port night. Generally speaking, the lamps of the day circuits light those parts of the ship situated below the protective deck, those of the night circuits are distributed between the batteries and compartments above the deck. There are always a few lamps from the day circuit in particularly dark places, offices, etc., above the protective deck. The supplementary circuits for "sea" and "action" have been rightly suppressed as causes of useless complications and expense. In the large compartments, principally in the engine-rooms, some lamps supplied by the port circuit have been placed on the starboard side, and *vice versa*, so that a failure of one circuit would not leave these important compartments in complete darkness.

Cut-Outs.—The safety of the installation is secured by numerous cut-outs interposed on each of the two leads, at each branch and to each lamp. We cannot too highly recommend the employment of movable porcelain bars for carrying the cut-outs as used in the "Bouvines" (Fig. 4). The fusible wire forming the cut-out is connected by two screws to two copper rings on the porcelain bar, and the bar is held by friction between the spring forks of two metal bearers to which the ends of the conductor are connected. The bar is thus easily removed by lifting the two ends without danger of shock, which is always disagreeable, and often the cause of an imperfect connection in fitting a new cut-out. It would be advisable, however, to replace the porcelain, which is easily broken, by some stronger material such as ebonite fibre, etc.

Thanks to these numerous cut-outs, the search for defects of insulation is much facilitated, and if for any reason it is required to isolate one portion from the remainder of the installation it is only necessary to raise the bar of the cut-out for this part of the circuit. The plan of the incandescent circuits (Fig. 5) shows the general arrangement of these cut-outs.

Lighting of Compartments.—The night circuits ensure the illumination more particularly of batteries and other compartments. In those occupied by the crew the switch of each lamp cannot be worked without a special key. Each officer's cabin is lighted by a portable lamp of 10-candle-power. The current for this lamp is taken so that the connection forms an interrupter, and a second interrupter or switch is fixed in proximity to the bed-place. These interrupters are formed of two flexible plates, which ensure communication between two diametrically opposite contact terminals. They are worked by a turn of 90° always in the same direction from left to right (see Fig. 6). In the figure the lamp is extinguished, and it is easy to see it will be lit up by turning the button through 90° , either of the interrupter of the circuit connection, or the one in the circuit, and can be put out in the same way by using either of them independently of each other.

Lighting of Magazines, etc.—All the lamps of compartments below the protective deck are supplied from the two day circuits.

In case of damage to one of the circuits, the lighting of ammunition-rooms and charging platforms for turrets is so arranged that a single circuit starboard or port can be used. For the disposition of the commutators employed to this end see Fig. 7. In the position 1 of the commutators the lamps of both sides will be fed by the port circuit; in position 3 the lamps are on the starboard circuit, and in position 2 are extinguished.

Engine-room Telegraph.—A similar commutator permits of either of the day circuits being used for the electric telegraph to engine-rooms, Perruise system. This apparatus, constructed by the firm of Sautter, Harlé and Co., is similar in principle to those already fitted in the majority of the squadron ironclads; it has the advantage over them of a greater facility in manipulation. A single movement of the handle, in fact, is sufficient to ring the call bell and to automatically light up the lamps, indicate the direction of motion required, and the number of revolutions (see Fig. 8). A second handle, independent of the first, serves to transmit orders for sudden changes of speed, which are executed by gaining or losing seconds by means of a Valessie counter. The coal bunkers are lighted by movable lamps, taking the current from the day circuits of both sides on the orlop deck.

External Lighting.—Is supplied by three circuits: signals, external lights, and course lights. There is nothing peculiar in their arrangement. On the "course," or head light circuits, there is an extingtor alarm, which rings a bell when one of the lamps goes out. The "signal" circuit is taken directly from the distributing switch-board at the after bridge, that of the external lights branches forward and aft. It would have been better, we think, to have had signal and external lights on one circuit. The two circuits are, in fact, always closed simultaneously on ordinary service in squadron, and the arrangement would much facilitate the displacements of the manipulators for signalling. These manipulators should be capable of being worked either from the after bridge, if the ship carried the flag of a senior officer, or from the fore bridge in other

FIG. 1.

PLAN OF DISTRIBUTING MAIN SWITCHES.

N.B.—The leads and distribution strips represented in this sketch plan are really doubled, forming complete supply and return circuits. All the commutators are bipolar.

FIG. 2.

MAIN SWITCHBOARD.

FIG. 3.

INCANDESCENT SWITCHBOARD

FIG. 4.

REMOVABLE BAR CUT OUT

FIG. 5.

cases. The circuit for external lights already reaches both bridges, it would have been easy to supply the signal lamps in both cases with the same circuit, whilst in the actual installation it would be necessary to modify the arrangements in order to work the signals from the fore bridge (this modification has been made for the position lights).

Electric Control Gear for Steering Engines.—The whole of this apparatus is worked by means of a special circuit branching off from the incandescent switch-board, having a mean current of 15 ampères. This circuit is divided into two, acting independently of each other, one for controlling the steam valve of steering engine, the other for the helm indicator. The electric motor for the first duty is situated aft, under the protective deck, in the steering compartment. It transmits the required movement to the steam regulating valve by means of speed-reducing gearing and two Gall's chains. Means are fitted for taking up the slack of these chains, due to wear, etc.

The control gear can be worked on the fore bridge from two positions. One of these working positions is in the armoured conning tower, the other above it on the upper bridge. The manipulators only control the armature circuit; the magnets are constantly excited in shunt with the main circuit of the apparatus. This arrangement has the advantage that it prevents unsteadiness in the movements of the motor, and gives instant stoppage when the armature circuit is short circuited. Each manipulator commands a commutator with six contacts:—

Left, slow speed.	Right slow speed.
„ mean „	„ mean „
„ full „	„ full „

The variations of speed are obtained by suppressing successively two resistances interposed in the motor circuit. A special switch "combinateur," placed in the conning tower (see Fig. 9), sends the current either to the commutator of position *A* or to that of position *A*₁ on the upper bridge, so as to prevent the possibility of contradictory orders being sent simultaneously from each post.

Relay System.—The so-called relay system is introduced so as to avoid the necessity of a great length of wire of large diameter. The leads in communication with the working position commutators are of $\frac{9}{16}$ millimetre diameter only, and they would naturally be unable to support the whole intensity of the motor current. These wires consequently only actuate electro-magnets placed close to the motor in a special box, called the box of relays.

These magnets on attracting their armatures make contacts which close the armature circuit of the motor, and start it in the desired direction. By this system the length of the large conductors is reduced to a few metres, connecting the armature brushes to the box of relays. We can follow in Fig. 9 the action of the different circuits:—*G* and *D* are the electro-magnets corresponding to the indications Left and Right, *F* and *F'* to mean speed and full speed. If we suppose the switch or "combinateur" *C* put into connection with the commutator of the conning tower *A*, and that we move the handle of the manipulator a very

little to the right, the current will first reach the electro-magnet D , and the motor will start slowly with a right-hand motion, the resistances R and R' being always in the circuit. By moving the handle, still more to the right we send the current successively to the magnets F and F' ; the resistances R and R' are successively cut out, and the motor increases its velocity at first to mean and then to full speed. If the handle is let go it is brought back to the initial position by means of a spring, the circuit of the magnets is broken, their armatures are brought back by the springs fitted, and the motor stops instantaneously; the armature being short circuited by a special arrangement of the relays G and D .

If the handle of the instrument is moved to the left the electric magnets G , F , and F' will act in the same way, and the motor will start to the left at slow, mean, and full speed successively.

The relays G and D are constructed as shown in Fig. 9. They are each composed of a lever ab , oscillating on a pivot C ; when at rest the spring d keeps the arm a down and makes the contacts g, g' . As soon as the current reaches the magnet G by the commutator A , the arm b is lowered and makes the contacts ih and $i'h'$, breaking the contacts $g'g$. In the general plan of the circuits we see that the arms a of the magnets S and D when at rest, make the connections gG , $g'G$ and gD , $g'D$; thus putting the armature of the motor on short circuit. When the current reaches the magnet of D or of G , the arms b make the double connections $hD - iD$, $h'D - i'D$, or $hG - iG$ and $h'G - i'D$, and thus sends the current in one direction or the other to the motor; the resistances still remain in the armature circuit until the magnets F and F' are actuated.

These two relays F , F' serve to vary the speed of the motor, and are more simply constructed than the relays G and D . Their arms a do not carry contacts, and each of the arms b carries two only instead of four. These contacts make the connections $hF - iF$ cutting out the resistance R when the circuit of one or both the magnets is made by the commutator A .

Starting Apparatus.—To facilitate the starting of the motor a special apparatus is fitted (Fig. 9), acting by means of centrifugal force, and when at rest sends the current to the relay F' only by closing the circuit at the contacts e . The motor thus receives at the moment of starting the necessary current even when the commutator A is put on the slowed speed. As soon as the motor starts, the masses M , M' separate, the starting current is broken at e and the magnet F' cut out, the resistance R is introduced and remains in the circuit until the handle of the instrument is put to full speed.

Safety Gear.—Two systems of safety apparatus complete the electro control of steering engine. The first S (Fig. 9) is worked by an index to the axiometer of the steam steering gear, and it automatically breaks the circuit of the right or left hand magnet when the tiller reaches the end of its travel on one side or the other. The magnet circuits being broken, the electric motor stops, although the handle of one of the instruments on the bridge may have been kept by mistake in its extreme position. The second safety apparatus first slows and then stops the

electric motor, if from any cause whatever the steam steering gear should not obey the movement of its slide. This, shown at *S'* (Fig. 9), is just as indispensable as the other. The steam slide valve is worked by the electric motor, and is constantly brought back to its middle position by the action of the steering engine. If as a result of the tiller jamming, the steam valve should not be sufficiently open or from any other cause the steering engine should not start or start too slowly, the slide valve would reach the end of its travel, and the motor continuing to force it in the same direction some injury might be done to the gearing. This risk is provided against by the safety gear *S'*, actuated by the movement of the steam slide valve itself. As soon as the slide valve moves a sensible amount from its mid position, the circuits of the magnets *F'*, *F*, and *G* or *D* are automatically broken, thus slowing or even stopping the electric motor until the steering engine has taken up its normal speed.

This apparatus has acted perfectly on the reception trials; its control is easy, and when tried at all speeds the safety gear has given every satisfaction. Five leads of very small diameter suffice for all the connections from the bridge to the steering engine; the commutators are simple in construction, and could be easily multiplied in action for any convenient posts of command. It is to be remarked, however, that the system as described is not sufficient. In working one of the instruments on the bridge it would not be possible to know the angle of helm, as this angle is in no way proportional to that of the handle of the manipulator.

It is, therefore, indispensable to complete the installation by a helm indicator at each post of command. On board the "Bouvines" an electric system is employed for this service, indicating the angle of the helm by means of lamps automatically lighted up or extinguished by the movements of the tiller.

Transmitter.—The transmitting apparatus is situated in the extreme after compartment and worked by the tiller itself. Five small copper arcs insulated from the hull are fitted below the tiller, and five contact pieces fixed to the latter bear upon them. These contact pieces are in connection with one of the electric circuits, and the arcs with the lamps of the receivers. The insulated portions of each arc are combined in such a manner that the movement of the tiller lights up successively the lamps of the receiving apparatus corresponding to the degrees 0, 1, 3, 5, 10, 15, 20, 25, 30. When the tiller arrives at each of these degrees, and also at the end of its travel, an electric bell is sounded in each of the receiving instruments. (See Fig. 10.)

Receivers.—The receiving instruments are three in number, two for the conning tower and upper bridge, and the other under the protective deck forward of the gear for controlling the steering engine. Each is fitted with seventeen lamps and electric call bell. A special system of connections allows the leading wires from the transmitter to the receivers to be reduced to ten. The sounding of the bell, combined with the lighting up and extinction of the lamps, permits the position of the helm to be always known with certainty to within 2 degrees, and

to a degree between 0 and 5 degrees. To this end the lamps are lighted up in the following order:—

Between 0 and $\frac{1}{2}$ degree,	lamp 0 alone
" $\frac{1}{2}$ " $\frac{1}{2}$ " "	" 0 and 1
" $\frac{1}{2}$ " $1\frac{1}{2}$ " "	" 1 alone
" $1\frac{1}{2}$ " $2\frac{1}{2}$ " "	" 1 and 3
" $2\frac{1}{2}$ " $3\frac{1}{2}$ " "	" 3 alone
" $3\frac{1}{2}$ " $4\frac{1}{2}$ " "	" 3 and 5
" $4\frac{1}{2}$ " 6 " "	" 5 alone
" 6 " 8 " "	" 5 and 10
" 8 " 11 " "	" 10 alone, etc., etc.,
to " 28 " 35 " "	" 30 alone

starboard and port alike.

It is therefore easy by seeing the lamps lighted to know the angle of the helm with sufficient accuracy, but the system has many defects notwithstanding.

Each of the receiving apparatus, consisting of seventeen lamps and bell, is relatively cumbersome. The lamps placed on the upper bridge or in the conning tower—which are fully illuminated—are visible with difficulty, and they do not stand well the fire of the guns and machine guns in their vicinity. The number of wires although reduced to ten is still considerable, and the reduction, moreover, has given rise to other defects. When certain lamps are lit up, others are glowing slightly, *en veilleuse*, producing before the man at the helm a series of lights of variable intensity, so that at first he has a difficulty in recognising the exact indication. Thus, when lamp 5 is lit up, another circuit partially lights up Nos. 10, 15, and 20. In a word, the helm indicating system as carried out in the "Bouvines" is far from possessing the same advantages as the controlling gear proper. A mechanical indicator, like that of the "Achéron," or any other more practical system, is in our opinion to be preferred, and it would be more in keeping with the general aptitude of the men who have to steer the ship. Practical experience of it at sea can alone sanction what we have said in favour of this electrical installation as a whole, but it would be very unfortunate if the defective action of the helm indicator should condemn the whole system, as it undoubtedly has many great advantages.

Electric Winches for Ammunition Hoists.—The circuits for these winches are controlled by three special commutators of the motor switch-board, bearing the following significations:—Starboard forward hoists, port forward do., after do. The motor switch-board (Fig. 11) is connected to the dynamos by the main distributing board; the contact strips, marked section *A* and section *B* of the former, being respectively connected with the centre of the commutators marked motors *A*, motors *B* of the latter (Fig. 2).

When the commutator of one of the winch circuits is put on to section *A* this circuit will then be supplied by the dynamo communicating with motors *A*, and when on section *B* by the dynamo communicating with the motors *B*. Two other contact strips marked "incandescent"

and "projectors" also allow of the winch circuits being supplied by the dynamos already supplying the incandescent and projector circuits. The motor switch-board also carries two more commutators for forward and after ventilators. The installation is completed by five ampèremeters interposed on each of the circuits, and by a voltmeter which, by means of a special commutator, can be shunted on to each of the supply circuits; section *A*, section *B*, incandescent, and projectors.

Each of the motor circuits can be worked with a relatively high current, which may exceed 400 ampères on one of the forward winch circuits, so that by working the switches when one of these circuits is in action, serious sparking might be produced between the contact plates. This danger is obviated by means of a bipolar interrupter near to each commutator, which ought always to be opened before working the commutator. Each circuit is protected finally by fusible cut-outs fitted at the connection to switch-board and at each branch, both on supply and return wires.

General Arrangement of Hoists.—They are all installed below the protective deck, and are eleven in number. Two of them are supplied by the circuit for "after" hoists; the nine others may be supplied as desired by the circuits for "port forward" and "starboard forward" hoists, by means of a special commutator placed near each of them. (See Fig. 13.)

As regards power, they are divided as follows:—Six of 205 kilos and 65 ampères for lifting ammunition from the platform deck to the upper deck and bridges; four of 150 kilos and 50 ampères for lifting ammunition from the magazines to platform deck; one of 120 kilos and a mean current of 45 ampères for lifting ammunition from platform deck to the military top. At the moment of starting it takes twice the current which it absorbs at its normal working condition.

Arrangement of Circuits.—The motors of these winches are all mounted in "shunt," with constant excitation, and are on the relay system, in a similar manner to that already described for the electric control of the steam steering gear. The box of relays, placed on the platform deck close to the winches to which it corresponds, carries three electro-magnets for "hoist," "lower," and "speed" regulation.

The circuits for the "hoist and lower" magnets are governed by two commutators situated at the two extremities of the lift for the ammunition. These commutators are worked independently of each other, but the lift itself will not move till both are in agreement; that is both at "hoist" or both at "lower."

The circuit of the corresponding magnets being then closed, it attracts its armature, and this movement makes the contacts which close the circuit of the motor armature, and starts the motor in the required direction. The motor is stopped automatically by a projection on the lift coming into contact at the ends of its course with another projection on the axis of the commutators and bringing it to zero, breaking the circuit of the relay. This circuit being broken the armature of the relay

is brought back by its recoil spring, the circuit of the winch motor armature is put in short circuit, and the motor stops instantly.

By this arrangement the lugs on the lift and axis of commutator for stopping form a safety gear, which prevents the handle being placed at hoist if the lift is right up, or at lower if right down. If, however, by a defect in the adjustment of the stopping lugs, the lift should not be exactly in position for loading, the circuit can be closed on the relays by a "push button" to correct the adjustment.

Speed Regulation.—The circuit of the third relay for change of speed is governed by a drum fixed to the winch, and partaking of its motion. Two cams with variable adjustment are worked by this drum alternately, and introduce automatically a resistance R (Fig. 12) into the armature circuit of the winch at the moment of stopping, and just before the lift reaches the end of its travel. By this arrangement the shocks on the transmitting gear by the motor instantaneously stopping and starting are much diminished, the lift having only a greatly reduced speed when leaving one end of its course and arriving at the other.

The four winches which are particularly designed for the 10-centimetre (4-inch) guns have been fitted with an intermediate stopping gear, so that they can be used for the two guns on different platforms, one above the other. This has necessitated a slight modification in the relay circuits. A working lever placed at the intermediate stopping point controls the action of the relay for hoist or lower of the upper and intermediate commutators, without the possibility of switching on both circuits at the same time by them.

A supplementary cam, fixed near the winch drum on the circuit of the third relay, controls the speed at starting and stopping for the intermediate position.

As the motors of all the winches are worked with a powerful current, it is not desirable in stopping them to put their armatures too directly on short circuit. The short circuit is closed across two magnets with large wire shown at T' and T'' (Fig. 12). The magnetisation of these magnets is utilised to assist the recall springs of the armatures of the relays for hoist or lower at the moment those circuits are broken. An attentive study of Fig. 12 will enable the arrangements adopted for these different installations to be understood.

Forward Winches.—The special commutators for putting either of the forward winches on to the general circuits of the starboard or port winches at will, are constructed so as to control the three circuits of each particular winch; armature, magnets, and relay. For this object they are arranged as shown in Fig. 13. The commutator of each particular circuit is connected to a sort of articulated parallelogram and the three commutators controlled by a single handle. In the position 1 of the commutators the winches are supplied by the circuit of the starboard winches; in position 3 by that of the port forward; and in position 2 are not in communication with either of the circuits.

Mechanical Transmission.—The electric motor transmits its movement to the winch drum by means of friction gearing. On this drum is

coiled the steel wire rope secured at its other end to the ammunition lift. The bracket support for the sheaves on which the wire rope runs are provided with Belleville springs to take up the shock of the lift when starting and stopping. Two handles are provided for each winch for working them by hand in case of failure of the electric machinery, and the gearing and un gearing of the hand gear is very simply and easily effected.

Safety Gear.—A safety gearing is fixed to the lift to prevent its falling in case of breakage of the wire rope. A Mégy brake and idle pawl complete the safety gear, and prevent the accidental running back of the winch and undue acceleration of speed in lowering.

Advantages of the System.—As installed in the "Bouvines" these electric winches appear to answer their purpose, and fulfil the necessary conditions for a rapid supply of ammunition to the guns. The system of relays for the motors requires no communication by voice-pipes nor mechanical transmission between the leaving and arriving stations of the lift. The relay circuits consist only of a small number of wires of small diameter, are the only leads above the protective deck, and are, consequently, the only ones subject to injury in action. An injury to these circuits would in no way paralyse the electrical action of the winches. The armatures of the electric relays on the platform deck could easily be worked by hand and the motors used. It would only be necessary to take care in this case not to keep the armature down when the lift reached the ends of its course.

To further provide against all possible failure, a very complete network of rails permits of transporting the ammunition to either of the winches on the platform deck from the magazines forward or aft. Another set of rails on deck serves for transporting the ammunition to the guns from either of the hoists terminating at the upper deck.

At the receiving trials these winches worked very well, the only fault to be found being the large expenditure of fuel caused by their employment, a defect inherent to all systems of electrical ammunition hoists. This expenditure, however, we consider amply compensated for by the facility of command which the motors present as installed in the "Bouvines." Since the trials they have been worked satisfactorily by men who have received no special training for the purpose. The working of the commutators always appeared to be simple and prompt, and there has been no difficulty whatever with them.

Electric Ventilators.—These on the "Bouvines" are fitted especially for ventilating the magazines and the extreme forward and after compartments, and are placed under the beams in compartments easily accessible in such a manner as to occupy as little space as possible. These ventilators draw the fresh air from above the protective deck, and thus contribute to the ventilation of the spaces between decks. The air is discharged into the magazine and thence through upcast shafts to the upper deck near the turrets. The motors are mounted in series and have a mean current of 10 ampères, supplied in two independent circuits for forward and after ventilators (Fig. 14). The commutators are similar

to those of the other motors. They allow of each circuit being supplied in four different ways by connecting them to the distributors for motors *A*, motors *B*, incandescent, or projector circuits. An ampèremeter is placed in each ventilator circuit, and fusible cut-outs on each lead and branch, and each ventilator is made independent by means of a hand interrupter placed close to it.

The ventilators worked well during the reception trial of 24 hours, the only inconvenience being a disagreeable noise caused by the vibration of their thin casings. Since then, they have been used on every possible occasion with excellent results. The carrying away of a lubricator pipe enables us to state that the dismounting and examination of these little apparatus is peculiarly difficult, and it would appear to be desirable to simplify this in future installations; it would certainly be necessary to carry out this examination after a certain period of working, and it should be easily effected.

Projectors.—These are five in number, arranged as follows:—

1. A search light fixed to a platform on the top of the military mast.
2. Four sweep lights, *feux rasants*, placed under the spar deck, capable of being run out about 4 feet clear of the side, and 14 feet above the water line.

They can be worked to give a light of 3,000 candles with 70 ampères, or 1,600 with 45 ampères, the normal voltage varying between 50 and 55. The mirrors are 24-inch (60-centimetre) diameter; they were supplied by Sautter, Harlé and Co. The projector on the military mast is about 75 feet above the water line; the standard support is similar to those ordinarily used, and it is furnished with an adjustable arm for fixing an elliptical mirror for long-distance signalling. The four sweep lights are installed on the system known as port-hole projectors, *des projecteurs à sabord*. In this method of installation the supporting column is suppressed, and the body of the projector is suspended at its upper part from a metal frame running on guides inside a rigid support fixed to the beams. When not in use, the projector is inside the ship, and is run out when required by means of a handle operating two Gall's chains. The supporting column being suppressed, the size of the port for the projector is reduced to a minimum.

The circuits for these five projectors are commanded by a special switch-board placed in the dynamo room, called the projector switch-board. (See Fig. 15.)

The two main connecting strips are in communication with the main switch (Figs. 1 and 2), and can, therefore, be joined up to either of the four dynamos without the possibility of joining up to two simultaneously through mistake or carelessness. Two other conductors connect the projector switch-board to the motor switch-board, so that one part of the motor circuit may be supplied by the same dynamo as used for the projectors.

Each of the five projector circuits lead directly from their switch-board, where each is controlled by a bipolar interrupter

A voltmeter and pilot lamp are inserted in shunt between the two connecting strips; an ampèremeter and two fusible cut-outs are also placed on each lead; the independence of each projector is thus completely assured (Fig. 15). The circuits for the two after projectors are led up to them directly from the switch-board through the large ventilating trunk for the dynamo compartment. The circuits for the three forward projectors follow the platform deck on the port side below the protective deck, and are led up inside the military mast.

Each of the projectors can be worked at a distance by electricity. The installation is divided into two parts, the post of command, and the mechanism proper for producing the two movements of inclination up or down, and to right or left. The posts of command, or working positions, have been installed so as to be directly under the control of the commander or of the officers acting on his behalf. They are raised above the port-hole projectors so that the man working the apparatus would not be blinded by their rays. The top projector and two of the port-hole projectors are worked from the fore-bridge, and the two others from the after-bridge. At each post of command is a cylindrical box carrying the two commutators for revolving and inclining the light, and enclosing the necessary resistances for giving the different speeds for these movements. The necessary current is taken in shunt off the lamp conductors of each projector. Two fusible cut-outs are placed at the junction of each lead in such a way, that if the working gear should prove defective it would not affect the action of the lamp itself, and in this case the elevating and sweeping movements could easily be carried on by hand. The commutators at these working positions work the light by transmitting the current in the required direction to the motors of the mechanism.

The mechanism is fitted in the supporting column of the projector in the top and in the supporting frame of the port-hole projectors. In each of them it consists of one electric motor with double armature; the two armatures are absolutely independent of each other, one producing movements of inclination, the other of revolution in a horizontal plane. The latter movement is unlimited, but the former is necessarily limited, and to prevent any injury to the mechanism for transmission, a special arrangement causes the instantaneous arrest of the motor when the inclination reaches its maximum amount up or down. By this means the armature of the motor is short circuited on itself, and its arrest is absolute and definite. It would be superfluous to enter into a detailed description of the circuits, as they are similar to those described in the course of the Torpedo School. Close to each post of command there is an additional commutator for lighting, extinguishing, or varying the intensity of the light from 3,000 to 1,600 candles. The exclusive employment of mixed lamps adds to the facility of working these apparatus.

The installation of the projectors on the "Bouvines" appears to fulfil the necessary requirements in a satisfactory manner, and the control at a distance worked perfectly during the trials for reception. In spite of

the fact that the port-hole projectors from their construction cannot be insulated from the hull of the ship, the insulation of the circuits was very satisfactory. The "sweep" lights are placed sufficiently high to be used under ordinary conditions of weather and sea, and at the same time are low enough to command a large zone around the ship. It is probable that these projectors might be kept outside the ship without being injured by the fire of the 4-inch guns in the lower battery, but the chase of these guns at present comes too close to the mirrors of the projectors. There is also a want of means of communication between each projector and its post of command, and it appears to us indispensable that a voice-tube should be fitted between these two positions so as to permit of a constant communication being kept up between the man working the commutators and the one in charge of the lamp.

For the communication between the posts of command and the main switch-board, the contract required the voice-tubes to pass through the central exchange. This arrangement, which is judiciously adopted for the protection of the voice-tubes to the magazines, turrets, or engine rooms, only causes inconvenience for the above unprotected communications, as the transmission is rendered too slow to be of practical use.

It will be easy to remedy these slight defects when further practical employment of the projectors shall have demonstrated the necessity of these modifications.

Conclusions.—As far as can be judged at present the electric installation of the "Bouvines" as a whole appears to be very satisfactory. The easy division of work between the generating machines allows in practice that one of the dynamos may be constantly dismantled and under examination. The working of the whole installation is perfectly assured by the three dynamos, even in the case of a sudden night attack, and we thus realise the possibility of having always one machine in reserve in case of one of the others giving out.

Under these circumstances it is to be hoped that the electrical apparatus of the "Bouvines" will always be able to satisfactorily meet the requirements for lighting the ship, both internally and externally, controlling the steering gear, ventilating the magazines, etc., and supplying ammunition to the guns, for which purposes they have been designed; and that no interruption in their successful working may detract from their success.

The "Bouvines," of which a photograph forms the frontispiece, is one of the new coast-defence battle-ships, of the following dimensions:—Length, 293 feet 9 inches; beam, 58 feet 3 inches; and with a mean draught of 23 feet she has a displacement of 6,610 tons. The engines develop 8,400-I.H.P., giving the ship a speed of 16·5 knots. Protection is afforded by a complete water-line belt 17·8 inches thick. The two turrets for the heavy guns have 14·5-inch armour, and the armoured deck is 4 inches thick. The armament consists of two 30-centimetre (12-inch) guns, one forward and one aft in turrets; eight 10-centimetre (3·9-inch) Q.F. guns; and sixteen small Q.F. guns, 3 and 1-pounders. Her normal coal supply is only 300 tons.

FIG. 6.

A, B, C, D, E, F, G, H, Contact Terminals.
1, 2, Leads in shunt on the night circuit.
3, 4, 5, 6, Supplementary Leads.

FIG. 7.

FIG. 8.

ELECTRIC ENGINE-ROOM TELEGRAPH.

FIG. 9.

FIG. 10.

ELECTRICAL STEERING GEAR.
SKETCH OF TRANSMITTER AND RECEIVER CIRCUITS OF INDICATOR

FIG. 11.

PLAN OF MOTOR SWITCHBOARD.

N.B.—The distribution strips are doubled for each circuit, one for the positive, the other for the negative.

FIG. 13.

FIG. 14.

ELECTRIC VENTILATOR CIRCUITS.

FIG. 12.

ELECTRIC WINCHES FOR AMMUNITION HOISTS.

WINCH WITH INTERMEDIATE ARREST.

FIG. 15.

PROJECTOR SWITCHBOARD.