The keel is very much produced forwards, where, at its lower apex, it has a rough surface of some extent, against which the united clavicles abut. Sufficient material is not at hand for me to say whether anchylosis ever takes place at this point or not: it may do so, because we find in Aluco these bones usually unite at this point; but yet we come across specimens of this owl where the union is no more perfect than it is here. The hypocleidium of the clavicles, and the manubrium of the sternum, are both about equally feebly developed. The upper extremity of each clavicle has a very broad abutment for the head of the corresponding coracoid, to the inside of which expansion these clavicular bones throw backwards a scapular process; but they fail to reach these elements of the shoulder-girdle, as we find them

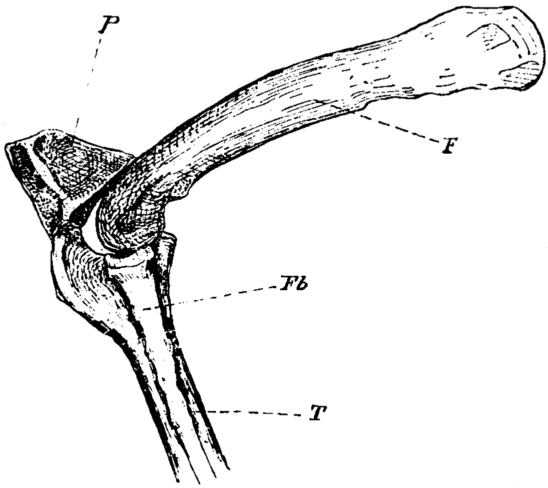

Fig. 3. — Knee-joint of Phalacrocorax bicristatus; right limb, life size. *F*, femur; *Fb*, fibula; *T*, tibia; *P*, patella.

in others of the class. All of the bones of the pectoral extremity, or the arm, are completely non-pneumatic, but otherwise well developed. Faint papillae for the quill-knobs of the secondaries are found along the entire length of the outer aspect of the ulna. The manus is composed of the usual number of bones,— one phalanx for index digit, two for the next, and one for the last.

In the lower extremity we find a femur of $6\frac{1}{2}$ centimetres in length; a tibia of $11\frac{1}{2}$; a metatarsus of 6; and the outer toe with five joints, measuring in all 10.7 centimetres. This limb is likewise non-pneumatic, in so far as its osseous structure is concerned. The fibula is carried unusually far down the side of its companion bone, to within 1.5 centimetres of the lower periphery of the outer tibial condyle.

The greatest interest, so far as the bones of the leg of this cormorant are concerned, centres about the knee-joint. Here we find a condition of affairs which is presented in my drawing. The femur, which is much roughened above for the attachment of muscles, articulates about equally with the leg-bones. In front of this joint is placed a very large and massive patella, of a pyramidal form, articulating with more than half its lower surface with the anterior and lower fifth of the femur, its inferior and anterior margin articulating at the same time with the upper border of the cnemial crest of the tibia. In front, we find that the groove that exists between the pro- and ecto-cnemial ridges of the tibia is produced on the entire anterior face of this patella, and, no doubt, the muscles of the leg are therein inserted, as in many divers. Such examples as this throw some light on such birds as Colymbus and Podiceps, where this bone becomes anchylosed with the tibia in the adult. I have not the skeleton of a loon at hand, to examine the process spoken of by Professor Owen ('Comp. anat. phys. vert.,' ii. 83), and followed by Dr. Coues in his osteology of the same bird ('Mem. Bost. soc. nat. hist.,' i. pt. ii.), as the analogue of the patella. The skeleton I have of Podiceps to examine does not show it; but it is one that has been in my collection for several years, and may have been lost. Penguins have a very large patella, that articulates with the tibia much in the same manner as it does here in Phalacrocorax. Professor Marsh describes a very large, free patella for Hesperornis regalis, and remarks that it bears a general resemblance to that bone in Podiceps ('Odontornithes,' p. 93). In examining this bone in the young of our cormorant, it seems to ossify from one centre. The ossification at the summit of the tarso-metatarsus includes the prominent process at the upper and posterior aspect of that bone.

Many other points of interest are to be found in the skeleton of the adult, as well as of the young of Phalacrocora xbicristatus, which space will not allow me to enter upon here: the leading points, however, I have endeavored to give, and these are always valuable when we wish to have them to compare with kindred forms.

R. W. Shufeldt.

THE ELECTRIC LIGHT ON THE U. S. FISH-COMMISSION STEAMER ALBATROSS. — I.

In pursuit of the hidden treasures of the deep, the work of the Albatross keeps her at sea many days at a time; and the operation of dredging in great depths often carries the day's labor past midnight. To provide for these emergencies, which are frequent, and to afford ample illumination for the naturalists, not only in assorting the contents of the dredge as it is delivered on deck, but to illuminate their microscopes, delicate balances, etc., in the laboratory, the commissioner of fish and fisheries determined to employ the best artificial illumination the country afforded. As the vessel is essentially a steamer, using steam for every labor where it is practicable, the idea of electrical lighting from a dynamo-electric machine, driven by a steam-engine, was readily conceived, and an examination of the different systems was at once entered into. The Edison company for isolated lighting, we found, was prepared to enter into a contract for a complete plant, including the engine and the wiring; and being able to divide the light into eight-candle power lamps, besides giving guaranties, their bid was accepted.

The arc-lamp, though admirable for our deck, where a great quantity of light in a limited space is necessary, can never, from its great brilliancy, be utilized for twelve or fifteen naturalists, each at a special work, in the laboratory. It also occurred to the commissioner, that a lamp which could be lowered into the sea, to attract fishes, would be useful, thus affording another reason for preferring the incandescent light.

Fig. 1 shows the way in which the arc-lights are placed in circuit. And as each arc offers a considerable opposing electromotive force, it is necessary, in order to get light in a number of such lamps placed in series, to use currents of high tension.

Fig. 2 shows the incandescent lamps in multiple arc. The main wires, *a* and *b*, are tapped at pleasure, and the lamps are hung in the short circuits. The carbon threads in the lamps (described beyond) offer so much resistance that the current heats them to incandescence. The electromotive force in the circuit is low, which renders shocks impossible.

The plant on board the Albatross consists of an eight and a half by ten Armington and Sims engine, an Edison Z dynamo having its field-magnets vertical, a resistance-box in the circuit of the magnetic field, the main and branch wires, lamp-fixtures, safety-catches, and lamps.

The steadiness and uniformity of brightness of the lamps depend largely on the engine driving the dynamo; and the success of the system lies more in the attention paid to the engine, when the plant is correctly installed, than in any thing else. Uniformity of speed is the great object sought; and, to secure this, Mr. Edison has wisely adopted a high-speed engine with a sensitive governor, which is found in the Armington and Sims engine, represented in fig. 3.

The superiority of this engine lies in its well-balanced working-parts, its relatively large bearing-surfaces, its sensitive automatic governor, and in its simple and well-balanced valve.

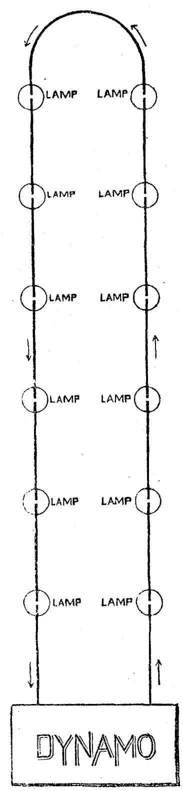

FIG. 1.

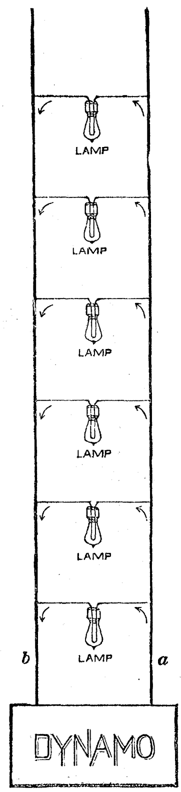

FIG. 2.

To secure high speed without the noise of 'thumping,' great lap has been applied to the exhaust side of the valve, whereby 'cushioning' is effected. This cushioning, or early exhaust closure, also effects a saving by retaining, in the clearance spaces, steam which would otherwise have been exhausted and wasted. To prevent an unequal expansion between the piston-valve and its chest, the castings are so made as to allow live steam to surround that part of the chest which surrounds the working-faces of the valve, as shown in fig. 4, in which *S* shows the steam space, and *E* the exhaust space. By this arrangement

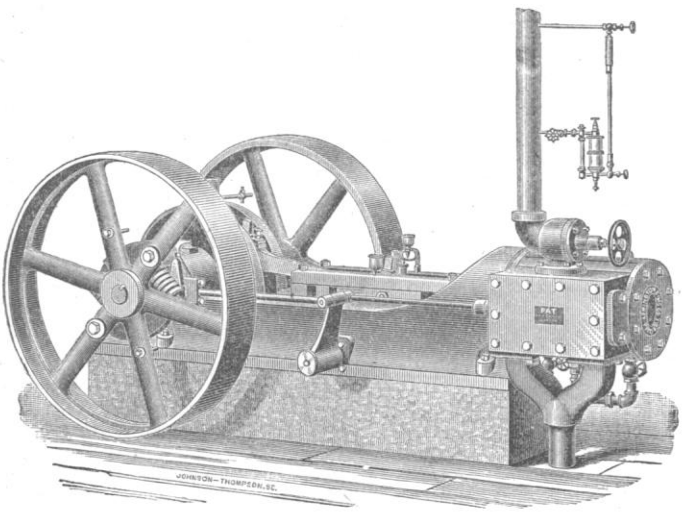

Fig. 3.

the valve-stem is packed against the exhaust instead of the steam pressure. The valve is ground to a sliding-fit, and, so far as I can ascertain, there has not been a particle of wear or leak during the ten months the engine has been in operation.

The governor of the engine, that part which makes it especially valuable for the purpose of electric lighting, is represented in fig. 5.

This automatic device is fixed in the fly-wheel, which is keyed to the shaft. There are two eccentrics, *E* and *F*, the one within the other, and both free to move on the axis. There are two weights, with their centres of motion opposite, and fixed in arms of the wheel. These

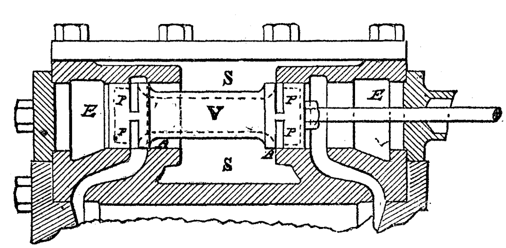

Fig. 4.

weights, *W*, *W*, are connected, each to an eccentric, and are connected together by an arm or rod. Springs are provided, to resist the centrifugal force of the weights. The system is so constructed that any centrifugal motion of the weights will throw one eccentric ahead and the other back, thus diminishing the throw of the eccentrics, and effecting a shorter cut-off without altering (within working limits) the lead of the valve. The engine used on board the Albatross has eight inches and a half diameter of cylinder, and ten inches stroke of piston: it runs without noise, three hundred revolutions per minute, requiring no more attention than the oiler can give it in addition to his other duties. When the main engines of the Albatross are in motion, a boiler-pressure of sixty-five pounds is often used, and twenty-six inches of vacuum is scarcely above the average. Lying in port, the boiler-pressure is kept at about twenty-five pounds; and, notwithstanding this great range of pressure, the governor regulates the dynamo to three hundred revolutions per minute, as closely as I can measure it.

In selecting a good engine, Edison has, to my mind, displayed as much genius as in using the Siemens form of armature for his dynamo.

The engines are placed on the starboard side

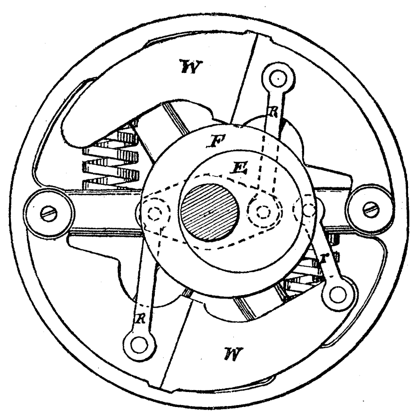

Fig. 5.

of the main engine-room, the engine taking steam from the main boilers, and exhausting into the main condenser.

The dynamo used on board the Albatross is known as the Z dynamo, and is installed for what is called a B circuit. It has its field-

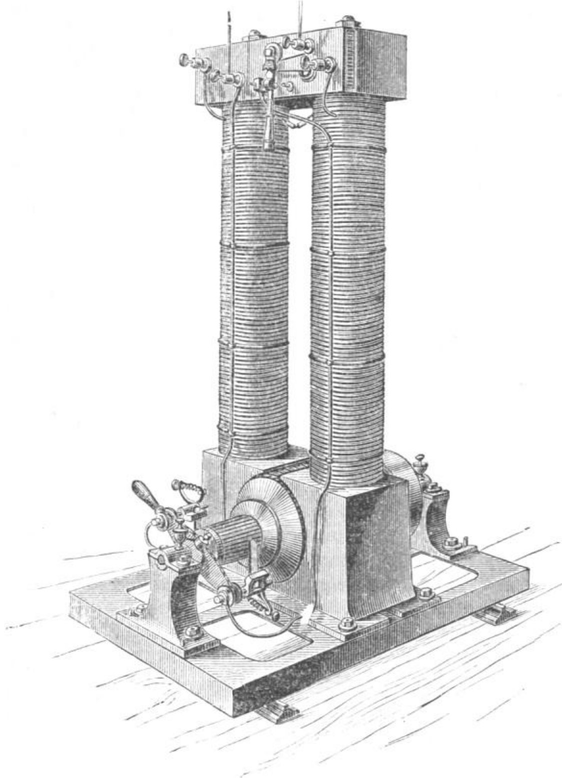

FIG. 6.

magnets vertical (fig. 6), and its armature revolves on a horizontal axis in the magnetic field. The field-magnets are arranged on what is called a ' derivation ' from the commutator, placing it in the circuit, as in the Siemens system. In adopting and utilizing known principles and devices, Edison has worked out the details to a state of perfection simply admirable. Wherever the eye rests, it is pleased by correct proportions, sound mechanical ideas, and agreeable outlines.

The armature, on Siemens's principle, is mounted on a wrought-iron shaft. About the shaft, and concentric with it, are circular cylinders of wood, separating copper plates, as shown in fig. 7. Between the plates *a* and *b*, and also between *c* and *d*, there are annular disks of copper, insulated from each other. Between the plates *b* and *c* are similar but very thin annular disks of iron, separated from each other by tissue-paper. This built-up cylinder is then bolted together longitudinally; the bolts passing through the thin iron and copper disks without touching them, but clamping them between the thick plates. Wire bundles or bars are placed equidistant from each other longitudinally, around the cylinder, connecting each a pair of the copper disks, i.e., one at each end; and these bars or bundles generate the current.

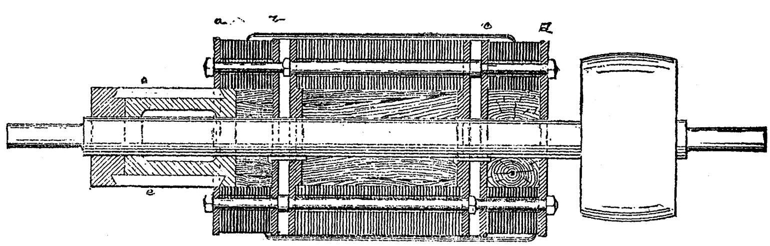

FIG. 7.

Bars of brass or copper, separated by thin sheets of mica, *e*,*e*, are dovetailed into the projecting end of the cylinder, which forms the commutator. The resistance of the generator is thus small, and allows great subdivision of the current in multiple arc.

To preserve the uniformity of the current, an adjustable resistance-box is placed in the circuit of the field-magnets; and, when a number of lamps are extinguished, additional resistance may be added to the field by a switch on this resistance-box, whereby the internal and external resistances are balanced, preserving not only the uniform brightness of the lamps, but also the economy of the machine. A test-lamp is suspended on the dynamo; and the fireman, who oils the engine, regulates the resistance according to the brightness of this lamp. Automatic regulators have been devised; but as it is necessary to employ a man to run the engine and dynamo, and as the incandescence is more frequently altered by slipping of belts than by the sudden turning-out of a large number of lamps, the same man can attend both: consequently the simple resistance-box answers every purpose on board ship.

(*To be continued.*)