The vitellus (Fig. 6) does not fill the entire cavity of the inner capsule, but is surmounted by a layer of colourless, somewhat cloudy, viscid albumen which is massed up, as it were, at the two extremities of the egg. The yolk is of a rich brown colour, of very fluid consistency, and sub-translucent. The surface of

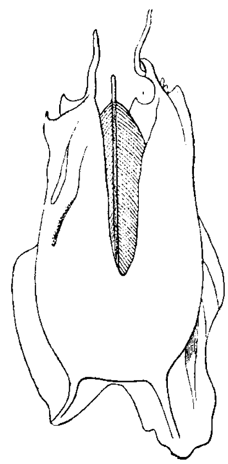

FIG. 4.—Another egg of *N. macromphalus*, seen from above, with the longitudinal slit in the upper wall of the outer capsule widened out so as to expose the inner capsule to view.

the vitellus is quite smooth. The length of the inner capsule is about 26 mm., while that of the enclosed vitellus is 17 mm.

I am not in a position to say much about the embryonic area at present, but I have observed an area pellucida about the

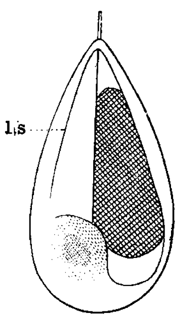


FIG. 5.—Inner capsule of another egg to show the dorsal ridge along the dorsal suture (*d s*) with its anterior terminal prolongation, and the lateral suture (*l s*). *o c*, remains of outer capsule.

middle of the lower surface of the vitellus in an egg which had been allowed to develop for twenty-four hours after being first seen. The large quantity of yolk points to the occurrence of a long period of incubation.

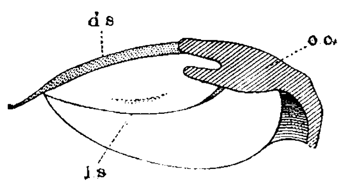


FIG. 6.—The inner capsule of the same egg, seen from below (*i.e.* from the side directed towards the surface of attachment). Half the lower wall of the capsule has been removed by slitting along one of the lateral sutures, and along the median groove (mentioned in the text), to show the brown-coloured vitellus lying in the capsule. The continuity of the lateral sutures in front is well seen. The shaded area represents a depression which occurred in the wall of the inner capsule in the region of the area of attachment of the outer capsule.

Sometimes the capsules of the egg are malformed, and, on opening such an egg, the vitellus is found to be already ruptured.

From the fact that in New Britain I obtained mature males of *Nautilus pompilius*, carrying a spermatophore in the cephalic region throughout the year, I came to the conclusion that the reproduction of nautilus took place all the year round. It now seems probable that the breeding of nautilus, as of so many other forms, is subject to a definite law of periodicity.

Finally, it may be mentioned that *N. macromphalus* varies with regard to the position of the spadix on the right or left side, and also as to the origin of the siphuncular artery, in the same way as *N. pompilius* does. The male of *N. macromphalus* carries a spermatophore in the same position as in *N. pompilius;* and, in fact, the only essential difference between the two species that I know of at present, is the difference between the shells in the umbilical region.

## *SIXTY YEARS OF SUBMARINE TELEGRAPHY.*

SIXTY years in sixty minutes—for thus Prof. Ayrton opened the lecture which he gave on Monday, the 15th inst., at the Imperial Institute. The undertaking seemed arduous, but, in reality, only the pioneer cables were dealt with, since later submarine telegraphy has no history—"Happy is the cable that has no history."

Another difficulty lay in the character of the audience; some were there knowing practically everything about telegraphy, while others were absolutely unfamiliar with the whole subject, except as regards the modern sixpenny wire. Prof. Ayrton, however, by a happy mixture of mathematics and magic lantern, electricity and elocution, seemed to entirely satisfy all classes among his audience.

The lecture opened with a letter of W. F. Cooke's, written in February 1837, in which he mentioned having seen Wheatstone—"a music seller in Conduit-street, but an extraordinary fellow." This acquaintance speedily ripened, for in the same year a partnership was formed between these two men, and the first telegraph line was constructed in this country; they also began to consider the possibility of laying an insulated wire under water.

The actual date of the commencement of subaqueous telegraphy seems, however, to be rather uncertain. Baron Schilling is said to have exploded mines under the Neva by means of an electric current as early as 1812, while it is certain that Colonel Pasley used this method to blow up the wreck of the *Royal George* at Spithead in 1838. But, as Prof. Ayrton pointed out, "it is to Morse that we can with certainty give the credit of having first used a wire under water insulated with india-rubber."

In 1842 this celebrated American inventor, then struggling in most dire poverty, laid with his own hands two miles of india-rubber coated wire between Castle Garden and Governor's Island. In the morning he found his cable broken, but not before he had successfully sent a series of the first subaqueous telegraphic messages.

It was not until after the introduction of gutta-percha into this country that submarine telegraphy became of practical importance. Sir Wm. Siemens first recommended the use of this "wonderful stuff" for insulation purposes, and in 1847 the firm of Siemens and Haske began to coat wires with gutta-percha, by means of a machine on the macaroni principle. Shortly afterwards such cables were laid in the harbour at Kiel and in the Hudson.

The history of submarine telegraphy, from a commercial standpoint, may be said to commence in June 1845, when Jacob Brett registered the General Oceanic Telegraph Company "to form a connecting mode of communication by telegraphic means from the British Islands across the Atlantic Ocean to Nova Scotia and the Canadas, the Colonies, and Continental Kingdoms"—certainly a bold project in those early days. As indicating the electric conditions of those times, the lecturer here quoted an extract from the *Weekly Register*, describing the transmission of the Queen's speech from London to Newcastle in 1847. "The speech was sent by special engine to Rugby, and thence by electric telegraph . . . so that the time occupied in its transmission was the *incredibly* short period of 6½ hours." Certainly, our modern minds do have some difficulty in crediting the time taken in transmission, but it is not due to its amazing shortness.

Meanwhile, Jacob Brett, together with his brother John Watkins Brett, applied to Sir Robert Peel for the purpose of obtaining a telegraphic monopoly; but the answer was unsatisfactory. Two years later the brothers petitioned again, with greater success, for permission to lay a cable between Dover and Calais. On August 10, 1849, Louis Napoleon granted them an absolute monopoly for ten years, provided that the wire was laid by September 1, 1850. Before this date a telegraph wire under the Channel became an accomplished fact, and messages were certainly transmitted through it, although they seem to have been slightly incoherent. The glory of this telegraph was, unfortunately, short-lived, for after the first evening it maintained an obstinate reserve, and "spoke no more."

The next year another concession was granted to the Bretts by the French Government, and on the strength of this the Submarine Telegraph Company was formed. But £300 was all the public would subscribe, as it had already been conclusively proved that submarine telegraphy was an impossibility. Happily Mr. Crampton came to the rescue, while Mr. Küper suggested armouring the insulated conductor with iron sheathing—a proposal also made by Willoughby Smith. Once more England and France were electrically connected, and on November 13, 1851, the public sent a message through a submarine cable for the first time in the history of the world.

The Bretts then applied to the Government for a monopoly to electrically connect England and Ireland. Prof. Ayrton read out the original replies they received on this occasion, in which each Government department in turn complimented the brothers on their perseverance and success, but regretted that the matter did not lie in their power, and referred them "next door." The laughter that was here heard among the audience was presumably due to the striking contrast this afforded with the promptness and celerity of Government procedure of to-day

As early as 1844 Morse had written to the American Treasury: "My experience is that telegraphic communication on the electromagnet plan might certainly be established across the Atlantic Ocean." Nothing was done in the matter until 1855, when a syndicate was formed, and in the following year Cyrus Field crossed over to England, where he signed an agreement with J. W. Brett, Charles Bright, and E. Whitehouse to start an Atlantic Telegraph Company.

Great difficulties foreshadowed the working of an Atlantic cable, due to the retardation of the signals. In connection with this subject, the lecturer stated the very different values which had been assigned by Wheatstone, Latimer Clark, and others to the velocity of electricity, before it had been deduced from a paper of Lord Kelvin's, in 1855, that electricity had no velocity in the ordinary sense of the word.

A mechanical model was shown illustrating the difference between the *sudden* opening of a door by a ball projected at it with a certain velocity, and the *gradual* opening of the door by the *gradual* increase of the pull at the other end of a long piece of india-rubber—the latter method being comparable with the action of an electric current. Experiments were also made on a water cable, and it was shown that by combining resistance and capacity, waves of water travelling in opposite directions could exist at the same time in a tube; also that if positive and negative pressures were alternately applied on one end of the tube, with an interval of time less than thirteen seconds between their application, no effect whatever could be detected at the other end of the tube, a distance of seven feet. The spots from three very dead-beat galvanometers, placed respectively at the sending, middle, and receiving end of an artificial Pacific cable, were then projected on the screen, and the gradual rise of current along the cable was made visible to every one, the current at the distant end taking six seconds to reach its steady value.

The lecturer here mentioned Fourier's *Théorie Analytique de la Chaleur*, published in 1822, which "mathematical poem," though written long before cables were dreamt of, enabled Kelvin thirty years later to attack a problem, the successful solution of which has created submarine telegraphy. For two other important conclusions were deduced from Kelvin's 1855 paper, namely, that the time elapsing before the current began to appear at the other end of a cable, only depended on the product of the resistance of the conductor into the electrostatic capacity, and practically not at all on the battery power. Also that the retardation of the signals was proportional to the square of the length. The first of these results was opposed to the opinion of such well-known engineers as Sir Charles, and Edward, Bright, who considered that the velocity of electricity varied with the use of high potential frictional, or of low potential voltaic electricity. From his own theory Kelvin calculated that the probable speed of signalling through the proposed Atlantic cable would be at the rate of three words a minute, which was subsequently found to be obtainable with his mirror galvanometer. Siemens, however, feared that only one word a minute could be sent, while Charles Bright, from experiments on 2000 miles of underground conductor, predicted ten or twelve.

Meanwhile the Atlantic Telegraph Company had been successful in their efforts, for in 1857 the U.S. frigate *Niagara* and H.M.S. *Agamemnon* started from Valentia with 2500 miles of cable coiled in their holds. About a tenth part of this was payed out, and then the wire broke in deep water; and so ended the first attempt to lay an Atlantic cable. The following year a second expedition started, and after several failures this cable was successfully laid, and England first spoke electrically to America. The life of this cable was, however, pitifully short; the signals grew weaker and weaker, and after one little month it died. It was not, indeed, until 1866 that a complete cable was laid by the Telegraph Construction and Maintenance Company, which also in the same year captured a cable that had been previously broken and lost. Thus two good cables were completed between England and America.

Prof. Ayrton then described the siphon recorder in some detail, and exhibited the earliest example of that instrument, constructed in 1870. Later forms were also shown, in which the electrified ink was replaced by the use of a vibrating siphon. The system of automatic sending was explained, and the question of signalling briefly considered, diagrams being thrown on the screen illustrative of the effect of condensers and of curbing in obtaining sharp signals. The word "imperial" was sent by an automatic sender at the rate of seventy-two letters a minute through the artificial Pacific cable in four different ways: (1) with no curbing nor condensers at either end; (2) with curbing only; (3) with condensers only; (4) with curbing and condensers at both ends of the cable.

Before concluding his lecture, Prof. Ayrton, not content with having his subject limited to the space of sixty years, looked ahead and saw, or rather failed to see, the cables of the future. For it is his belief that in the days to come copper conductors, gutta-percha insulation, and iron wire-sheathing will be relegated to the museum of antiquity, and when a person wishes to telegraph to a friend, he knows not where, he will call to him in an electromagnetic voice, which will be heard distinctly by him who has the electromagnetic ear, but will be silent to every one else!

The hall was hung with the portraits of the chief of the early workers in submarine telegraphy, each in its turn being illuminated with a projector when reference was made to it; the lecture was illustrated with historical letters and documents, specimens of all the important early cables, as well as of the latest, hydraulic and other models; and an artificial cable electrically 3600 miles long, fitted up with signalling apparatus at each end, was shown through the kindness of Dr. A. Muirhead.

Mr. Preece was unfortunately absent through illness, but his place as Chairman was filled by Sir Henry Mance. Thus a compensation was afforded in having an opportunity of admiring not Mance's method of finding faults, but his method of finding merits in Prof. Ayrton's sixty years of cable.

## *THE VALUE OF IRRIGATION CANALS IN INDIA.*

THE deplorable state of large districts in India at the present time is attracting a great deal of attention, owing to the famine which is devastating the country, caused by the failure of the crops from the drought and want of rain. Under such conditions, every drop of water is as precious as gold, and the canal authorities have to strain every nerve to make the available water supply spread as far as possible. Any information bearing on the canals cannot fail, at such a time, to be of interest. A return recently issued by the Public Works Department bears testimony not only to the great benefit that has already been conferred on India by the system of irrigation pursued during recent years by the Indian Government, but also shows that these works have been a financial success.

Lord Lansdowne is reported strongly to have urged that public works of irrigation do more good than any other form of public works; and it is a matter of regret that more has not been done in the past in the matter of canal construction. The total area irrigated in India from Government works is about $13\frac{1}{2}$ millions of acres, the estimated value of the crops raised on this area amounting to 37,000,000*l*., taking a crore of