protects the interior of the apparatus from every rapid variation of temperature. By the movement of the carriage the observer brings successively under the microscopes, the two metres the difference between which he wants to ascertain; he bisects the lines of both, and this operation made at the two extremities furnishes the equation desired between the two rules.

Another of the comparateurs represented in the accompanying diagram (Fig. 1) is designed for the measurement of expansions. As in the preceding comparateur we here also find two microscopes with fixed micrometers and a carriage moving on rails. Here, however, the carriage contains two distinct boxes or troughs; each at a distance of about one metre from the other. The two rules to be compared are placed one in each of these troughs. They are thus to some extent independent of each other, and may therefore be introduced at different temperatures. To measure the expansion of one rule, you place it in one of the troughs, and in the other trough the other rule called "*de comparaison*." This latter, so long as the process of determination lasts, is maintained at an invariable temperature, while the other is alternately cooled and heated throughout the series of consecutive experiments between sufficiently extended limits. The latter rule then alternately contracts and expands, and in the case of each particular experiment you compare the length the rule has reached at the temperature to which it is then subjected, with the constant length of the "*de comparaison*" rule. One of the great difficulties connected with these measurements is the maintenance for a sufficiently long time of an exactly uniform temperature, particularly when this temperature is notably at variance with the surrounding temperature. To secure this requirement the rules to be compared are immersed in a liquid, and this liquid is heated by means of a constant circulation of water within the double walls of the trough. Indiarubber pipes, as may be seen in the diagram (Fig. 1), are used for this purpose. The water is supplied from a large metal reservoir outside the chamber, being heated by a regulating system that causes it to issue at an invariable temperature. Thence by pipes it is conveyed to the comparateur, traverses the trough in a continuous stream, and is then carried off by waste pipes, conveniently arranged, into a drain. By this means a constant thermal state is maintained, within a few hundredths of a degree, at any point up to forty degrees, for whole hours at a time.

The diagram (Fig. 1) indicates the principal details of the mechanism employed. In front is seen the handle which by means of an endless cord draws away the carriage and allows the rapid substitution of one trough in place of the other under the microscopes. On the sides, the long rods provided with buttons, which the observer finds always under his hand whatever position he may occupy round the instrument, have the power of acting equally on the carriage by means of a cog-wheel placed under it, and of moving it backwards and forwards by a uniform slow movement. On the lids are perceived the heads of the different keys which enable rectifications of all adjustments to be made, as also the lenses by means of which the thermometers are read. The fly-wheels placed in front of the troughs serve by means of cords and pulleys to convey a movement of rapid rotation to the agitators which are placed in the trough, and thus vigorously intermingle the strata of the liquid, and secure uniformity of temperature in all parts of the bath.

With these apparatuses the difference can be determined between two metres at a given temperature with an exactness reaching to some ten-thousandths of a millimetre. In order to obtain such nicety, it is of course necessary that the lines of the metres be traced with sufficient fineness and distinctness to fit them for the magnifying power employed.

The two instruments just mentioned are fitted for the comparison of metres alone. The *comparateur universel*, on the other hand, allows comparisons to be made of any lengths whatever from below a metre up to two metres. The aspect of this new comparateur is entirely different from that of the two preceding. The microscopes which in all cases constitute the essential parts, instead of being fixed, are here mounted on carriages, which can be moved over a kind of bridge placed horizontally between two stone pillars. This bridge is formed by a large block of brass furnished with steel surfaces on its upper edges, which serve as a support and guide to the microscopes in their movements. It is perfectly rectilineal and horizontal When, by moving the carriages, the microscopes have been brought into the position they require to occupy for a given work, they are fixed by tightening a lever with the aid of a knob which controls a screw. Below, as in the preceding comparateurs, is a massive carriage likewise bearing supports on which are arranged the rules needing to be examined. These supports are equally furnished with all the necessary means of adjustment. These latter, again, are worked by a mechanism too complicated to allow so much as an idea of it to be communicated without the help of diagrams. The comparateur contains, besides, a standard rule of two metres, divided along its whole length into centimetres, two supplementary microscopes mounted on a special carriage and designed for marking the subdivision of a metre, various accessory pieces capable of serving for comparison of measures *à bouts*, either one with another or with measures *à traits*,[1] &c. It is entirely inclosed in a large mahogany box. This box is furnished with windows necessary for lighting the various parts, and with the orifices required for the transmission of movements to the interior, &c., and has the appearance of an imposing and elegant piece of furniture.

We have still to mention a comparateur for metres *à bouts* by Steinheil's method; and to add that this beautiful collection will in the course of a few months be completed by the introduction of a geodetical comparateur for rules of four metres, which is actually in process of construction, and the object of which is indicated by its name.

(*To be continued.*)

THE VIENNA INTERNATIONAL ELECTRIC EXHIBITION

FOR two weeks, the arrangement of the machinery being nearly complete, the Exhibition has been open in the evening from 7 till 11. The effect of the illumination of the immense interior of the Rotunda and its annexes by the various incandescent and arc lamps, and of the surrounding places which are lighted by large reflectors, is brilliant. The electric railway of Siemens and Halske between the Rotunda and the Praterstern is already in operation. The theatrical performances at the "Asphaleia" Theatre, which is lighted by 1500 Swan lamps fed by a large Zipernowsky alternating current machine, have also begun this week.

The series of lectures to be held at the theatre during the Exhibition was inaugurated on August 27 by Sir C. W. Siemens, with a lecture "On the Temperature, Light, and Total Radiating Power of the Sun." After a short introductory sketch of the nature of the terrestrial sources of light, the lecturer gave an account of the ratio of the three forms of radiant energy, viz. heat, light, and actinism, as produced by the sun and terrestrial light sources. Then referring to the difference between the statements of various astronomers and physicists relating to solar temperature, he expressed his opinion that the temperature of the sun could not exceed 3000° C., and explained the experimental methods he used for measuring the solar temperature. The second lecture was delivered on Sep-

[1] A metre or other measure *à bouts* is one whose ends exactly coincide with the ends of the material of which it is made; a measure *à traits* is bounded by lines within the margins of the material on which it is traced.

tember 1, by Dr. Aron of Berlin, "On the Telephone and Microphone." In this lecture the principles were explained on which the construction of the different telephones and microphones is based. There were also mentioned the variations of timbre as produced by these instruments; according to the experiments of Helmholtz the higher tones are transmitted better by the telephone, and therefore the timbre becomes clearer, while by the simple microphone, as Dr. Aron had found, the deeper tones are better transmitted, causing a duller timbre, but this failure is avoidable by using microphones with two coils. The lecturer explained also the principle of a new instrument, invented by himself, called the semaphone. In this instrument the variations of the current in a coil of insulated wire are transmitted by induction to another coil joined to a telephone or microphone. Dr. Aron has made experiments with his semaphone at Berlin, and was able to hear signals, the distance between the two coils being 70 feet. A similar experiment was carried out by Dr. Aron in the course of his lecture, and we could hear the noise made by a Neef's interrupter far from the lecture room, using a Siemens' telephone; the distance between the two coils being 3 feet.

Electric lighting is very well represented at the Exhibition, and a variety of new incandescent and arc lamps is to be seen there. As to the number of lamps exhibited, the first place is taken by the Swan lamps. Nearly 2000 Swan lamps are distributed at the theatre, the splendidly furnished interiors, and other parts of the building, fed by dynamo machines or by Faure-Sellon-Volckmar accumulators. The durability of these lamps is tested by a collection of lamps exhibited by Ganz and Co., used 1720 to 2330 hours. The carbon filaments do not show any damage, only the glass bulb being darkened by a carbon deposit. The exhibition of Edison lamps is not so extensive as it was at previous exhibitions. The Maxim lamps are used for lighting the Oriental pavilion and some of the interiors. The Lane-Fox lamps are also lighting some furnished apartments, and show the applicability of incandescent lamps for street-lighting by lighting the "Ausstellungsstrasse." The lamp of C. H. R. Müller has a screw-like curled carbon filament to make the emission of rays uniform in all directions. The U-shaped carbon strap of the Greiner and Friedrich's incandescent lamp is prepared from lamp-black and graphite, coal-tar being used as cement. The coal-tar, at first treated with sulphuric acid, is heated till it becomes an asphalte-like mass, to which lamp-black and graphite are then added, so that a stout paste is formed. By pressing this paste through a little fine hole a thin thread is obtained, which is cut in pieces and dried. If dried, the U-shaped pieces are burned. The carbonised fibres of *Musa textilis* are used for the incandescent lamps of Dr. Puluj. Very interesting is the Bernstein lamp, exhibited by the Bernstein Electric Light Manufacturing Company of Boston. It is claimed by the inventor to have many advantages over the other incandescent lamps. With an electromotive force of 23 volts and a current of 7 amperes, it has an illuminating power of 65 candles; it is stated to be more durable than the other lamps, and more economical, by rendering the light-giving carbon able to expand and contract without being liable to injury and breakage, and therefore capable of withstanding the action of strong currents, so as to avoid the disintegration which takes place in carbon filaments of high resistance. A large number of lamps can be used in series, and long distances can be lighted by means of a thin wire; the lamp is very appropriate for street-lighting. A hollow U-shaped carbon cylinder as big as a lucifer match is used as the light-giving part, having a comparatively large illuminating surface. This carbon cylinder is quite elastic, and its surface resembles knitwork. Though the manufacturing process of the carbon is not yet published, it seems to be very probable that the carbon cylinder is prepared by carbonising a hollow knitted or woven string, a metallic wire being put through during the burning process to support it. The ends of the U-shaped cylinder are connected with pear-like socket pieces of carbon, to which the two conducting wires are attached, entering the thin end of the carbon blocks, secured by means of a reddish cement. Such a lamp, fed by sixteen Faure-Volckmar accumulators, gave, as could be seen at the lecture delivered by Sir William Siemens, a white, dazzling light resembling an arc lamp.

Vienna, September 10

THE EDINBURGH BIOLOGICAL STATION

THE proposal to form a biological station at Granton, which was some time ago brought before the Royal Society in a paper by Mr. Murray of the *Challenger* Commission, has now taken definite shape. A lease of Granton Quarry for fifteen years has just been granted by the Duke of Buccleuch at a nominal rent, and Mr. Alexander Turbyne, salmon fisher, has been appointed keeper of the station, and will enter on his duties next week. Meantime some preliminary experiments have been made, and cages have been put down at the station, and structural work has been commenced in the way of fencing, building of walls, and putting the banks into proper order for further operations.

The proposal for the formation of the station, which it is meant to call "The Edinburgh Marine Station for Scientific Research," had its origin in the resolution of the Committee of the late Fisheries Exhibition in Edinburgh to hand over the surplus funds derived from the Exhibition to the Meteorological Society, to be applied to the purpose of carrying on investigations with respect to fish, with a recommendation to establish a zoological station, and to apply to Government for assistance in the work. The Meteorological Society appointed a sub-committee to consider the best means of applying this money to the purposes for which it was granted. This Committee had many consultations, and set afoot investigations at various ports as to the temperature of the water, habits and food of the fish, &c. They also had their attention carefully directed to the advisability of establishing a zoological station; and the suitableness of the old quarry at Granton for the purpose has been in various ways brought before the public, both at the Royal Society and at the meetings of the Meteorological Society. The scheme for founding a station there first took definite shape on the offer of a gentleman interested in research to build a floating laboratory at the quarry for the purpose of making experiments and investigations. Recently this gentleman was again communicated with, in respect that, after full consideration, it was thought that a floating laboratory, although an essential part of the scheme, was not, perhaps, the first that should be undertaken. In reply to a representation to this effect, the gentleman has written to Mr. Murray, the convener of the Station Committee, expressing his readiness to adopt the alterations proposed, and to give the 1000*l*. for the purpose of founding a zoological station for scientific research at Edinburgh, instead of building a floating laboratory, as originally suggested. He was not surprised to hear, he adds in his letter, that it would cost more than that to carry out the whole of the scheme. It seemed to him that they would require at least 1500*l*., in addition to his 1000*l*., to carry out all their proposals, and they should consider if this additional sum should not be raised before they commenced operations. However, he left the matter in the convener's hands to apply the money as he thought best, inclosing 100*l*. to cover preliminary expenses, and repeating the two conditions of his donation, viz. (1) that the convener should take the general direction of the station for at least three or four years; and (2) that his name was not in the mean-