Messrs. A. Eden, F. Heppenstall, H. W. Lee, A. P. Pyne, R. C. Quin, D. C. Wardlaw, L. Wilson; and to the *Benevolent Fund* from J. W. Fletcher, J. G. Wilson, and J. H. Woolliscroft, to whom the thanks of the meeting were duly accorded.

The PRESIDENT: Mr. W. R. Cooper, who has been the Institution's representative on the Committee of *Science Abstracts*, has been elected Secretary of the Physical Society, and therefore he can no longer represent this Institution. Mr. Kingsbury has kindly consented to take his place, but the Council particularly instructed me to mention this matter to the meeting, because we feel that the Institution is very much indebted to Mr. Cooper for the immense amount of hard work he has done as editor in past days, and the work he has most recently done as the most active member of the Committee.

At the last meeting I reminded members of the Institution that the Council would be glad to receive any suggestions of names for the candidature of the new Council. As I then explained, the Council do not bind themselves in any way to nominate people so recommended, but they will be very glad of any names suggested by members, and they will be carefully considered.

I will now ask Mr. J. Stöttner to read the paper in his name on the Nernst Lamp.

THE NERNST LAMP.

By J. STÖTTNER, Member.

Few inventions in electrical science have created greater expectations, excitement, and speculation than the Nernst Lamp, and with few have there been such immense difficulties in obtaining practical and satisfactory results.

From the time of the earliest application of the Edison glow-lamp attempts were made, first, to discover a substitute for the carbon filament; secondly, to avoid the necessity of evacuating and sealing the globe; *and thirdly*, in case of the filament giving out, to accomplish its exchange without at the same time throwing away the body of the lamp itself.

In 1877 Jablochkoff took out a patent for a lamp in which the illuminating body consisted of kaolin and similar refractory earths, which become conductors of electric current as soon as heated to a certain temperature.

Partly on account of the very low efficiency, but more particularly by reason of the necessity for very high-tension currents, this invention —in common with all other attempts—proved a failure, until Professor Walther Nernst came to the front with his lamp in the year 1898.

I have lately visited the extensive lamp works of the Allgemeine Elektricitäts-Gesellschaft, and will endeavour to make you acquainted with the development of the Nernst lamp manufactured there from its earliest stage up to its present design, for which purpose the A.E.G. has been kind enough to supply me with original samples of the lamp in its various stages of development and design. The filaments of all these lamps are made of rare earths, principally of zirconia.

The earlier types of Nernst lamps had no automatic heating arrangement, and the filament or glower, as our cousins in America call it, had to be heated to the temperature required (on an average about 700° C.) to make it a conductor, by means of a spirit lamp or match.

The very first lamp brought out was type No. 1 (Plate I.) with a straight filament, the compensating resistance (or bolstering resistance as it is termed on the Continent) of which, consisting of a fine platinum wire, was arranged in parallel with the filament at a distance of about ¼ in.

In type No. 1A (Plate I.) the filament was bent in a similar manner to that of the first Edison bamboo carbon incandescent lamp, and was in the shape of a horseshoe. The burner of this lamp could be exchanged.

The bulb was open in order to facilitate artificial heating of the filament, as mentioned before. The bolstering resistance, to which I shall refer again later, consisted of fine platinum wire wound round two small porcelain tubes, and was exposed to the air to obtain a better cooling effect.

The filament in type No. 2 (Plate I.) was exactly the same as in No. 1A, but the bolstering resistance was wound on one small porcelain tube only, and partly covered with kaolin.

In type No. 3 (Plate I.) the resistance consisted of thin iron wire wound on a very small kaolin tube, which was sealed and enclosed in a glass tube. This tube was evacuated and afterwards filled with hydrogen gas. All these models, however, proved unsatisfactory, and platinum wire was again resorted to as a bolstering resistance, as type No. 4 (Plate I.) shows.

In this lamp the large loop is the resistance, which was prepared in almost exactly the same manner as the heater of the present day, a very fine platinum wire being wound in a spiral on a thin kaolin tube and then steeped in a solution containing kaolin. The small loop is the filament. It will be noticed that in this lamp filament and resistance are fixed for the first time on a porcelain base. This shape of resistance was in use for a considerable time and will be seen again in the later types.

The trouble of lighting the lamps by means of a spirit lamp or match, however, prevented their being brought into general use. They were exhibited for the first time in public in conjunction with some automatically-heated lamps at the Paris Exhibition of 1900, where the patentees, the Allgemeine Elektricitäts-Gesellschaft, of Berlin, had a magnificent pavilion lighted entirely by Nernst lamps. At this time the difficulties had by no means been overcome, but seemed rather only to have commenced, and it was found absolutely necessary to effect the heating of the filament automatically in order to bring the lamp into practical use.

In type No. 5 (Plate I.) the automatic heater will be observed for the first time. The filament in this type was again a straight rod, placed horizontally to the base of the lamp. The thick porcelain tube next to it contained the heating wire, and the smaller tube the bolstering resistance. Both filament and bolstering resistance in this lamp could be exchanged. The automatic cut-out was embedded in the socket. It will be observed that the magnet had great masses of iron and a heavy armature, in consequence of which a great deal of energy was required to actuate it.

In type No. 6 (Plate I.) we see for the first time a heater in the form of a coil, in the centre of which the filament is placed. The heating coil was prepared in a similar manner to that in type No. 4, but mounted together with the filament on a somewhat larger base, and could be easily exchanged. The bolstering resistance was the same as in type No. 3 and could be exchanged, but was firmly fixed to the socket. The magnet was identical with that of type No. 5, and the glass bulb similar to that of an ordinary incandescent lamp.

Type No. 7 (Plate I.) is very similar to No. 6. This lamp was designed for 220 volts. The filament could not be arranged in a horizontal position on account of its length, and therefore both filament and heater were mounted vertically to the base.

A great improvement is shown in type No. 8 (Plate I.). Here for the first time will be observed in the bolstering resistance spirals of thin iron wire suspended free of the carrier.

Type No. 9 (Plate II.) was a departure from the usual practice, in which a loop filament was again used and a magnetic cut-out placed alongside of the bolstering resistance instead of being embedded in the socket.

Up to this time the lamps had been manufactured only in small numbers, but types Nos. 10, 11, 12 (Plate II.) and 13 (Plate III.) were now designed and for the first time produced in considerable quantities. These lamps show two distinct forms, the "A" type with large body and globe, and the "B" type with small round globe and body so arranged that it could be used in an ordinary Edison screw lamp socket.

The "B" lamps, types 10 and 11 were manufactured for an energy consumption of 40 and 80 watts and potentials of 110 and 220 volts respectively. The bolstering resistance in these types again consisted of platinum wire as in type No. 4. As on account of their small size it was impossible to combine these filaments with a modern iron resistance they were all arranged in a horizontal position. The heating spirals were mounted firmly on the porcelain baseplate, which could be easily exchanged. In these lamps the magnet of the automatic cut-out received its final shape, being marked by very small masses of iron and a very light spring, and in consequence thereof by a very small loss of energy. The "A" lamps were for higher currents up to 1 ampere, and had to be separately connected in a similar manner to that in which an arc lamp is connected.

Types 12 and 13 were designed for an energy consumption of 100 and 200 watts with a corresponding lighting capacity of 65 and 130 standard candle-power respectively. In this type the burner, as well as the bolstering resistance, could be independently exchanged. These lamps were made for 110 and 220 volts. As opposed to the "B" lamp, the filament and the heating coil were arranged in a vertical position. The design of the magnets of the automatic cut-outs was exactly the same as that in the "B" lamps. The metal cap covering the resistance was provided with ventilating slots, so that the bolstering resistance was cooled by the circulation of air.

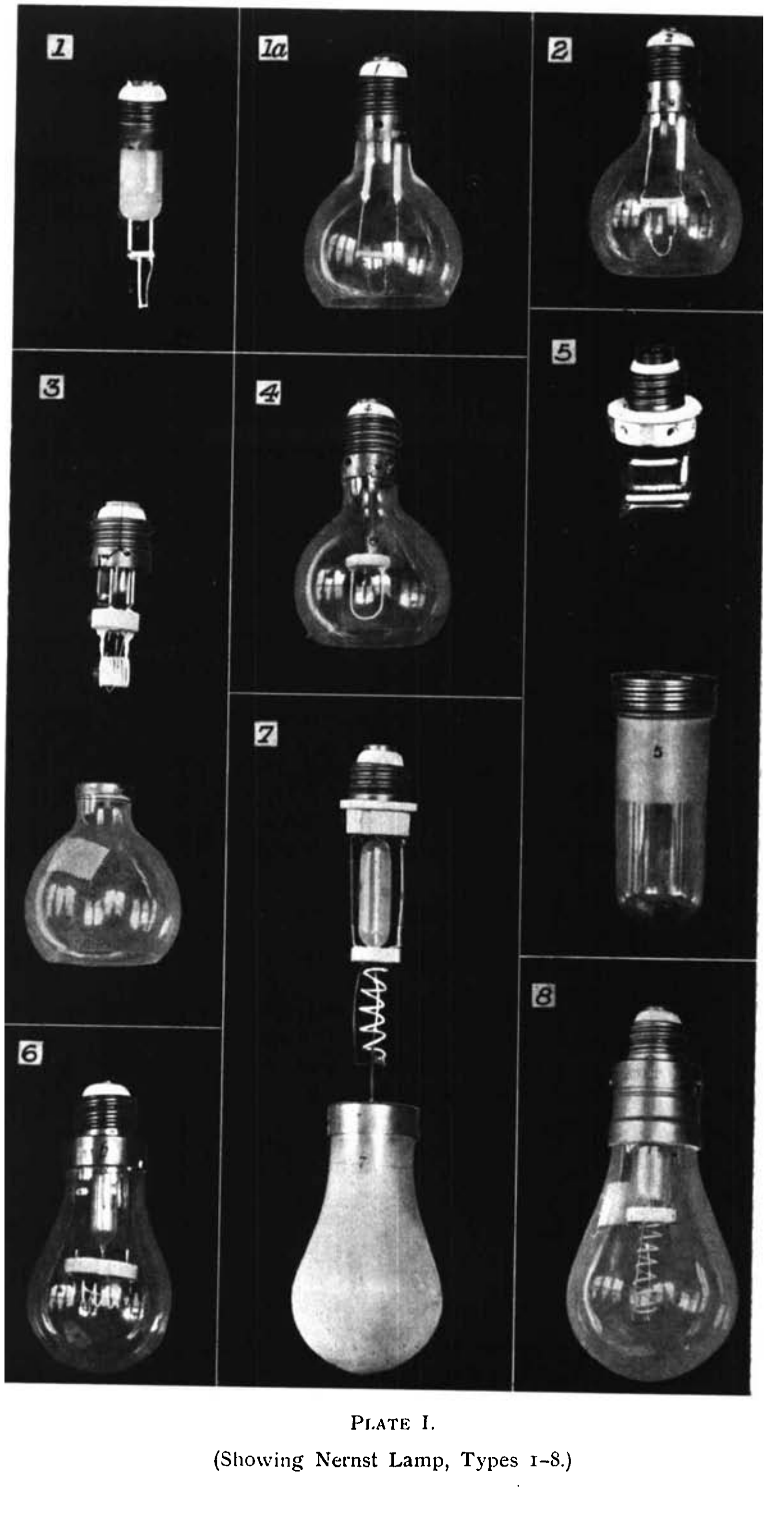

PLATE I.

(Showing Nernst Lamp, Types 1–8.)

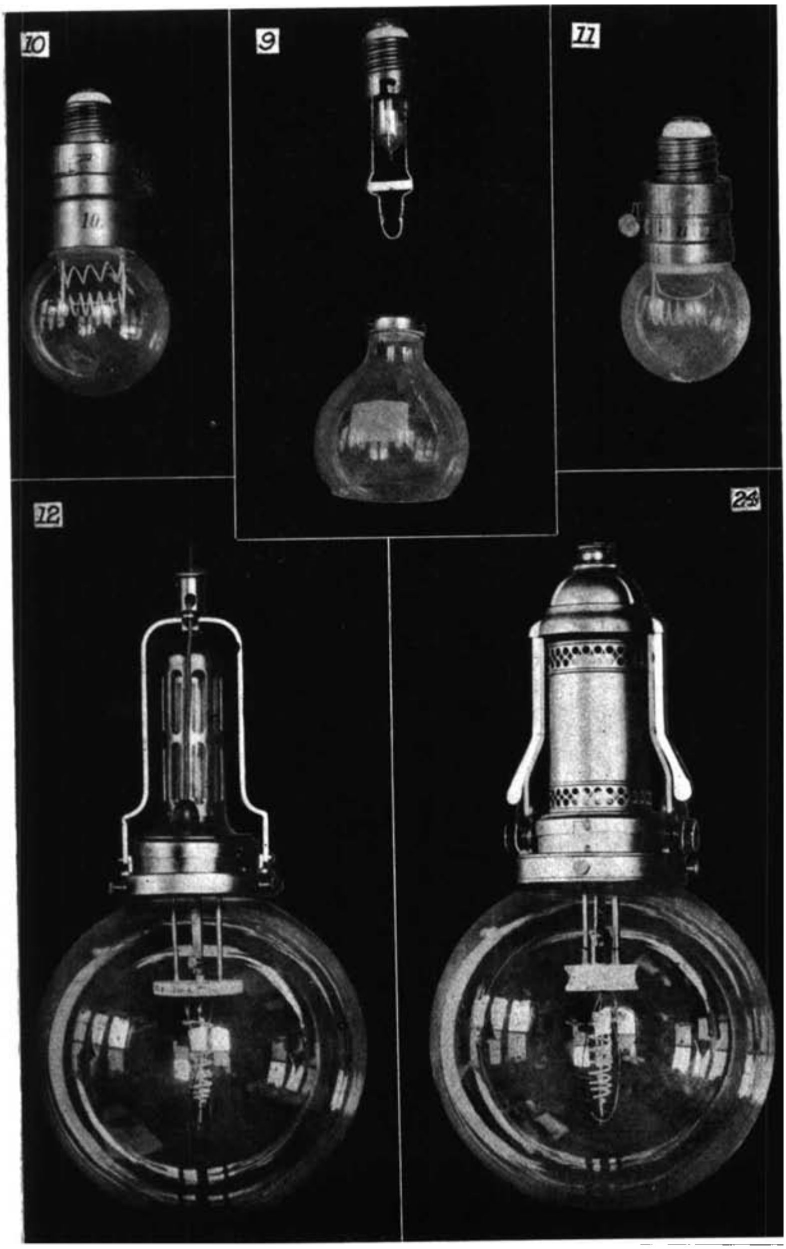

PLATE II.

(Showing Nernst Lamp, Types 9–12, and 24.)

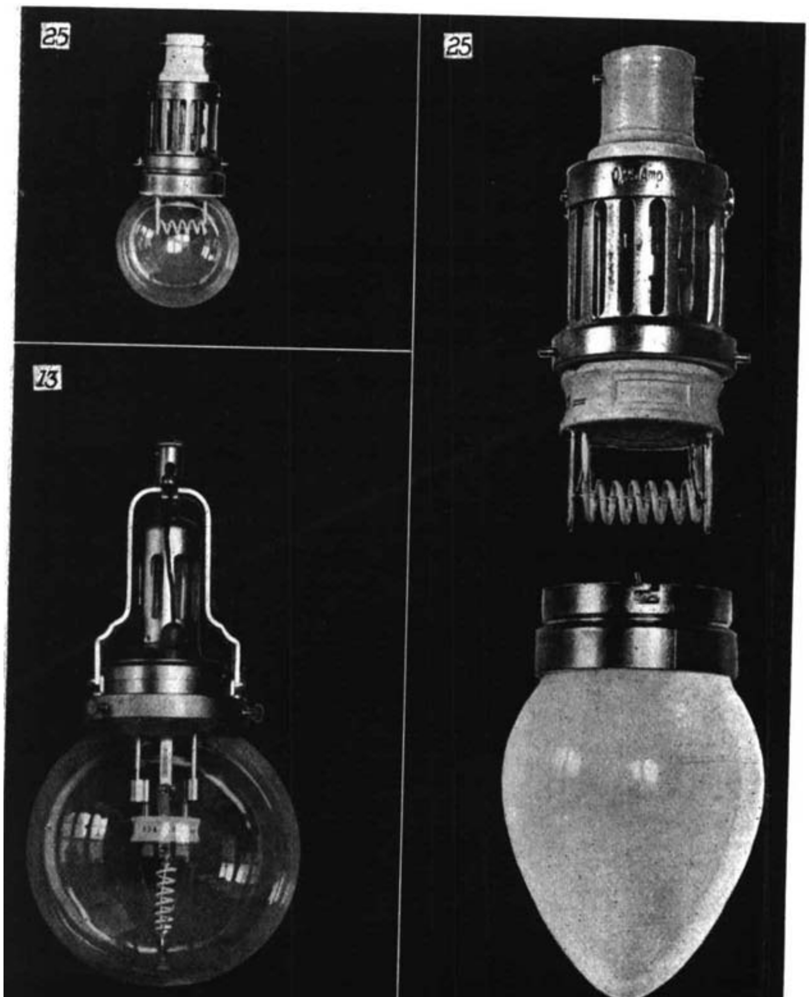

PLATE III.

(Showing Nernst Lamp, Types 13 and 25.)

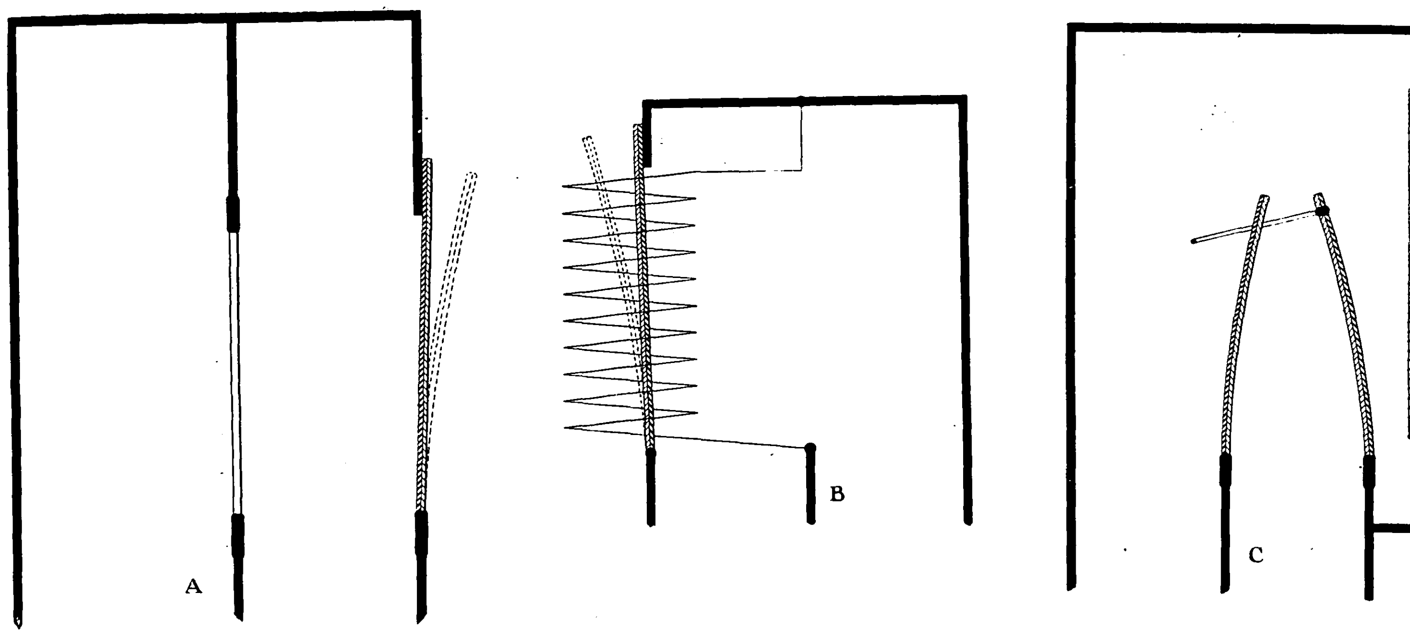

PLATE IV.

Types Nos. 14, 15, 16, 17 and 17A show the development of the Nernst lamp as a candle lamp for chandeliers, etc. These lamps do not deviate materially from those described up to now, but correspond with the ordinary lamps in each successive stage of development.

In Nos. 18, 19 and 20, the gradual reduction of the iron masses in the magnet will be noticed. The first magnet weighs about three times as much as those in use at the present day.

Nos. 21, 22 and 23 (Plate III.) show experiments in disconnecting the heater by other means than that of an electromagnetic cut-out.

Sketches A, B and C (Plate IV.) show the corresponding diagrams of current in these devices. The springs of compound metal bend to one side as soon as heated. These inventions, however, did not come into practical use and, indeed, never left the laboratory. I merely mention them to show that all kinds of researches were made with the object of improving the details of Nernst lamps.

Nos. 24 (Plate II.) and 25 (Plate III.) show the latest patterns of Nernst lamps, as now in use by the million.

No. 24 is the A type lamp. The burners are manufactured for 1 ampere up to 250 volts, and for ½ ampere, only, from 200 up to 250 volts. The metal hood is furnished with metal combs of thin sheet copper in the inner cover, for the purpose of cooling the bolstering resistance. Between this inner tube and the outer mantle are a number of tubes for ventilation purposes and to facilitate the radiation of heat.

The replacing and fixing of burners is a very simple manipulation, and can be effected by any unskilled person.

For customers who have A lamps of the old type we have designed special adapters, so that the new burners can be used on such lamps.

No. 25 (Plate III.) is the latest B type lamp, which is manufactured for ¼ and ½ ampere up to 150 volts, and for ¼ ampere up to 250 volts.

The replacement, etc., of burners is quite as simple as in the case of the A type lamp.

Nos. 26 to 36 are various bolstering resistances, all made of iron wire, sealed in glass globes which have been evacuated and afterwards filled with hydrogen. Iron wire is used on account of its high temperature correction, which makes it particularly suitable, as, for instance, should the current increase 5 per cent. the resistance of the iron wire increases about 75 per cent., thus preventing the destruction of the filament. The increase of resistance in the iron wire is not proportionate throughout, and it is therefore necessary that the sectional area should be chosen with a view to heating the wire to a critical temperature by the current with which the lamp is intended to burn, in order to arrive at the above-mentioned result, i.e., the balancing of current by resistance.

Nos. 37 and 38 show filaments which have burned 1,400 and 1,600 hours respectively. Unfortunately No. 37 is broken, but from No. 38 it can be easily seen that the filament has become crystallised. It is also black throughout; this discoloration starts at the negative pole and gradually extends over the whole filament. The precise cause of this crystallisation and blackening is not at present known, but we presume that it is due to electrolysis.

As to the efficiency and life of the Nernst lamp, I refer to the table of tests made at the Physikalische Technische Reichsanstalt at Charlottenburg.

A number of lamps have been under test at the Electrical Testing and Standardising Institution at Faraday House, London, since the middle of December. The results, however, are still outstanding.

A great many errors in the treatment of Nernst lamps are committed, in consequence whereof numerous complaints of short life, etc., are lodged with the suppliers; but if instructions are carefully followed a life of about 300 to 400 hours—as practical results show—may be expected. One great mistake generally made is that the current is sent through the lamps in the opposite direction to that intended, particularly in the "B" type lamp. Another mistake is to overrun the lamps, as the surplus current is then taken up by the bolstering resistance and practically the light is not in the least increased.

On the Continent the screw holder is in almost universal use, and the standard rule is to make the centre contact minus; it is therefore immaterial how frequently the lamps are taken out of their holders, as they always come back to their proper position. With bayonet lamps it is different: the poles can be easily changed by inserting the lamps the wrong way, and to prevent this the A.E.G. have designed a tool to cut out a slot, and have provided the porcelain socket of the lamp with a third pin, so that it is impossible to get the lamps into the holders the wrong way.

To determine the polarity on bayonet sockets special pole-finders are supplied, the negative pole being invariably indicated by the red appearance of the solution.

I have studied the principles and designs of the Nernst lamps manufactured in the United States, and think that we here in the Old World may pride ourselves on being at least as up-to-date as our American cousins.

Mr. Drake.

Mr. B. M. DRAKE: We are indebted to Mr. Stöttner for kindly giving us the history of the evolution of the Nernst Lamp, as worked out by the Allgemeine Elektricitäts-Gesellschaft, of Berlin, and it may be of interest to compare what has been going on in this country in connection with the same problem. As you may know, when this invention was first brought to public notice, attempts were made at a meeting at Berlin of the holders of all the patents of Nernst for the world to arrange for an interchange of experience by which the lamp might be brought to perfection in less time than would be possible if each worked on his own account. At that meeting, which Mr. Swinburne and I attended on behalf of the Nernst Electric Light Company, there were present Mr. Westinghouse, the Allgemeine Elektricitäts-Gesellschaft, and Messrs. Ganz. Two days were spent in discussing the invention, which was regarded as marking a new era. There was a serious discussion as to the result on the electrical industry when the lamp should make its appearance. One influential member said there was no doubt that if these lamps were put upon the market indiscriminately the supply companies' business throughout the world