electrodes 27 or 28 in (68.5 or 71.1 cm.) in diameter will be required. Perhaps these can be made and can be used continuously as described above, but the writer believes that development in this direction is a mistake, and that far better results can be obtained by multiplying the number of electrodes and keeping the size within reasonable limits. This is not merely a question of avoiding the difficulties of large electrode manufacture, but involves more efficient and satisfactory working of the furnace. It will readily be seen that distribution of temperature in the furnace is bound to be better as we multiply the relatively small areas where the heat is generated, and this is an important consideration. The objection that is raised to this proposal is the difficulty of regulating the rate of generation of energy at the various electrodes. It does not seem that this difficulty is a real one.

The roof problem is altogether a different one. It must be remembered that the heating effect in the steel furnace is generated in an arc and in a resistor formed by the slag, and that consequently the surface of the slag is intensely hot, particularly where the arc strikes it. These conditions are very severe and combined with the corrosive action of the lime which is vaporized from the slag, make the roof renewals a heavy item in the cost of electric steel.

This problem has recently been the subject of careful study in two research laboratories, with one of which the writer is connected. As a result of a great deal of experimental work a brick made of silicon carbide has been manufactured which it is believed will have a much longer life in the steel furnace than the silica brick now used. The brick is made by taking powdered or granular silicon carbide, mixing it with a suitable temporary binder, such as a solution of dextrine, molding and then heating in an electric furnace to the temperature at which silicon carbide is formed. Bricks made in this way have been used in the roof of an experimental steel furnace in one of these laboratories and then put to the severest test possible. The bottom of the furnace was purposely raised well above the normal level so as to bring the surface of the slag as close to the roof as possible, the actual distance in some experiments being only 10 in. (25.4 cm.) Then the furnace was worked at double the normal rate of generation of energy so that the heating of the roof was very intense, so much so that an ordinary silica roof would melt down rapidly and be completely destroyed in a single heat. Even under these very severe conditions the silicon carbide roof stood up perfectly. Experiments have also been made in other steel furnaces and these results confirmed. The most serious objection to a roof of this kind is its relatively great cost, but if it lasts a sufficiently long time it is nevertheless economical.

Twenty-five years ago Ferranti in England and Colby in this country worked on the very interesting furnaces known as the induction type. In this the secondary of a transformer consists of the metal to be melted. As in the case of the Siemens furnace the original inventors were too far ahead of the times and it was not till 10 or more years later that any commercial application of the furnaces was made. Since then the induction furnace has developed considerably and is now used with success in the manufacture of steel. An objection to the induction type is that its first cost is very great and certain problems connected with it become very serious when it is desired to build furnaces of large capacity.. The worst of these is the very low power factor of the furnace. To overcome this objection it is necessary with large furnaces to have a generator furnishing currents of excessively low frequency. Thus, at the Völklingen steel works a generator giving a current of 15 cycles is used, and for larger furnaces it has been proposed to use a five-cycle current. In an experimental induction furnace plant built by the writer's laboratories for an electric furnace company at Niagara Falls, the low power factor was corrected by using a synchronous motor as a condenser.

Nearly thirty years ago the Cowles brothers were working with the electric furnace in attempts to heat the charge of zinc retorts by electrical means. The principle involved in this case was mixing with the ore to be reduced a certain amount of carbon which not only acted as a reducing agent, but made the charge as a whole a conductor of the current. This furnace may be considered the forerunner of an immense number of electric furnaces in operation to-day, furnaces for making calcium carbide, the ferro alloys, iron ore smelting, graphitizing, etc. The Cowles furnace was a small one, but since its day the development of the electric furnace helped by the corresponding development of electrical apparatus has led to the construction of units of continually increasing size. To follow up the development of these furnaces would certainly trangress the limits of this paper, and instead, the development of a somewhat different type will be considered because the writer has been more intimately associated with it, and because it contains points which are, perhaps, of more particular interest to the electrical engineer.

In Acheson's first experiments which led him to the discovery of silicon carbide (carborundum) he used a furnace of the Cowles type. It consisted of a small brick box with carbon terminals at each end so arranged that they could be moved in and out in a horizontal direction. This box was then filled with the mixture of sand and coke (clay and coke in the earlier experiments) and the terminals brought together, or very close to each other, and then gadually withdawn as the furnace heated. It was soon observed that a more satisfactory way of constructing the furnace was to have stationary terminals connected to each other by means of a resistor composed of granular carbon and then surround this with the charge. With such an arrangement it was necessary to have some means by which the voltage could be regulated so as to keep the rate of generation of energy in the resistor constant throughout the run. This was found by Acheson to be a much more satisfactory way of working the silicon carbide furnace, and by experiment he found the best dimensions for his resistor. In the original small plant, where the furnaces had a capacity of about 100 kilowatts, the generator supplied current to a great bank of small transformers so that variations in the voltage could be obtained by suitable connections of the secondaries. When, however, a plant was established at Niagara Falls using furnaces of 750 kilowatts, the problem of varying the voltage at the furnace terminals became important. This was solved by the construction of a large induction regulator to be used in the secondary circuit of the transformer which stepped down the primary current of 2200 volts to 160 volts. The induction regulator then made it possible to vary the e.m.f. by 60 volts on either side of this, so that at the furnace terminals the total range was from 100 to 220 volts. For furnaces of this resistant type the induction regulator is an ideal apparatus, and it is to be regretted that it is not more generally used. The objection raised to it is usually its relatively high cost, but the convenience and simplicity of the apparatus far more than compensate for the extra cost. In working with a furnace having a carbon resistor the resistance when starting is high and, consequently, to save time it is necessary to start the furnace with a high voltage. When the resistor