about which he knew nothing, as they felt he would squander his money. The mill he first built was called the Federal Slitting Mill. In 1810 he bought a saw-mill property on the Brandywine, near Coatesville, which he converted into an iron mill. This mill, which at the time was called the Brandywine, has since developed into the immense plant it now is.

In 1816 Dr. Charles Lukens, a son-in-law of Isaac Pennock, came into possession of the property, and carried on the business of iron-making until his death, which occurred in 1825; and it is claimed that it was between these dates that the first boiler plates were made in this country and in this mill. At the death of Dr. Lukens, his widow, in accordance with his special request, continued to carry on the business, although handicapped by the fact that there were no railroads in those days and the finished iron had to be teamed to Philadelphia, a distance of 36 miles, or to Wilmington, Del., 26 miles, while the coal used was hauled from Columbia, about 35 miles away; yet, in spite of these difficulties, she carried on the iron-making business, hiring a superintendent to look after the works and the workmen, while she herself managed the business of the office. Mrs. Lukens was considered an extraordinary business woman. She built up a business which has been continuously successful up to the present, and which has remained in the same family for four generations; and it was in honor of her extraordinary abilities that the name of the works was changed from Brandywine to Lukens.

Originally the sheets were made from a single charcoal bloom, the bloom having been made in the old-fashioned forge fire, then reheated over an ordinary grate fire and rolled into plates or sheets, which sheets were shipped without being sheared, the shearings in those days being cut into nails. But afterward they put up a reverberatory heating furnace, in which they worked up the scrap themselves. The plate rolls, as near as can now be ascertained, were about 16 to 18 in. in diameter, and from 3 to 4 ft. long in the body, and were driven by an undershot water-wheel. It is said that many a time, when it looked as if the mill would stall, the workmen would rush for the water-wheel, climb upon its rim, and by their united weight help the pass through the rolls, thus preventing a stall, which meant fire-cracked rolls, and, later on, broken ones. This water-wheel was afterward supplemented by a breast-wheel so geared as to give more power to the rolls. This enabled them to use larger rolls, but the gearing gave so much trouble that they finally abandoned the use of the water-wheel and put in a steam engine and enlarged their rolls to 21 in. in diameter and 66 in. between the journals. This was again changed to 25 in. in diameter and 84 in. long chilled rolls. After several other changes, they at last put in three high-chilled rolls 34 in. in diameter by 120 in. long, a large Corliss engine to drive them, automatic lifting tables, etc.

The weight and size of the early boiler plates, as made on the oldest mill, I have been unable to get; but it is not supposed that they attempted anything weighing over 500 lbs., and probably 300 lbs. was nearer their limit. As an illustration of the changes that have taken place in this one mill I would say that, as now enlarged, they readily roll plates 119 in. wide and 50 to 60 ft. long. The little old mill, in which the workmen had to climb on the wheel to help make it go round, is one of the best plate mills in the country, and its owners and managers are the great-grandchildren of Isaac Pennock, who in 1790, built the Federal Slitting Mill on Buck Run, and, in 1810, on the banks of the Brandywine, what was called the Brandywine Mill.

In the year 1845 I went to Norristown, Pa., and assisted in the building of what, at that time, was considered the best mill for making bar iron in this country; in fact, it was called a model mill, and in many respects it was so. While it was a geared mill, it was so much better built than any other mill of the kind that it was expected that it would give little or no trouble on that score. But we were sadly disappointed; for, soon after starting, the gears began to give way, the back-lash and the jar of the rolls causing the teeth to break and drop out.

I was given charge of the machinery, and, of course, had to look after the gear-wheels. At times the entire wheels would seem to go to pieces at once; at other times the arms would crack, and then again the teeth would break—each break, of course, stopping the entire mill. Then all hands had to work day and night to get started again. At first we had to go to the foundry to get such parts as had been broken made over. This, of course, caused considerable delay, and to avoid this loss of time we began to keep segments of gearing on hand, and we had separate wrought-iron teeth made ready for insertion, and kept clamps ready to strengthen broken arms. With such extended experience, I became quite an expert in inserting teeth, and it was no doubt due to this fact that on the occasion of several hundreds of my friends coming to Bethlehem not long ago I was arrested at the banquet and tried on the charge of practising dentistry without first having procured a license or diploma!

Soon after the mill started, I was placed in charge of it on the night-turn, including the puddling furnaces and the few heating furnaces used for rolling covers. While this added somewhat to my duties, it proved of great advantage to me, as it gave me an opportunity to obtain a practical knowledge of iron-making. Later on, I was given charge of the mill on the day-turn, which practically meant both day and night, as it was during the day that everything had to be arranged for the night-work before supper could be eaten or rest obtained, and often to the loss of both. In a short time I received, in addition to my other duties, that of having charge of the roll-turning and of seeing that the iron rolled was properly finished. In short, I, who had entered the mill as a machinist, was now in charge as an iron-master; and it was in connection with this new departure that my troubles began.

In those early days the chemistry of iron-making was unknown—at least in this country—and iron-makers were often but the blind leading the blind. At the present time, if there is any trouble with the product of an iron or a steel mill, the chemist is sent for, and he is expected to carefully analyze the ore, fuel, flux, cinder, and even the furnace linings, and find and eliminate the troublesome element, whatever it be, that is damaging the product. But in the early days of iron-making we had no such help, and had to feel our way as best we could.

The process of making bar-iron by the use of the charcoal forge had become too expensive for iron to be used for ordinary purposes, and the art of making bar-iron by the puddling process was the only other means of any promise to which we could turn for relief. Puddling was at that time done by what was called the fermenting process, in which white iron only could be used; and we soon learned that only a few brands of pig iron could thus be worked into merchantable bar-iron, as by reason of being cold short it often proved worthless; and the worst of this was, we did not know what caused it. As the works were built to make high-grade bar-iron, which must be neutral, we were in a great quandary, not knowing which way to turn; but as the only way out was to keep on experimenting, we did so, sometimes finding a pig metal that gave good results. Then all at once it would go wrong again, and why, we could not tell, but it was always in order to lay it on the poor puddler and to give him a good "blowing up."

At times we found that by mixing several brands of charcoal-pig we would get good results; but as the price of bar-iron was low we could not afford to use high-priced pig, and so we began to experiment with anthracite iron—and with the old-time troubles, or even worse, as we got both cold and red-short iron. At this time one of the blast furnaces which had been making charcoal-iron began to use anthracite coal for fuel. In our distress we tried some of their pigs and got quite good results, the bars not being cold-short, but quite inclined to red-shortness, and for many purposes, such as shafting, car axles, heavy bolts, etc., proving very suitable. But for the use of the blacksmiths the iron was quite unfit. They then knew nothing about working red-short iron, and, of course, they condemned it.

We have now learned that good fibrous iron can be made from anthracite pig-metal, but for the highest grades of bar-iron we were still compelled to use charcoal-pig, and in the old way. It would occupy too much of your time to relate in detail the long series of experiments, often ending in disaster, we went through, never knowing when the iron would be good or what it was that made it red, until at last, by accident, we stumbled on the cause of the trouble.

We noticed that when, after making red short iron for a time, a change was made to neutral iron, the iron was still inclined to red-shortness. In a day or two the red-shortness would die out, and we would get on to good bar iron; and it gradually dawned on us that the trouble might come from the cinder that was left in the furnace when red-short iron was being made. So when we next changed over from red-short to neutral iron we cleaned all the cinder out of the furnace with great care, and refixed it with neutral cinder, and to our great joy found that the secret of our troubles had been discovered, and that we could now make neutral or red-short iron as we wanted to, with a tolerable degree of certainty.

While the experiences and trouble gone through were both perplexing and annoying, they proved of great value to me in after years, and especially when we began to make steel by the Bessemer process; for I had early learned how a very small percentage of an objectionable element, either in the ore, the metal, or the fuel, would greatly damage the product. In addition to the trouble we were having in making the iron, we were constantly breaking gearing, spindles, or rolls and couplings. In order to reduce the cost of repairs as much as