location proved interesting; for here Edison would sometimes come to relax himself with strumming on that instrument, staccato fashion with a forefinger—which performance, I assure the reader, helped to let down the mental pressure of all within hearing.

My first real electrical experiment took place a few days after my arrival at Menlo. The laboratory was at that time lighted with lamps in ceiling fixtures. It happened upon this occasion that a lamp mounted in a wooden stand on a table was undergoing a life test. Of course, I was inquisitive about everything so new to me. Innocently I picked up a short piece of copper wire that was lying on a table near by, and holding one end of it against one binding post of the lamp stand I gingerly touched the other to the second binding post, merely to see how the brightness of the light would be affected. I never before realized that electricity could be so quick. In less than a jiffy a sputtering spark at the contact between the wire and the binding post and a hiss overhead as from a spitting cat made me jump. The wire connection was broken! To my surprise the lamp was not only out but remained out until a melted lead wire fuse (then called a 'safety catch') in the lamp supply circuit overhead had been replaced. The experiment was a good joke to the others, especially to Edison. I forthwith learned from him what constitutes short circuiting, why it occurs, and how it can be avoided. Yes, in a few minutes I learned a lot about the multiple-arc lighting system, information that was timely because it put me on the right track practically at the start.

Laboratory life with Edison was a strenuous but joyous life for all, physically, mentally and emotionally. We worked long night hours during the week, frequently to the limit of human endurance; and then we had time off from Saturday to late Sunday afternoon for rest and recreation. Our activities were all thus co-ordinated to fit the habits of work of the central originating and guiding mind and personality.

The psychological atmosphere of the place partook of the inspirational as a sort of reflex from Edison's genius, which was happily joined with a common sense and a sane human nature that made him 'one of the boys'—mightily for his own good as well as the good of those about him. Here breathed a little community of kindred spirits, all in young manhood, enthusiastic about their work, expectant of great results; moreover, often loudly explosive in word, emphatic in joke and vigorous in action. For isolated as they were in the monotony of a rural neighborhood, they were sometimes under the pardonable necessity of 'working off steam' for very safety.

Let me here digress from my immediate story to mention Charles Batchelor, the chief assistant who was with Edison before his removal from Newark to Menlo Park, and whose name should not be left out of any account touching the laboratory life there. It was my good fortune to have a table next to his in the laboratory, and though our work was not of the same nature we often found ourselves mutually helpful. I welcomed the association with this genial, fair-minded and able man.

My memorabilia of 1880 indicates that on February 12 Edison started me experimenting with the expansion or contraction, as the case might be, of carbonized Manila fiber when used as a lamp filament. This work was followed by investigation of the capillarity of chalk cylinders for the motorgraph in the loud-speaking telephone; calculation of a candle power scale for a new Bunsen photometer; calculation of the wall illumination of a room of stated dimensions when lighted by gas jets and when lighted by the Edison lamps under specified conditions; calculation of the all-round candle power of the horseshoe lamp with carbonized Bristol board filament (the spherical photometer was

as yet unborn); development of a sensitive device for quick weighing of lamp filaments; investigation of the carbon deposit in lamp bulbs, especially with respect to images produced by the intervening filament legs and the clamps for fastening them to the leading-in wires; investigation of telephone diaphragm vibrations by means of the well-known powder figures; calculation of the merit of Edison's feeder-and-main system of electrical distribution in saving of copper as compared with that of a straightaway distributing system without feeders, in which lamps are supplied all along the system from its connection with the central station source of electricity to its outermost ends.

I was constantly observant of all that was going on about me, *working and studying overtime*, as the ambitious young should ever do if they expect to move onward and upward. I was beginning to grasp much of what was then known about practical electricity. The Wheatstone bridge, the Thomson mirror galvanometer and other electrical apparatus about the establishment became old friends for understanding and use. I was delving into the mysteries of the construction and operation of Edison's dynamos, which I first saw in early January. I was interested in their installation on the Steamship *Columbia*, of New York, as part of the first commercial Edison lighting plant, and when that ship started regular service on May 2 I witnessed the send-off. Of course, dynamos of this sort were in operation day and night at Menlo Park. My work in dynamo design came somewhat later.

Edison's central station system of lighting with distribution by underground conductors looked promising as thus far tested and developed. The men financing the enterprise, which was fathered by the Edison Electric Light Company, desired that a complete operative system be installed on a suitable scale for testing the economy of the system and uncovering weak spots if any existed inherently in mere bigness, before they should risk much money in commercially exploiting it.

Installation of this trial system at Menlo Park was soon under way. I was called upon to calculate the sizes of the underground conductors on the basis of a 10 percent drop in voltage from the central station to the outermost limits, with a full load of lamps on the system. The total length of underground circuits was 39,000 feet, of which the longest was 3,800 feet. It was a simple straightaway distribution without feeders, which were unnecessary in this trial.

The conductors were built up of the requisite number of strands of Number 10 Birmingham gauge copper wire and bound together with a wrapping of homemade insulating tape. They were laid in wooden box conduits in trenches along the side of the grass-grown streets of the place. A hot tar compound was poured over them for better protection, the conduit covers were put on, and the trenches refilled. Underground taps were taken from the conductors to the wooden lamp-posts along the streets. I well remember the hot, mussy, tedious work of laying those conductors that summer and fall!

Early in the year Edison began the installation of an electric railway. The first trial of the system was made on May 13. Of course, as a civil engineer I watched its building and operation with great interest. I cannot say that I had much to do with it—though I sharply recollect that in John Kruesi's office in the machine shop I was the center of a lively discussion into which half a dozen others pitched, Edison included, regarding the merits of a worm gear drive in the electric locomotive for regulating the high-speed armature to the locomotive driving wheels. I was opposed to the device. It was tested out, though under unfavorable conditions, and was not used. Non-locking worm