Hope-Jones, who up to then had worn the expression of a man "who thinks he is conversing with a maniac," was taken aback. He immediately became extremely apologetic and insisted that no payment was necessary until he had made good on delivery of all three clocks. But Loomis insisted on handing over the check, much to the other man's amazement.

While in England, they paid a visit to Sir Oliver Lodge, the eminent British physicist known for his pioneering research in radio frequency waves, who presented each of them with an autographed copy of his latest book, *Evidence of Immortality*. They then called on Sir Charles Vernon Boys, another noted physicist, who was famous for his highly sensitive instruments, including his invention of the radiomicrometer for measuring radiant heat, and an automatic recording calorimeter for testing manufactured gas. Loomis took an instant liking to Boys and invited him to return with them to the United States and spend the remainder of the summer in Tuxedo. Boys, who was then seventy-three years old, protested that he was pretty feeble to make such a journey. But Loomis urged him to accept and reassured him: "All you have to do is be in Plymouth on July 4, and I'll arrange everything else." They spent the last few weeks motoring around England, presented motion pictures of their experiments with super–sound waves before the Royal Society, went to the Derby, dined with "celebrities," and then flew to Copenhagen, where they met with Niels Bohr.

Their last stop was Berlin University, where they again showed the motion pictures of their experiments, and Wood introduced Loomis to "most of the other famous scientists then alive in Germany," including testing manufactured gas. Loomis took an instant liking to Boys and invited him to return with them to the United States and spend the remainder of the summer in Tuxedo. Boys, who was then seventy-three years old, protested that he was pretty feeble to make such a journey. But Loomis urged him to accept and reassured him: "All you have to do is be in Plymouth on July 4, and I'll arrange everything else." They spent the last few weeks motoring around England, presented motion pictures of their experiments with super–sound waves before the Royal Society, went to the Derby, dined with "celebrities," and then flew to Copenhagen, where they met with Niels Bohr.

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Loomis saw to it that they had "the best of everything on the boat."

The chief steward prepared a fine French dinner for them every night. On the last day, he announced that he had prepared a grand surprise for dinner, something that was very unusual, he promised, "a great luxury!" That night, after the soup and fish courses were cleared, he solemnly rolled a wagon over to the table, bearing a large covered silver dish. It was a meal Wood never forgot: "He rubbed his hands together and smiled at us, and then lifted the cover, displaying in all its stark nakedness a huge shapeless mass of shivering, steaming corned beef, garnished with cabbage and cauliflower and whatever else goes with this, my pet abomination, a New England boiled dinner."

Upon their return to Tuxedo Park, Loomis and Boys spent the rest of the summer doing lightning experiments, using a special high-speed camera designed by Boys expressly for photographing rapidly moving objects such as bullets and lightning bolts. Together they succeeded in taking a series of photographs that proved Boys' theory that the path of the lightning bolt was cleared by an electric "beam" that preceded the bolt. Although they did not have a hand in creating the dark thunderclouds that hung low over Tuxedo's rolling hills, many of the residents reportedly blamed the atmospheric disturbances on the activities up at Tower House.

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When the Shortt clocks finally arrived, Loomis installed them in a vault excavated from the solid rock of the mountain on which the laboratory stood, mounting them on three massive masonry piers that were, in effect, part of the bedrock. The location was "especially favorable," according to Loomis, because it was practically free from traffic and electrical disturbances and was carefully temperature controlled. This meant the fourteen-pound pendulums were swinging in a near vacuum and in planes 120 degrees apart. Loomis then went to Bell Laboratories and bought "the best" quartz crystal clocks they made to use for comparison purposes. These one-hundred-thousand-cycle quartz oscillators, invented in 1928, were accurate to one second in thirty years and were built primarily for the U.S. Bureau of Standards. The advantage of the quartz crystal clocks was that they were inherently stable and relatively free from extraneous effects. Because they were not dependent on gravity, they could, without any adjustment, operate at the same rate in any latitude and at any altitude.

Equipped with the most accurate, reliable—and expensive—clocks then available, Loomis began collecting all sorts of data it had been previously impossible to record. He was able to achieve spectacular results and to publish major findings, in part because quartz crystal clocks were still such a novelty and few scientists at the time had access to the superb assembly at Tower House. Loomis proved that there was no such thing as keeping perfect time, showing that even the five most accurate clocks in the world—the three in his vault and the other two in the Naval Observatory and in Greenwich, England—were subject to numerous errors. All that was possible was to make comparisons between the different clocks.

Loomis set up such an accurate system of precision clocks and comparative time recording that he was able to register infinitesimal fluctuations in the clock rates due to the fact that the pendulums coupled and influenced one another despite all the precautions taken against disturbances. Describing his test at the winter convention of the American Institute of Electrical Engineers in January 1932, Loomis said, "This would seem to show that, massive as the piers have been made, they are not infinite in comparison to the fourteen-pound pendulums, and that strains are set up by each pendulum that are felt in some degree by the others through the piers and solid bedrock." He found that when he placed the clocks at the corners of an equilateral triangle, facing inward, the coupling was broken. He even found a way to calculate the change in gravity pull if a clock was raised one foot and concluded that the loss as a timekeeper would be one and a half seconds in a year.

Over the next few years, Loomis and W. A. Marrison, a researcher at Bell Labs, conducted a series of important experiments comparing the performance of Loomis' free-pendulum clocks and the quartz clocks at Bell Labs in New York, some fifty miles away. Loomis installed a private strains are set up by each pendulum that are felt in some degree by the others through the piers and solid bedrock." He found that when he placed the clocks at the corners of an equilateral triangle, facing inward, the coupling was broken. He even found a way to calculate the change in gravity pull if a clock was raised one foot and concluded that the loss as a timekeeper would be one and a half seconds in a year.

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The experiment required that he simultaneously record for several weeks on miles of tape the minute variations in the time shown by the gravity clocks in the different locations. As this was long before the advent of computers, to help with the painstaking data analysis of the tapes Loomis hired a battery of women who operated desktop computing machines and ran the numbers. The figures were then studied by Ernest Brown, the eminent Yale astronomer, who confirmed the distortive effect of the moon's gravitational pull on earthbound gravity clocks. Loomis published the final results later that year in his paper "The Precise Measurement of Time," in the *Monthly Notices of the Royal Astronomical Society*, followed by a paper with Brown's findings.

Brown, in remarks before the winter convention of the American Institute of Electrical Engineers, explained that time "is relative in more than the purely Einsteinian sense." Accurate time could be obtained only by comparing our clocks with a standard clock, but the standard itself was subject to various errors. Some of the sources of error were known and could be adjusted for, but there were many other causes—terrestrial and celestial—that act as "time thieves." Loomis, Brown reported, had "just lately" caught the moon stealing time from the earth: "For the first time the action of the moon, which is the greatest external effect, was measured by the Loomis chronograph and shown to give accumulated errors which were always less than two ten-thousandths of a second as indicated by theory."

Loomis' work won him memberships in both the Royal and American Astrological Societies. He became so obsessed with precise time, he only by comparing our clocks with a standard clock, but the standard itself was subject to various errors. Some of the sources of error were known and could be adjusted for, but there were many other causes—terrestrial and celestial—that act as "time thieves." Loomis, Brown reported, had "just lately" caught the moon stealing time from the earth: "For the first time the action of the moon, which is the greatest external effect, was measured by the Loomis chronograph and shown to give accumulated errors which were always less than two ten-thousandths of a second as indicated by theory."

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> What time is it?—you ask.
> It is p.m.—hour 12, minutes 2, second 0.0003.

Loomis would remain a "time nut" for the rest of his life, according to Luis Alvarez, who recalled that Loomis always wore "two Accutrons—one on his right wrist and one on his left wrist." He would check them every day against WWV (the standard frequency broadcasting station of the National Bureau of Standards), and if one was gaining a half second on the other, he would wear it on the outside of his wrist instead of the inside, so that gravity changed the rate of the tuning fork and the two watches tracked each other, and WWV, "to within less than a second a day."

Loomis' scientific investigations followed a pattern in which he set out in one direction after another in search of a new discoveries, seemingly only to abandon it. Even to the most casual observer, his feverish efforts, followed by a brief triumph and equally feverish desire to be off again on another tangent, must have appeared somewhat self-indulgent, even frivolous. There was also a constant shuttling of European scientists and experts back and forth across the pond, for he needed playmates. After a while, it seemed that Loomis' attention was as transient as his guests. Who could have known then that it was fortunate that he would give his imagination such free rein—from his earliest explorations of high-frequency sound waves to his chronograph and experiments with quartz crystal clocks—for it would lead him into his research of the nascent field of radar, which would become critical in the coming war.

The day after Loomis' forty-first birthday, Ellen wrote to Henry Stimson that she sincerely doubted her husband, "who is getting all grey over the ears, though it is becoming," would ever stop playing with his mechanical toys and grow up:

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> Not that it makes any difference, he will always be a boy, no matter how brilliant he is, no matter if he lives to be 98, as Stimsons should. Henry [their youngest son] consulted as to when we could celebrate his birthday with appropriate ceremonies of cake, and candles and gifts. Alfred is so surrounded and encompassed with scientists all the time nowadays. Lunch, tea, and dinner yesterday were full of short wave radio men, marine bacteriology men, and chemists, that we held our little private festival at breakfast. . . .

In another letter to Stimson after Christmas, Ellen's loneliness was apparent in her touching description of having her boys back at home