Edison the scientist

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This year marks the 100th anniversary of Edison's invention of the electric lamp, one of many heralded accomplishments that brought him lasting fame. For much of life Edison enjoyed a popular reputation as a laboratory genius who personified the spirit of scientific discovery. Was he really a scientist, or only an inventor? His participation in the Draper Expedition to the solar eclipse of 1878, told here, offers a chance to evaluate the youthful Edison as an astronomer and infrared physicist.

Introduction

In 1973 we Americans saw the first photographs of the United States taken from a spacecraft on a clear night when all the land was dotted with the glow of electric lights. Ocean boundaries were traced by strings of lighted coastal cities, megapolitan areas fused together in massed illumination, and scattered across the hinterland like fireflies were the lights of smaller towns. We could see our mark upon the planet and sense the Electric Age in which we live.

The photographs were also a reminder of a touching tribute paid by lights in these same cities on an autumn evening forty-eight years ago, the night of 21 October 1931. Following a suggestion by President Hoover, electric lamps in homes across the land were voluntarily switched off at ten o'clock, then on again—a silent signal in the night. As one ship dips its flag to the passing of another, the nation honored the passing of the father of our Electric Age, Thomas Alva Edison, who was buried that day in New Jersey. At his death some had suggested that power stations should switch off electricity momentarily everywhere, but so fitting a gesture had long passed the point of practicability by 1931. Edison had created in his lifetime a system so literally indispensable that it could not be turned off even for a moment.

He had lived eighty-four years, and for most of it was a living legend: Edison, the Great Inventor, better known and more universally respected than any scientist of his day or ours. For nearly half a century it was Edison who typified science in the minds of common men, and it was in part through his popularity and reputation that scientific endeavor had acquired a glorified name.

Fame came early into his life and stayed to the very end. In 1877, at age 29 and with scores of other patents to his credit, Edison gave the world the phonograph and was a hero from that day on. Two years later came his equally heralded work on the incandescent lamp and electric power generation and distribution. In those same early years and before he was yet thirty, Edison pioneered the concept of the modern research laboratory, in a risky venture launched in two-story frame buildings put up in Menlo Park on borrowed money. Later, in a move equally bold and risky, he expanded into a larger and grander research complex in brick buildings at West Orange, New Jersey.

From these laboratories and from his remarkable mind flowed an impressive stream of technical advances and improvements that drew upon almost all branches of science, including chemistry, physics, astronomy, nearly all aspects of engineering, and even botany. His skills and knowledge in practical physics, where most of his inventions lay, included not only electricity and magnetism, but sound, heat, and light, mechanics, thermodynamics, telegraphy, telephony, and cinematography, IR radiation, and some early work in electronics and radio waves. He was, among other things, an applied optician, at home with the microscopes, spectroscopes, and telescopes that were always a part of his working collection of laboratory equipment. He knew the sun and the stars and called them by name.

Edison is remembered as a self-educated and self-made man, a lone genius who scorned formal education and degrees and accolades, but even as a young man he hired and administered Ph.D.s and made presentations before such societies as the Smithsonian Institution and the American Academy of Sciences. In later years, he served the same dreary sentences on national advisory committees in science and technology that drain creative people of time and talent today. He was an advisor to the Navy on antisubmarine warfare in World War I and played a major part in establishing the present Naval Research Laboratory. He rubbed shoulders not...
only with industrialists, like Henry Ford, the Vanderbilts, and J. P. Morgan, but with the leading scientists of his day, including Joseph Henry, Lord Kelvin, Henry Draper, Louis Pasteur, Bell, Marconi, and Langley, and loaned his test equipment, sometimes with regrets, to academic scientists down the road at Princeton.

In later life Edison, like Einstein, produced far less than he did in the prolific years of his early professional life. His contributions peaked well before he was forty, although he continued to drive himself and others around him in search of solutions until nearly the day of his death. His failures—some of them financially catastrophic, like his heavy losses in magnetic mining, or his fruitless searches for synthetic rubber, or improved storage batteries—were notable features of his later life. Thus the pattern of Edison's achievement, sad to say for most of us, fits the actuarial norm in scientific creativity, lending weight to the grim suspicion that our real value in creative research, as in professional sports, dies long before our ardor for the game.

We can learn lessons from Edison's successes and from his failures, for they are well documented. He was in the game of research for a long time; he knew it well, and he wrote some of its rules. And most of us more ordinary scientists can still identify with him; if Edison was a genius, as so many thought, he was an undereducated one who never saw himself as uncommonly intelligent. He recognized the gaps in his own knowledge but was unafraid, when necessary, to enter almost any area. Then he would start, as we are taught today, by gathering together all the books he could understand on the subject; after learning all he could, Edison would begin with the most basic fundamentals, proceeding from one empirical test to the next only after he had understood every detail that had gone right or wrong. It was the hardest possible way to do research—and perhaps the only way to really succeed. As a practical inventor he knew there was no point in trying to fool himself or to gloss over any uncertainty however small. It demanded continuous attention and hard work. He was quick to admit that in his experience invention was one part inspiration and ninety-nine parts perspiration. And he was human enough to know how hard it is to give full measure to that simple formula. "There is no expedient to which a man will not resort to avoid the real labor of thinking," Edison liked to say, attributing the quotation to Sir Joshua Reynolds.

Questions

But how much of a scientist was he? Or was he one at all? Much has been written about Edison, and during his life it was mostly adulation. Of late the balance swings the other way: modern and more skeptical analyses of his life and work have questioned his style and methods, his attention to publicity, and his precedence to some discoveries, including that of the incandescent lamp. To scientists and engineers of today, Thomas Edison is remembered, if at all, for his skill at cut and try: the inveterate empiricist, clever but formally ignorant, whose only trick in solving scientific problems was trying everything within reach. For the famous filament in 1879 it was first platinum, then a host of other things—bamboo, fishline, coconut shells, human (fine red) hair, and finally eureka! Coates & Co. No. 29 cotton thread. "Mr. Edison, do you think there could ever be an antigravity substance?" "I don't see why not," goes the apochryphal reply, "there are enough things to try."

Edison was certainly adept at handling publicity and the press, for early on he had come to know how necessary they were to his successes. It was his modus operandi to secure funding for the considerable overhead of his research laboratories by announcing, a little prematurely if need be, his inventions to the press and with fanfare. So it was that in 1878, he announced that he had solved the problem of the incandescent light. That was a year before he actually did it, in the face of competition that had started on the knotty problem long before he had, and with a good appreciation of how difficult it would be. It was a move like that of Babe Ruth, who stepped to the plate for all to see and pointed where he would next hit a home run. Some call that bravado, others self-confidence; it was certainly one of the important differences between Thomas Edison and almost all the other lesser-known inventors of his time or ours.

Was Edison more than a clever confident tinkerer who happened along at just the right time? In the 1870s and 1880s, when he did the things that made him famous, modern technology was a coming wave, an inevitable result of the Industrial Age that was destined to break in time on the beaches of all the areas where Edison worked. Did he do more than sense its pull and ride it in? Had he stayed in telegraphy, his first love and technical interest, would not others have come along at about the same time with a talking machine, an incandescent lamp, movie camera, and all his other inventions? Was he the one that made it happen? Or was Edison a nineteenth century Armstrong placed in public view upon the moon by accumulated works of others who had gone before and through a chance coincidence of time and age and place?

These imponderables need not be answered here. What we can ask, and hope to answer, is whether Edison was indeed a scientist.

Scientist vs Inventor

We shall need appropriate definitions of science and scientists before we can measure Edison against either of them. In the 1870s, at the time of his early work, the popular notion of science was much closer to technology; since then the popular definition has shifted from the practical toward the profound. One can sense the change by flipping through Omni magazine or, better, by comparing the articles found in Scientific American today with those of the same magazine a century ago; then it dealt not so much with muons as with mowing machines. Still, then as now, purists would probably have insisted that real scientists were those who sought pure knowledge as opposed to practical solutions or paying discoveries. Edison was assuredly a commercial inventor without academic affiliation, whose scientific
papers were patent applications. In later years he was an industrialist himself, heavily involved in the founding of the General Electric Company and a number of other corporations of his own creation. Were his motives at any time those of the pure scientists of today in search of truth and truth alone? Edison answered that one himself:

"I'm not a scientist. I'm an inventor. Faraday was a scientist. He didn't work for money . . . said he hadn't time to do so. But I do. I measure everything I do by the size of the silver dollar. If it don't come up to that standard then I know it's no good."

I thought of these words of Edison while recently sitting through two different project reviews for the National Aeronautics and Space Administration. In each case the question that scientists discussed involved the sun and whether it seemed opportune to undertake a new thrust in a direction that would involve a series of manned and unmanned space flights over the next ten years. The meetings were described as scientific symposia, but the crucial discussions dealt of necessity with questions of cost and time and competitive advantage in the real market of restricted new starts. We were asked to judge whether these proposed programs, weighed against others, would produce enough of value to make them worth the professional investment and public costs. We heard how a proposed payload could be designed to fit sideways into the Space Shuttle to minimize the payload costs—now figured by the linear foot of fore-and-aft cargo storage space. As seems necessary and prudent in planning any scientific effort, we measured everything by the size of the silver dollar, and if it did not come up to that standard, we knew it was no good to proceed. As far as I could tell, all of us there, like Edison and probably Faraday, worked for money and indirectly stood to profit in one way or another by doing better work.

Edison and the Astronomers

In the spring and summer of 1878, when he was riding high in private accomplishment and public acclaim, Edison made a brief excursion into astronomy and the esoteric world of what must be called pure science. It was an intended side trip—a diversion that neither took him long nor lured him to stay. But the unusual episode tells of his interest at the time in the pursuit of knowledge for knowledge's sake and reveals, I think, a desire in the young inventor to try some of the hidden delights of the perfumed gardens of academia. In any case it gives us occasion to take his measure as an astronomer and a pure scientist.

We find him in an unusual setting, in a different role, and in the company of academic scientists, offering a chance to compare Edison directly against their standard and on their ground. The press, who followed his every step, was quick to make these very comparisons; its accounts, though surely biased in his favor, and Edison's own habit of keeping detailed records help to illuminate this unusual meeting of two worlds. Much later, as part of his memoirs, Edison recorded his impressions—not wholly favorable—of his distinguished colleagues.

The little-known episode deals with Edison's participation as an IR astronomer in the Draper Eclipse Expedition to Wyoming in 1878. It is well-timed for our purpose, for it samples the young Edison at the peak of his creative life, in a brief interlude sandwiched between the phonograph (1877) and the incandescent lamp (1879). At the time he worked in the almost magical atmosphere of his first laboratory complex in Menlo Park with a hired staff of twelve loyal assistants: a Camelot where at thirty-one he was both King and Merlin.

On an April day in that year, Edison had taken the train to Washington to demonstrate his new phonograph before learned institutions and the President of the United States. There he met an earlier friend and admirer, Professor George F. Barker, a physicist of the University of Pennsylvania. Barker urged Edison to join him on a rail trip to Wyoming Territory as part of an expedition to observe the eclipse of the sun on 29 July at the place where the shadow path crossed the Continental Divide. Leader of the expedition was Dr. Henry Draper of New York University. Edison was no stranger to Draper; they had corresponded earlier regarding Draper's work on oxygen lines in the solar spectrum. Edison, who kept a spectroscope in his laboratory, was interested at the time in the shape of spectral lines and had written Draper with questions on the subject.

To Edison, as to many of us today, the lure of the eclipse lay mostly in the travel and adventure involved, and it was through this guise that Barker offered his invitation: here was a chance to see the West on the new Transcontinental Railway and to take a needed vacation. Edison agreed on this basis, but soon elected to take along one of the new inventions on which he was then working. It was an electromechanical IR detector, and with it he proposed to measure the heat of the solar corona: a bold challenge indeed! Edison's IR detector, which he called the tisometer, had been in his mind about a year and in his laboratory in breadboard form for some months. The preceding autumn he had written Samuel P. Langley about it.

Langley (Fig. 2), himself a man of diverse interests, was then Director of the Allegheny Observatory in Pittsburgh and just beginning his pioneering studies of the IR radiation of the sun that led to later measurements of the solar constant. He recognized, as much as any scientist of his day, that it was detectors that held up progress in the new field of ultrared, as it was then called. Langley, surprised or possibly amused by Edison's query, delayed in sending an answer. When he did, more than a month later, he included with his reply one of his more sensitive thermopiles, then the best of the IR detectors, and with it a challenge: if (Edison) "could make something in the same compass, say 100 times as sensitive, equally prompt, and capable of being uninfluenced by alien radiations, he would not perhaps produce anything commercially paying, but you certainly would confer a precious gift on science."

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moreover, he probably released it to the higher branches of science to put it to roost—for it was, after all, something of a turkey.

**Edison's Tasimeter**

The tasimeter had come to life in a typically Edisonian way: not through any determined effort to discover what was eventually found nor through pure chance or serendipity. Rather he arrived at it through a chain of loosely linked discoveries that led him through several fields, which he was willing to follow hand over hand wherever it took him. He could not always afford this kind of free adventure or the diversion from other specific assignments, but when he found himself upon this course he was at his very best. It was a style of research that fitted Edison well because of his breadth and imagination, his freedom from disciplinary boundaries, and his dogged determination to track down every detail in any of his experiments.

In 1873 Edison was working on schemes to speed up telegraphic transmission in the Atlantic cable. To duplicate in his laboratory the electrical resistance of the 3000-mile cable, he had experimented with a variable resistor made of compressed powdered graphite and had noted the marked electrical sensitivity of powdered carbon to pressure. Four years later, while working on ways of improving Bell's telephone, Edison recalled his Atlantic cable experience and adopted compressed carbon as a telephone transmitter material; thus was born his "carbon button" telephone. There was a problem, however. The hard-rubber telephone mouthpiece was then handheld; heat from the hand transmitted as pressure to the carbon button produced loud static on the telephone line. He first tried to avoid the problem by switching to a cast-iron mouthpiece; this only changed the character of the noise, producing creaky sounds that he attributed to (thermal) motions of iron molecules, which he called "molecular music."

Edison realized he was being beaten in the telephone game by thermal expansion. Given a lemon he made lemonade. For here was a new device that transformed temperature to resistance: a sensitive heat detector with a readout in the realm of electrical measurement where he was master. It could be made to detect radiant heat by putting the carbon button in mechanical contact with an expandable rod on which heat was focused. He could make it supersensitive by placing the button in one leg of a bridge circuit. To be sure there were a few mechanical details to be worked out and materials to be tried, but the principles were easily in his grasp. This much he knew when he wrote Professor Langley to offer a gift to science. Who cared that it was not at first appreciated? Another of nature's wily signals—this time heat—had wandered into the jaws of one of his traps, and he had it by the hind leg.

To the final instrument Edison added a small conical horn to focus heat and a dial to record compression, presumably for calibration. For the expandable rod he chose vulcanite—the same material that had caused the original problems in the telephone transmitter. The finished instrument was made of machined brass and
was small enough to be held in the hand. A photo and contemporary woodcut are shown in Fig. 3.

In principle of operation the tasimeter was not unlike a thermometer or the modern Golay cell: in each, the expansion or contraction of an absorbing material indicates a net heat flow between the detector and its environment. As a class, such detectors are slower and generally less responsive than those that measure a nonmechanical effect of heat such as the thermopile or modern semiconductor detectors. Edison undoubtedly appreciated the principle of the more elegant thermopile, but experience had taught him that the simpler way was often better.

That the tasimeter was accidentally conceived and rather casually born did not deter Edison from giving it a proper and fitting name. Preserved in the Archives of the Edison National Historic Site in his careful hand are lists of fourteen candidate names—largely permutations of the words micro, thermo, carbo, electro, and meter. Edison selected the most esoteric of the list and later explained his choice:

“This instrument I have named the tasimeter from the Greek words ταινία, extension, and μετραν, measure, because primarily the effect is to measure extension of any kind.”

The tasimeter lived as an instrument but a year or two. As a word it was kept around for fully eighty years after its brief life had ended, eventually embalmed as a common noun in successive editions of the Merriam-Webster unabridged dictionary. In 1961 Edison’s handmade word finally disappeared in the housecleaning that accompanied publication of the Third New International Edition.

Fig. 3. (a) Edison’s tasimeter of 1878, as it is preserved for display at the Edison Institute, Henry Ford Museum, Dearborn, Michigan (courtesy Henry Ford Museum and Greenfield Village). (b) A woodcut of the same instrument from Am. J. Sci. 117, 52 (1879). The horn is about 7 cm in diameter. A is a cylindrical rod of hard rubber (vulcanite) that absorbs thermal radiation, expands, and compresses the carbon button C.

It was one thing to concoct an instrument whose electrical properties would change in a measurable way with temperature; it was quite another to isolate it from ambient changes and unwanted signals. Edison considered encasing the tasimeter in an ice-filled enclosure or, later, one filled with boiling water; but he never did either. Instead the time he could allocate to the tasimeter was spent in electrical refinements and demonstrations.

To sense the minute change in resistance of the carbon button he employed a Wheatstone bridge, then in common laboratory use. He also needed a delicate indicating galvanometer, and for this Edison chose the most sensitive one available: the mirror galvanometer invented by Sir William Thomson in the course of his own work on the Atlantic cable twenty years before. In Fig. 4, from Scientific American, we see the breadboard tasimeter system including the tripod mounted galvanometer and its kerosene reference lamp.

An obvious measure of merit of the tasimeter was its ability to sense heat or IR radiation—its “sensitivity” in the words of Langley. To the scientist of 1878, sensitivity was expressed quantitatively as the minimum detectable change in detector temperature. The bulb thermometers used by William Herschel in 1800 in his early searches of the IR probably could detect a minimum change of $10^{-1}$–$10^{-2}$°F. The first thermopile (used by Melloni in 1830) had a sensitivity of roughly $10^{-30}$°F. In 1877 Langley’s best thermopile probably could detect $10^{-40}$°F. Thus, to better existing detectors Edison needed to demonstrate sensitivity better than $10^{-40}$°F and, to meet Langley’s challenge, $10^{-69}$°F.

Edison’s early claim for the tasimeter for $1/24,000$°F...
in the late spring of 1878. In the next few months its sensitivity, as documented in newspaper reports, improved at a most incredible rate. In May, newspaper correspondents were told that the instrument was capable of detecting $1/50,000 \degree F$ and “will register heat influences smaller by thousands of divisions than any that have yet been registered.” In July on the eve of his departure for the eclipse, Edison announced from the rail platform that with the tasimeter “it will be possible to measure the 1/500,000 part of a degree, and do it accurately,” adding that “it will measure any degree of heat that can be measured.” Later in July to correspondents in the West, he proclaimed that the tasimeter could indeed measure $10^{-6} \degree F$—meeting the goal proposed by Langley seven months before. And in September, writing to a prospective user in Germany, Edison confided that “the delicacy of the instrument is infinite.” We may only conjecture whether the improvement with time was real and indeed whether Edison ever made a quantitative measurement of the tasimeter’s sensitivity.

More to Edison’s taste were qualitative demonstrations of the instrument (Fig. 5). In this he was masterful. A typical demonstration began with the tasimeter connected to an ordinary meter galvanometer, the Thomson galvanometer being held in reserve for later in the show. Marked meter deflections were produced with the horn directed at Edison’s little finger 4 in. away, a match at 6 in., or a lighted candle at 10 ft. The Thomson galvanometer was then connected, endowing the tasimeter with almost unmanageable sensitivity. In a still room, the heat of the hand 30 ft away would plainly deflect the mirror galvanometer, sweeping the lantern beam across the numbered scale. In a more competitive mood Edison would demonstrate that the tasimeter, with conventional galvanometer, was 6 times more sensitive to heat from his little finger than a thermopile was to a red-hot iron. Perhaps the most expressive testimony given the tasimeter was that written by a Wyoming newspaper correspondent:

“It is so sensitive that let a person come into the room with a lighted cigar, and it will drive the little animal wild.”

Astronomers grew more interested. In early June, Langley offered to test the tasimeter at Allegheny Observatory and asked Edison to send him one, along with specimen carbon buttons whose absorptivity he wished to measure. Langley’s interest was in taking IR spectra: he was extremely anxious to secure a detector small enough for use at the spectrum image plane and asked Edison if the tasimeter could be made small for spectral lines. By 22 June, Langley had received only the carbon buttons and reminded Edison of the “promised tasimeter which I shall have great pleasure in testing.” In the same letter, Langley, apparently unaware of Edison’s own plans for taking the tasimeter to the coming 29 July eclipse, proposed the same experiment:

“I expect to go in the beginning of July, to observe the solar eclipse; if the tasimeter arrived this month I might perhaps be able to put it to practical trial at once in eclipse work.”

Langley planned to take advantage of a truly unique eclipse path to observe from the top of Pike’s Peak, 14,100 ft above sea level, where the IR transparency was certain to be good. Edison apparently agreed to fill Langley’s request but with a procrastination that exasperated the older scientist. The young and popular Edison was at the time already overcommitted, under
constant pressure by visitors, the press, his creditors, and a steady stream of mail with requests for this or that. His hands were in many different enterprises, among which the tasimeter was but a recreation and the eclipse a coming vacation. Langley operated in a wholly different style and saw things differently. He had observed the 1870 eclipse in Spain and knew the amount of preparation needed to ensure success. He had some notion of the difficulty of establishing himself on top of Pike’s Peak. On 4 July there was still no tasimeter in the mail from Menlo Park. On the next day, with less than four weeks until the eclipse and only three days until his own departure, Langley sent a terse telegram to Edison: “Send by express to Allegheny. I leave Monday.”

Langley left without it. From the summit of the great mountain he watched the sun eclipsed and, along with other experiments, attempted to measure coronal heat with another detector but without success. It seems unlikely that Edison willfully withheld a tasimeter from Langley, although Langley may have suspected this, particularly when the inventor continued to stall him long after the eclipse was over. Fifteen months later, while perfecting his new bolometer, Langley was still asking Edison, apparently without success, for a tasimeter to test.

Also interested in the tasimeter for possible use in the eclipse was the prominent Princeton astronomer, Charles A. Young, a frequent visitor at Menlo Park and a scientist whom Edison knew and trusted. After learning of the tasimeter, Young built one himself, making his own carbon buttons. By early June the Princeton tasimeter was only partially successful. Young informed Edison that he had been experimenting “pretty successfully” with the “heat measurer” without getting “quite all we want out of it” and asked him for one or two of his special buttons. He did not know, apparently, that Edison’s carbon buttons came in fact from the work of his night watchmen, who pressed carbon scraped from lamp chimneys into simple molds (Fig. 6). Young planned to observe the eclipse in Colorado with varied spectroscopic apparatus, including a grating spectroscope for the IR chromospheric and coronal spectrum.

On 1 July, the day before the Princeton expedition left for the West, Young received a tasimeter from Edison. It was probably the second that had ever been built. Tests in the field near Denver soon convinced Young that it would be impractical to employ the Edison tasimeter for the eclipse; it was altogether too sensitive to movement of the equatorially mounted spectroscope on which it was to be used. The only hope was to redesign the entire apparatus, replacing the equatorial mounting with a coelostat mirror system and mounting the tasimeter on a firm base; but there was no time for so drastic a change. Young decided to use instead a backup thermopile, laying the tasimeter aside. The press was quick to paint the incident colorfully, as evidence of the practical inventor’s superior abilities: “The instrument was too new to succeed in other hands, even those of Professor Young.”

**Expedition at Rawlins**

When Edison made his departure for the eclipse the New York press were there to see him off. That night the *Daily Graphic* devoted its whole front page to Edison and the tasimeter, with an account of the solar experiment he would perform, the results he expected, and a popular description with a full-size illustration of the
instrument. Evening readers learned that the tasimeter was in some respects “the most remarkable of all his discoveries, and his one which, had he invented nothing else, would have made him famous in the world of science.” His parting words at the station were also given:

“Yes, said Thomas Edison, as he stood on the platform of the Pennsylvania railroad depot on Saturday evening, about to start with the Draper observing party, it will measure any degree of heat that can be measured. If the Sun’s corona has any heat of its own or possesses any heat reflecting power the tasimeter will measure it accurately.”

It was the sort of glaring prepublicity which few astronomers have ever received, which fewer still would ever want, but which Edison had come to enjoy and put to good advantage. It was indeed the combination of this great knack of showmanship with innate ability that had made him both famous and successful. It was only natural that Tom Edison would announce his astronomical results three weeks before the moon had eclipsed the sun.

The publicity given the inventor and his experiment did not end at the station in New York. Throughout the trip he was accompanied by a special correspondent of The New York Herald, his friend, Marshall Fox. At each stop along the way, other newspapermen waited to greet the great inventor, as did the railroad telegraphers, who knew of Edison’s early start in their trade and held him proudly as their own. On the trip Edison carried letters from the Union Pacific Railroad Company, which introduced him as “Mr. Edison, the celebrated inventor and telegrapher,” giving authorization for his free passage and directions to “send all messages of Mr. Thomas A. Edison free.”

Rawlins, Wyoming Territory, in the eclipse path, had been chosen by Draper for his expedition because of its direct access by rail. It was a frontier railroad town, nine years old, with about 800 persons and one hotel. We cannot be surprised that the astronomers who came there for the eclipse were looked upon with awe and considered “wise men from the East.” Edison surely relished these associations and later kept on his library wall a group photograph taken against a backdrop of telescopes and wooden sheds in Rawlins (Fig. 7).

Edison had no degrees and had written nothing. He was at least ten years younger and far less experienced than Langley or any of the other astronomers at Rawlins, yet it was Edison and not they who was met with crowds wherever he went. Upon the uneducated inventor the press quickly bestowed the cherished titles of academia: “Professor Edison accompanied by a party of scientists . . . .” We can imagine their looks and feelings and sympathize perhaps with their final retaliation: in the 1878 scientific eclipse report—a massive tome of 500 pages published by the Naval Observatory—Edison’s name is nowhere to be found, as though to even the score.
The opposite side of the coin—Edison's feelings toward the scientists and formal education in general—is better preserved, in opinions he freely gave in later years:

"I wouldn't give a penny for the ordinary college graduate, except those from institutes of technology ... they aren't filled up with Latin, philosophy, and all that ninny stuff."

His especial disdain was directed at theoretical or mathematical physicists, who seemed to typify dreamy dilettantes in ivory towers. In Edison's pragmatic mind there was no question as to the relative worth of theoretical vs practical science: "I can hire mathematicians at $15.00 a week, but they can't hire me."

Edison took interest in the pre-eclipse work of the astronomers at Rawlins and found amusement in their efforts to determine their precise position:

"It seemed to take an immense amount of mathematics. I preserved one of the sheets which looked like a timetable of a Chinese railroad."

One astronomer who sought Edison out was J. Norman Lockyer, editor and founder of the British journal, *Nature*, and a famous solar physicist. Lockyer had followed Edison's work and had attempted to visit him at Menlo Park *en route* to Wyoming. He was especially keen to entice the young inventor to announce his future discoveries in *Nature*. Impressed with Edison and the tasimeter, Lockyer developed a kind of summer friendship with the inventor and became the third astronomer, after Young and Langley, to secure from Edison the promise of a tasimeter. Three nights before the eclipse, he watched (and probably helped) Edison test the instrument on Arcturus. With telescope and tasimeter directed at the star, Edison achieved "five uniform and successive deflections" on the Thomson galvanometer; moreover, when a dark slide was inserted, the instrument returned to zero. The next day Lockyer sent the following message to *Nature*:

"One of the many points of interest here to me has been the Observatory in which Mr. Edison has been experimenting on his tasimeter. It is truly a wonderful instrument, and from the observations made last night on the heat of Arcturus, it is quite possible that he may succeed in his expectations. For its extreme delicacy I can personally vouch. The instrument, however, is so young, that doubtless there are many pitfalls to be discovered. Mr. Edison, however, is no unwary experimenter."

Though well known and enough respected to be later...
knighted, Lockyer was himself a controversial character of no small ego. “And Lockyer, And Lockyer/Gets cockier, And cockier/For he thinks he’s the Owner/Of the solar corona” went a limerick republished in one of his obituaries. We can understand why he and Edison, with tastes so similar, hit it off so well, particularly when they were clearly not in competition. Still, we must accept Lockyer’s pursuit of the young inventor and his laudatory words about him as a measure of what the editor of a major scientific journal thought of Edison as a scientist.

Eclipse

Those who have dared to test themselves at solar eclipses will know some of Edison’s feelings on the afternoon of 29 July as the moon moved inexorably to cover the last crescent of the sun. Some will sense it especially keenly if ever they, like Edison, were not quite ready.

He stood alone in the doorway of an old henhouse, to protect his all-too-delicate apparatus from Wyoming’s incessant winds—the heralded tasimeter and associated circuitry attached to a tripod-mounted refractor, pointed at the sky. As the last glint of sunlight vanished and stars appeared, Edison worked feverishly to bring the balky tasimeter and Wheatstone bridge to the needed null that would not come.

Darkness increased. Time ticked by. Totality at Rawlins—Edison’s moment of truth in astronomy—would last less than 3 min. Nature would grant no stays, even to the world’s greatest inventor, and no second chance. In that brief time, fast slipping by, he would have at most one shot to prove himself and the tasimeter, not only to the scientists who worked around him, but to a waiting, watching world, for through his habits of prior press emphasis he must now do it in the full glare of public attention.

Just before totality ended Edison finally succeeded in balancing the Wheatstone bridge and, shooting from the hip, pointed the telescope at the inner corona. The spot of light on the Thomson galvanometer raced off the end of the scale. Then the sun burst out and the eclipse was over. Edison stepped out into the growing light of day. He had done what he said he would do and to an eager press announced success. He had detected a heat signal at least 15 times stronger from the corona than from Arcturus.

Newspapers were quick to bestow the distinction of discovery upon the inventor in the next day’s headlines and in articles for months to come. The Times (of London) announced to British readers that Edison “the modern magician” had measured the heat of the corona and that he had “perplexed many, including some of the astronomical elect.” Henry Draper telegraphed New York on the day of the eclipse that “Edison’s tasimeter gave decided indications of heat in the corona.”

Edison himself, though cautious at first, came more and more to accept his own hasty measurement and in subsequent press interviews left no doubt that he had in fact detected heat from the diffuse corona, ninety-three million miles away. As to whether he was first, he was accustomed to precedence in everything he did, though in this case he left that to the academic experts. His friend Professor Barker made it clear that “this eclipse is the first in which any attempt has been made to measure the heat of the solar corona.” Just as ready to confer the honors of discovery on Edison was Norman Lockyer, who in a posteclipse dispatch to his journal, Nature, had written that “for the first time thermo-electric observation forms part of eclipse work.” Lockyer’s unbridled feelings are more apparent in another dispatch which he sent to London’s Daily News:

“The daring genius of Edison has left its mark on this eclipse. Soon as he had completed his tasimeter he saw its applicability to eclipse work in determining the presence of heat waves in the radiation from the corona. I had the rare privilege of seeing the great inventor at work gradually increasing the sensitiveness of his wonderful instrument with the most consummate knowledge of principles and contempt for elaboration, until at length during the eclipse he was rewarded by seeing a speck of light on the attached galvanometer give a decided swing from its zero on the dark moon when the image of the corona was brought on the fine slit in the plate which shielded the tasimeter from its surroundings.”

The more careful Charles Young politely pointed out the true precedence of Edison’s measurement in his summary paper on the eclipse: “Experiments with the tasimeter...of Mr. Edison showed, as was ascertained many years ago, that the heat of the corona is quite sensible.” Young’s reference was undoubtedly to a measurement made at the eclipse of 7 July, 1842, five years before Edison was born. At Milan, Professor Luigi Magrini, with a thermopile and a reflecting telescope, had detected a strong heat signal from the corona, which he observed throughout totality. In reporting the results Magrini also noted that no heat radiation was received with the same system directed at the moon at full phase. Magrini’s measurement was published in two journals at the time, one in French and one in German, but in 1878 Magrini’s result was probably known only to the most scholarly astronomers.

Critical Assessment

Edison’s heralded measurement, though a personal victory, was thus no discovery at all and of little value to science. Perhaps this was why he and Barker, who later prepared a paper for him describing the instrument, never did more with it. Edison soon became totally submerged in problems of the incandescent lamp and electric power, and the Wyoming experience was pushed aside and later used only as fodder for reminiscences. It is a pattern that we can recognize today. In fact, without ever realizing it, Edison proved to be a rather typical eclipse goer. He postponed serious preparations until shortly before leaving on the expedition, elected to defer final assembly and tests until he arrived at the eclipse site, and never reduced his data or published his findings. In this case it leaves no doubt as to what his real motives were: the eclipse was an
adventure and his coronal experiment a stunt—not a title bout but an exhibition match to prove himself and the tasimeter.

Although he never did it himself, it seems of some historical interest to establish whether Edison did indeed measure the feeble IR radiation from the corona (now known to be a poor emitter) and whether his "wonderful instrument" really met its advertised sensitivity of $10^{-6} \degree F$.

Several years ago, to answer these questions, I reanalyzed Edison's measurements made in 1878, using what we now know of the corona, what I could reconstruct of the theoretical properties of his refractor, and the recorded details of the Rawlins measurement, from his own notes and from newspapers. As a relative calibration point I could use his observation, attested by Lockyer, of Arcturus, whose near IR radiance we now know. Though we can never know where in the corona his telescope was directed, the deflection achieved falls nicely within the range of expected values. Thus we can conclude that Edison did indeed sense near IR coronal radiation in 1878.

The detection of Arcturus enables us to establish in a way that he could not the absolute sensitivity of the tasimeter. Near IR and visible radiation from the star would have deposited about $1.7 \times 10^{-8}$ W on the tasimeter; from the known dimensions and thermal properties of the vulcanite rod we can show that this should have raised its temperature about $3.8 \times 10^{-7} \degree C$ or $0.7 \times 10^{-6} \degree F$. With this, according to Lockyer, Edison achieved "five uniform and successive deflections" of the Thomson galvanometer. The sensitivity of the tasimeter was thus every bit as good as his claim. Though not inclined to the mathematical drudgery of quantitative calibrations, Edison's uncanny intuition seemed to make such steps unneeded, giving him a license to boast that one must respect.

End of the Tasimeter

For a time the tasimeter seemed destined to fulfill its vaunted destiny and so to make a place for its maker in the halls of pure research. Fueled by a generous press, interest in the device grew, and with it grew Edison's own plans for its future in astronomy. In a most interesting interview in *Scientific American* a month following the eclipse Edison laid out his strategy for the future of the amazing little instrument: he planned to attach the tasimeter to a large telescope and to explore those parts of the heavens that appear blank, and thus "to detect by their invisible radiation stars which are unseen and unseeable." Infrared maps of the sky made in recent years have shown the wisdom of Edison's prediction and have proved the existence of IR sources. The editors of *Scientific American* were caught up in this enthusiasm and proclaimed that "a new agent or organ of scientific sense for space exploration has been given to the world by the tasimeter." Astronomers urged Edison to turn the tasimeter on the night sky without delay, initially on the planets, to determine if any were self-luminous.

Edison had suggested many nonastronomical uses for the detector: to measure wind, to weigh infinitesimal objects (he had demonstrated its use in weighing a gnat), to test the compressibility of substances, to determine the electrical conductivity of different materials under pressure, to detect fire in a ship's hold, and to warn of the presence of icebergs. In this last application, Edison proposed that the tasimeter be attached in the bilge to the inner surface of the ship's metal keel, to sense the presence of icebergs through their conductive cooling effects on surrounding seawater. Surely an iceberg—even a distant one—would cool the surrounding ocean by $10^{-6} \degree F$! The system as Edison envisioned it would be completely automatic with a wire running from the tasimeter on the keel directly to a bell in the captain's cabin. This patently impractical scheme aroused the interest of the shipping industry, and, as late as December 1879, the White Star Line was still pressing Edison to adapt the tasimeter for iceberg detection in its ships.

The inventor was not alone in thinking up uses for the tasimeter, with its ability to detect a temperature change of one millionth of a degree Fahrenheit. Unsolicited suggestions came from near and far. In marine navigation the tasimeter was suggested as an IR sextant to take sunsights through clouds. In meteorology the tasimeter was proposed as the ultimate measurer of wind speed and of delicate changes in atmospheric temperature and pressure. A physician suggested its use in detecting minuscule changes in body temperature, which might signal the onset of disease. Various engineering uses were offered: to detect friction in mechanical devices, as an automatic governor to signal the overheating of an engine, and so on. Other uses were suggested in chemical research and in mining technology.

Edison modified the tasimeter at one point to convert it to a "moisture tester" on the basis of evaporative cooling, and for this application he replaced the vulcanite rod with one of gelatin. With this modification he found he could detect damp paper at a distance of 3 in., a drop of water on the tip of the finger at 5 in., and water in a bottle held nearby. He was also intrigued with the potential uses of the device as an "odorometer," and he liked to demonstrate the ability of the tasimeter to sense the presence of perfume spilled on the floor.

Through all of this there were no moves at Menlo Park to patent it or to exploit the tasimeter commercially before endowing it, as later announced, to science, although at this time Edison's full attention was needed for work on the incandescent lamp. Transfer of the tasimeter to "the higher branches of science" was effected in the end by giving rights of manufacture to two instrument manufacturers: John Browning in London and Partrick and Carter in Philadelphia. From what we can gather of the agreement, Edison was to receive no royalty or fees in either case and, moreover, would provide each manufacturer with carbon buttons. Browning, a highly respected scientific instrument maker of England, promised in return to exhibit the tasimeter at the soirées of the principal scientific societies in Europe and to further honor the inventor by

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Arrangements with the American manufacturer, Partrick and Carter, were less dignified and more intriguing. Partrick and Carter dealt in railroad and telegraph supplies, and judging from their frenetic correspondence with Edison, they found the tasimeter a challenge indeed. It is quite possible that Edison's choice of this unlikely company to build the potentially profitable instrument was made to relieve a debt that he owed the firm. The Philadelphia company began by sending circulars of advertisement to every college in the country, referring technical questions to Edison, since they could have known little of its characteristics. In six months they had interested, among others, J. W. Gibbs, but had sold only one instrument with "three or four bites." Then, as now, the commercial producers found the college market slow to buy but quick to borrow—a situation which did not improve Edison's personal opinions of academe. We may sense his mood in his terse response to a letter from Robert College, Istanbul, which had asked for a gift tasimeter in September 1879: "I have no tasimeter now. Made a dozen and gave them to colleges."

To the dismay of John Browning and the disgust of Partrick and Carter, the tasimeter never sold. Charles Young and Samuel Langley, who knew it best, had abandoned hope in the instrument soon after the eclipse. Lord Rosse, who had published work on the IR radiance of the moon and who was perhaps the leading IR astronomer of the day, examined the tasimeter in Ireland in October 1878, spending several hours making experiments with it. Rosse found the instrument sensitive but noted that its return was slow and somewhat uncertain. We can still feel the chill in his parting comment to Edison's agent, W. F. Barrett, who had shown the device to the renowned astronomer; Barrett could come again when he had "more thoroughly mastered the instrument."

The trouble with the tasimeter was that, although it was very sensitive, it was nothing else. It was erratic and difficult to use. Its response was very slow. It gave nonrepeatable results. It was a nonquantitative device, entirely too delicate and touchy to be of practical use. The heralded sensitivity of the tasimeter was itself a drawback; especial care was required in using the instrument to exclude the effects of changing background or mechanical vibration, as Young had so early noted. Physicists and astronomers understandably insisted that the detection of weak thermal sources required repeated quantitative confirmation, a capability eminently lacking in the supersensitive tasimeter. Perhaps only the master himself could operate the instrument. J. C. Simpson of Reading, England in a letter to a popular journal in 1878 told of his experiences in operating a tasimeter made from Edison's model: he found the instrument extremely sensitive to touch, to mechanical mounting, to rigidity. Movements of the needle were erratic after once having been deflected. The meter deflection did not fall back gradually to the starting point as one would expect of a reliable instrument but kept on describing various arcs, up and down, with no sort of method or regularity. With the application of sudden heat, Simpson found that the needle moved forward a little, then stalled, then moved more rapidly: an indication of a nonlinear and slow detector. In ominous words Simpson concluded that "at present it appears to be more of an indicator than a measurer of pressure—a tasiscope rather than a tasimeter."

The tasimeter was after all a lecture hall device—splendid for parlor demonstration but unsuited for accurate physical measurement. Langley was quick to highlight this distinction when two years later he perfected an IR detector of a different sort: the bolometer.

"There is probably no instrument in the whole range of scientific apparatus which demands a longer experience for its successful use...where we are employing it not for the purpose of a lecture experiment, but for the determination of some one almost infinitesimal radiation in the midst of numberless others which our only concern with, is to avoid."

Langley's bolometer, which is still in use today, was originally less sensitive than the tasimeter but smaller, faster, and more repeatable. In announcing his invention Langley omitted explicit mention of Edison or the tasimeter, but there is little doubt to whom Langley referred when he wrote in introduction:

"I, therefore, tried to invent something more sensitive than the thermopile, which should be at the same time equally accurate—which should, I mean, be essentially a "meter" and not a mere indicator of the presence of feeble radiation. This distinction is a radical one. It is not difficult to make an instrument far more sensitive to radiation than the present, if it is for use as an indicator only; but what the physicist wants, and what I have consumed nearly a year of experimenting trying to supply, is something more than an indicator—a measurer of radiant energy."

The sudden demise of the tasimeter and the good reasons for it were surely known to its maker, who had little more to do with the instrument until the setting down of his memoirs some thirty years later. There he must have thoroughly enjoyed the irony in dedicating the device, without patent or further claim, to the dilettantes in the higher branches of science.

**Final Assessment**

Most of us in modern research may not like what Edison thought of our work or appreciate his unorthodox style. Nor would I, for one, have wanted to conduct an eclipse experiment beside him in the field. Yet in his brief adventure in astronomy, he measured up well, I think, as a scientist. The assessments of Lockyer and Draper and Young, who saw him closest and measured him best, must be honored: each tells us that he considered the young Edison a colleague in science and worthy of the name. That he was a good experimentalist none could deny. Through alertness and in the process of other work he chanced upon a tool that seemed at the time to offer promise in a number of scientific disciplines. He had the imagination to recognize
its potential and the cleverness and drive to harness it and to make it known. He put his new tasmeter to test in the most trying crucible, with his reputation on the line. Through his own skill and dexterity and a little bit of luck, Edison snatched victory from defeat and successfully demonstrated what it could do. In boasting of it he stayed within the truth. Throughout he was careful and logical and in control; he kept within the bounds of his own knowledge and he made no mistakes. For a time he dreamed expansive dreams and shared thoughts that were pie in the sky but still pure science and a little ahead of their time. Though brash and flamboyant, he was unselfish in research, perhaps more so than many of us today. When he found what he thought was a secret he approached the experts concerning its adaptability to their work and at a busy and trying time in his career made components and a few instruments for them to test and use. In the process he found himself in competition with those he offered to help—the real world of infighting that has always gone on behind the walls of the perfumed garden. And he handled it well. In a brief bout with the heavyweight Langley, Edison was awarded the first round, although he surely lost in the end to the more persistent and methodical man. Best of all, in this case he had the wisdom to know what to do when he sensed that his own creation was a loser: he quit and went on to other things.

Were he here today might not Edison produce from his bag of tricks the 80-mpg automobile engine or a breakthrough solar energy system? With the confidence that buoyed him up in 1879 he surely would have tried. And he probably would have announced successful solutions long before they were found. But these third and fourth generation challenges of a burgeoning technology seem a different sort from the fresh ones that Edison naively tackled as a pioneer in the young Industrial Age. Indeed, when in later years he tried to improve the automobile storage battery, he failed to accomplish much in spite of a massive investment of time and resources.

Nor does it seem likely that a young Edison or a da Vinci would rise very far were we to drop them down in JPL, or Draper Laboratory, or one of the other vast research laboratories of today. It is an ironic fact that Edison’s own creation—the organized research laboratory—made his personal style of science obsolete even in his own time. As he expanded his enterprises to even greater laboratories, their productivity went steeply down. Edison’s early genius lay in imagination and breadth and bold initiative, individual qualities that when unrestrained make it possible for a gifted person to create a Mona Lisa but impossible for a committee of artists to paint one. When he tried to incorporate his gifted insights or to expand them to a team approach as he did in later years, the results were always measured in diminishing returns.

Edison is renowned for perseverance and determination—he felt the key to his success. He is famous for staying at his laboratory bench until solutions were finally found to knotty problems—five days and nights without sleep during an endurance run to find needed improvements to the phonograph in 1888. But it is hard to picture him hanging in there for that long as one of a team of project engineers in 1980. Can we imagine a young Tom Edison restricted to a limited aspect of a problem, as is so often done in the divide-and-conquer research strategies of today? Would Edison have stayed at his desk for five days and nights to write a subsection of a research proposal or a bid response? Or for even one day refereeing a paper or proposal from George Westinghouse or Samuel Langley had the world of science then been the world of science of today? And how would his proposals have fared under similar peer review?

In most cases the young Edisons of today operate under tighter restraints than did he, and they must, in some instances, produce far less because of it. Some of the more binding of these restrictions come from the disciplinary bonds with which we constrain modern science and technology. Is there room left for the practical genius of an Edison who is far broader than he is deep? Edison at thirty had risen from an ordinary telegrapher to a technical expert in a narrow but timely field, with eighty-nine patents to his credit. In today’s world he might have come as far, but by then he probably would have been trapped in a box canyon of specialization, under real pressure to delve deeper and deeper and narrower and narrower, until, as we say of specialists today, he might have known everything about nothing.

One suspects that Tom Edison would not stay long in most of our laboratories today. He would be soon discouraged. And he was too much a maverick and a little hard to supervise. He would probably leave, as in fact he did, to start a company of his own, to blossom a while but then, as he did, to get bogged down in administrative duties and corporate battles, and the more tangled webs of constraints imposed on public research and private business today. And that seems sad. Somehow we should make a way for a few young Tom Edisons to flourish, whether or not they fit the mold in which the rest of us have been stamped out.

References and Notes

Most of the factual material on which this essay is based has come from the critical biography, Edison by M. Josephson (McGraw-Hill, New York, 1959), the authorized biography Edison, His Life and Inventions by F. L. Dyer, T. C. Martin, and W. H. Meadowcroft (Harper, New York, 1929), and my own paper “Thomas A. Edison and Infrared Astronomy” in J. Hist. Astron. 3, 165 (1972). The first of these is a particularly apt resource in judging Edison as a scientist and an excellent and very readable book for any who are interested in a modern appraisal of Edison and his contributions.

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The upstairs room of Edison's Menlo Park Laboratory shows Edison in the center (wearing cap) seated with a group of his assistants. Note the incandescent lamps mounted on the old gas fixtures. The date of the photograph is 20 February 1880. *Photo credit:* U.S. Department of the Interior, National Park Service, Edison National Historic Site. See also page A235.