United States Standards of Weights and Measures

THEIR CREATION AND CREATORS

Arthur H. Frazier

Smithsonian Institution

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United States Standards of Weights and Measures

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Arthur H. Frazier

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ABSTRACT

Frazier, Arthur H. United States Standards of Weights and Measures: Their Creation and Creators. *Smithsonian Studies in History and Technology,* number 40, 21 pages, 10 figures, 1978.—Establishment of standard weights and measures in the United States necessitated the solving of technical and mechanical problems of instrumentation and the establishment of a government agency to carry out this mission. This study considers the contributions and relationships of the principal contributors, Joseph Saxton, Ferdinand Rudolph Hassler and his son Edward, and Alexander Dallas Bache, to each other and to the tasks they were dedicated to fulfill.

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Introduction

Perhaps the most difficult problem which the early Congresses of the United States had to solve was that of selecting standards of weights and measures that all of the original thirteen states would be willing to accept. Article 1, section 8, clause 5 of the United States Constitution states in part that "the Congress shall have power . . . to . . . fix the standards of weights and measures." For many years after 1789, Congress took practically no action toward asserting that authority. While everyone agreed that fixing such standards was indeed desirable, it was rendered practically impossible by international problems (European standards were also undergoing changes) and, particularly, because of local political rivalries. The local difficulty was the decision that had to be made as to *which* lengths, *which* weights, and *which* volumes should become the national standards.[1] All of the original thirteen states had been operating with standards of their own choosing and to which they had long since become accustomed, but no two sets were exactly alike. In fact, a few of them differed quite drastically from those of the others, and changing them would have entailed serious local hardships. No Congressman who hoped to be reelected dared vote in favor of changing his constituent's standards. Much time elapsed, therefore, before any uniform set of national standards could be adopted.

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Problems at the Philadelphia Mint

America's First "Standard" Weight

Prior to 1828, officials in charge of the national currency were faced with a closely related problem, that of knowing exactly how much gold should be put into their coins. Appeals for guidance were made to Congress, but to no avail. Finally, on 19 May 1828, that body passed an "Act to continue the Mint at the City of Philadelphia, and for other purposes," section 2 of which provided that

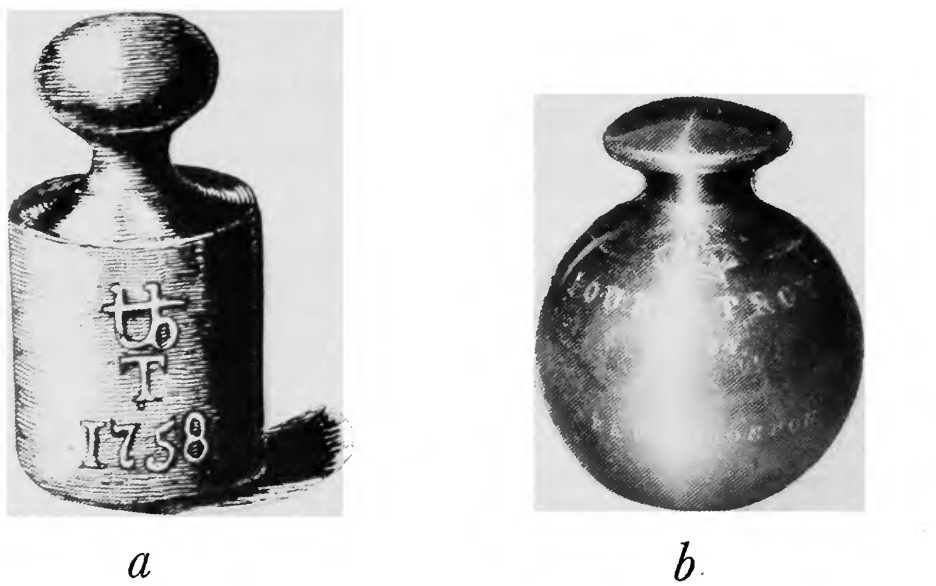
> for the purpose of securing a due conformity in weight of the coins of the United States . . . the brass troy pound weight procured by the minister of the United States at London, in the year one thousand eight hundred and twenty-seven, for the use of the mint, and now in the custody of the director thereof, shall be the standard troy pound of the mint of the United States, conformably to which the coinage thereof shall be regulated.[2]

Although no longer considered to be an official national standard, this weight has remained in the possession of the Philadelphia Mint. Carefully

guarded, it is now on view at the mint's present location at the eastern boundary of Independence Mall. Inscribed on it are the words: POUND TROY/ 1824/BATE LONDON. Robert Brittell (also spelled "Brettell," "Bretsell," etc.) Bate, who made this weight, was a prominent optician and mathematical instrument maker, whose shop was at 17 (later 20–21) Poultry Street, London. In 1824, he had supplied five weights identical to this one to the eminent British scientist Captain Henry Kater (1777–1835), who had been commissioned by his government to adjust them to match the official British imperial troy pound of 1758. Subsequently, Dr. Samuel Moore, director of the U.S. Mint in Philadelphia from 1824 to 1835, asked the United States minister at London, Albert Gallatin, to obtain for him a weight exactly equal to the imperial troy pound. Gallatin negotiated with these same Messrs. Bate and Kater to furnish it. Figure 1 shows a drawing of the imperial weight and a copy of the one they produced for Dr. Moore.[3]

Since the date "1824" appears on Moore's weight, Bate may have provided him with a leftover from the earlier lot or perhaps with a newly cast model from the original pattern. When Bate delivered this new weight to Captain Kater, it weighed slightly less than the required amount. All such weights had a hole drilled and threaded in them to accommodate the "button" by means of which they were handled with a special wooden fork. The hole was slightly deeper than the button. To correct the weight's deficiency, Captain Kater placed three tiny pieces of wire, one weighing 0.2 grain, the second weighing 0.02 grain, and the third weighing 0.01 grain into the hole before screwing in the button.[4] presumably these bits of wire still remain within the weight at the Philadelphia Mint.

Soon after this new troy pound arrived in Philadelphia, it was unpacked (12 October 1827) with appropriate ceremonies in the presence of President John Quincy Adams. The ceremonies included making public a document from Captain Kater



a *b*

FIGURE 1.—British and American standard troy weights: *a*, the British imperial troy pound of 1758 (from C. G. Evans, *History of the United State Mint of Philadelphia*, 1885); *b*, the pound troy of the Philadelphia Mint, America's first official standard weight, adjusted to match the weight of the imperial troy pound by Captain Henry Kater in 1827 (photograph by the author). (Actual size)

certifying that it deviated less than 0.0012 grain from the 1758 British Parliament's imperial troy pound.[5] Several months later, as indicated above, Congress declared this weight to be the United States' official standard, the first such national standard of weight or measure to be officially adopted in this country.

Search for a Better Balance

Although this Congressional action may have solved the mint's most pressing problem, it created another—and it was at this point Joseph Saxton became involved. It seems that the new weight was of a considerably higher order of precision than any of the mint's balances. Accordingly, a need arose for new and better balances. That, however, was only one need among many. During Moore's tenure as director of the U.S. Mint in Philadelphia, he wanted the organization to have the best possible equipment and to be operated in keeping with the most advanced methods. By a fortunate coincidence, early in 1833, he received a letter from Franklin Peale (1795–1870), son of the famous artist, Charles Willson Peale, asking for a job.[6] It occurred to Moore that Peale might be a good man to send to Europe to gather information about the equipment and methods used in mints there. Accordingly, he wrote to Dr. Robert M. Patterson (who was better acquainted with Peale, and who later succeeded Moore as director of the mint) asking about Peale's qualifications for such a mission. Patterson replied that his skill, perseverance, and "address" all eminently fitted him for such an errand, and that his knowledge of the mechanical art would undoubtedly help him gather valuable information from European mints on the subject of coining.[7] Moore subsequently employed Peale, who proceeded to Europe on 8 May 1833.[8] An item on his itinerary that became unexpectedly important, was a visit with his old friend, Joseph Saxton, who was then in London.

Joseph Saxton's Contribution

Seldom has any American whose formal education came to an end at the age of twelve and whose vocation was that of a "mechanician" (i.e., one skilled in the theory and construction of machines) ever attained distinctions such as membership in the American Philosophical Society or in the National Academy of Sciences. Joseph Saxton (Figure 2) was an exception, for he was to become a member of both.

During his youth, he had become obsessed with improving the precision of his workmanship. In pursuit of that unusual objective, he left his native town of Huntingdon, Pennsylvania, to work at prominent scientific centers—first Philadelphia, then London had the *world's* best, and his obsession he and Isaiah Lukens had installed a new tower clock of their own construction in the steeple of Independence Hall. Saxton felt that, while Philadelphia had *America's* best instrument makers, London had the *world's* best, and and his obsession with precision workmanship impelled him to go there. His combined workshop and residence was located at 22 Sussex (now Huntley) Street, one block west of University College. Before Peale arrived in 1835, Saxton had become acquainted with London's leading engineers and scientists and had done work for many of them.

Two examples of that work are especially worthy of attention. The first was the apparatus he built for the famous British engineer, Thomas Telford. It enabled Telford to conduct an important study on the resistance canal boats encountered when traveling through water at various speeds. The second was an electric generator and an electric motor, which he constructed after hearing Michael Faraday announce the principle of electromagnetic induction. The generator was finished just in time for him to take it to Cambridge, England, and demonstrate it to members of the British Association for the Advancement of Science who had assembled there late in June 1833, for their third annual meeting. As to the electric motor: his diary, which is preserved in the archives of the Smithsonian Institution, contains a sketch, dated 4 January 1835, of what must have been his first concept of the motor. Apparently he constructed a considerable number of them, as evidenced by their having been listed as "Saxton's Magneto-Motive Machine" (at £4 each) in Watkins and Hill's popular 1836 catalog.

What Peale saw of Saxton's work no doubt made a strong impression on him, because in his Janu-

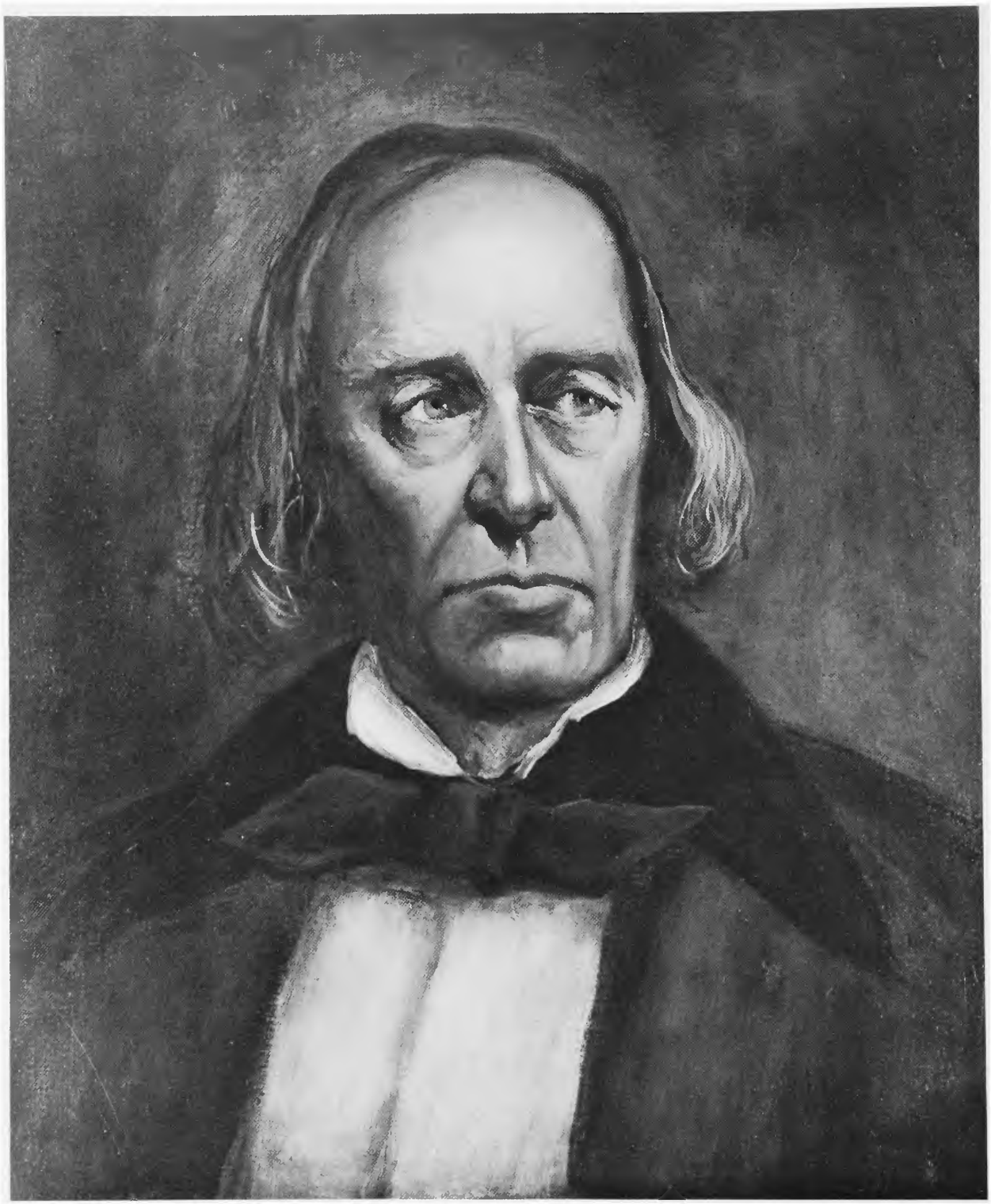


FIGURE 2.—Joseph Saxton, 1799–1873, age 61, after Schussele, "Men of Progress."
(Courtesy Mr. and Mrs. Joseph Saxton Pendleton)

ary 1836 report to Dr. Moore, Peale mentioned that he had decided to employ Saxton to make a balance for the mint, "which in simplicity of construction and excellence of workmanship . . . will possess all that is required in an eminent degree . . . "[9] Peale's decision met with Moore's prompt approval, and Saxton proceeded to build the balance—probably the first he had ever made. It was finished in time for Peale to take with him when he returned to Philadelphia.

Although neither that balance, nor even a full description of it, are known to still exist, it could not have been a very large one, because Saxton charged only £26 for it in comparison with the approximately £140 he later charged for a larger balance (Figure 3). In any event, the gold content of the coins at the Philadelphia Mint could now be maintained with greater accuracy than had been possible previously.

Unfortunately, Dr. Moore died suddenly in July 1835 and never saw the new balance. He was succeeded by Dr. Robert M. Patterson, who conducted the examination of the new balance. The following letter attests to his satisfaction:

Philadelphia, Nov. 5, 1835.

Dear Sir:

I wish you to make, for the Mint of the United States, five Assayer's balances, after the model of that which you made for us while Mr. Peale was with you while in London. One of those balances is for this Mint, two are for the Branch Mint at New Orleans, one for the Mint in North Carolina, and one for the Branch in Georgia. You will not, of course, allow the price to *exceed* that of the balance in our hands, which I understand, was £26. It is expected that they are to be in no respect *inferior* to the model.

We are also in want of several other Beams, viz Four for Gold, to weigh up to 25 lbs. and Two for Silver to weigh up to 80 lbs. I do not give an order for these, but would be glad to know if you could undertake them.

Will you allow me to take this occasion of communicating

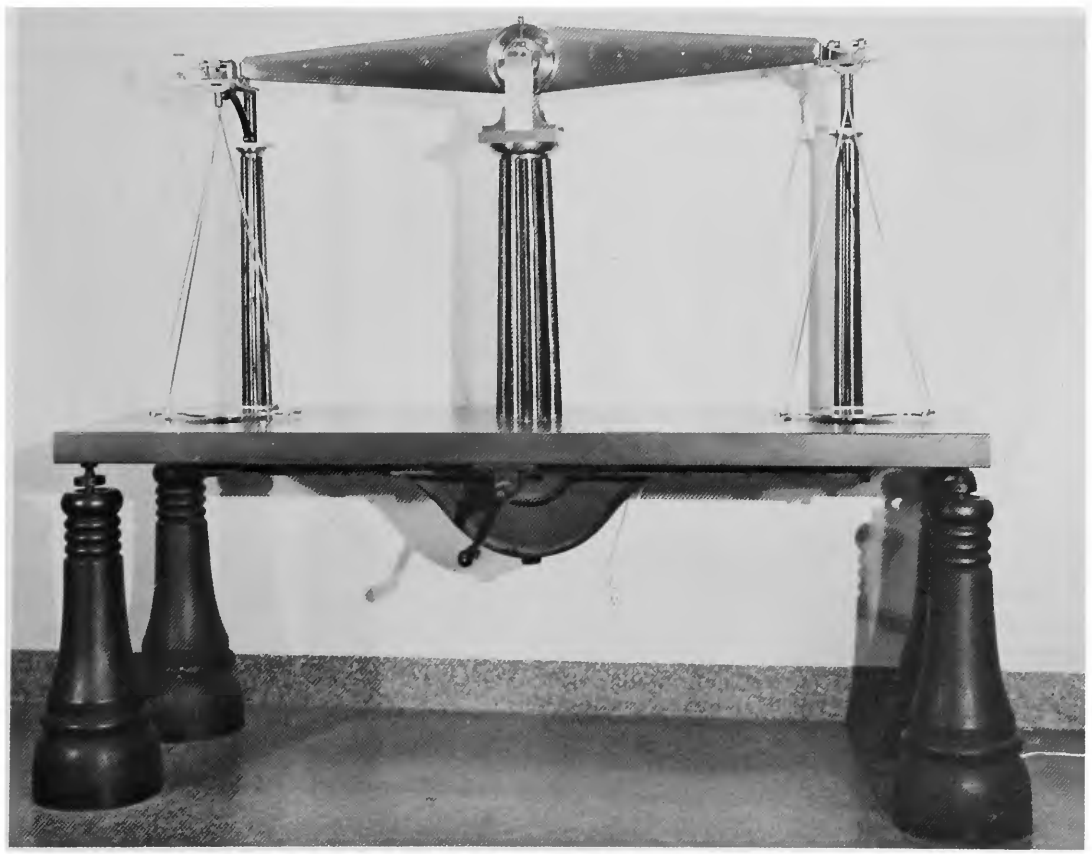


FIGURE 3.—The large balance built for the U.S. Mint in Philadelphia by Joseph Saxton in 1838; its base is about 6½ feet long by 2 feet wide. (Photograph by the author)

to you the wish of many of your friends, that you should return to Philadelphia. You see that we shall at once give you a good job to begin with, and I have no doubt that you will find your situation here better than in England. I am not, therefore, without some hope of seeing you here in the course of two or three months.

Very respectfully, your friend and servant,
R. M. PATTERSON
Director

To Mr. Joseph Saxton.[10]

Here, at long last, Saxton had been offered the kind of a job for which his lifelong devotion to precision workmanship had eminently qualified him. Moreover, it afforded him an opportunity to associate with men who fully understood and appreciated the merits of such workmanship. In his response, dated 15 January 1836, Saxton accepted both the order for the balances and Dr. Patterson's offer of a "good job" in America. He indicated that he would try to return to Philadelphia during July or August.[11] As it finally turned out, Saxton did not begin his return journey until the first week in May 1837, but the "good job"—constructing and maintaining the balances at the mint—was still waiting for him. As evidence of his superb workmanship, there is still on display at the present mint in Philadelphia (Figure 3), a large "mint balance built by Joseph Saxton, 1838, . . . one of the finest he built while serving the United States Mint." [12]

Soon after his return to America, Saxton renewed his earlier affiliation with the Franklin Institute. He became a life member in 1838 and served on at least two of its permanent committees, one that dealt with its monthly meetings and another that dealt with its cabinet of arts and manufactures.[13] The May 1839 issue of the Institute's *Journal* (page 304) shows that he had exhibited one of his balances at its previous (1838) fall exhibition, and received the highest award, a silver medal. On 18 August 1837 Dr. Patterson and Saxton's old friend Isaiah Lukens nominated him for membership in the American Philosophical Society,[14] and he was promptly elected.

These events constitute the first of a series which culminated in Saxton being placed in charge of the Office of Weights and Measures in the United States Coast Survey. Before Peale had visited him in London, his work had consisted largely of constructing scientific equipment for British engineers and scientists. Practically every item was for a different purpose, and seldom were any two of them alike. In consequence of Peale's visit, however, he focused his attention predominently on the design and construction of high-precision balances. Yet, before he could assume that duty with the Office of Weights and Measures, there were obviously two major requisites: the position had to become available and someone had to appoint him to it.

Advent of the U.S. Office of Weights and Measures

All of the earliest presidential messages to Congress included an appeal for legislation for standardizing the nation's weights and measures. Yet, with one exception, such legislation was extremely slow in forthcoming. The exception occurred in 1799, when the fifth Congress, at its third session, passed an act ordering the surveyor of each United States port of entry "from time to time examine and try the weights and measures, and other instruments used in ascertaining the duties on imports with standards to be provided by each collector at the public expense for that purpose." [15] This was the first Congressional act regarding national weights and measures, but since it failed to specify just *which* weights and measures should represent those standards, the persons responsible for enforcing that legislation were at a loss as to how it should be done.

The Hassler Era

Ferdinand Rudolph Hassler, the remarkable Swiss mathematician, surveyor, and metrologist (Figure 4) was the person primarily responsible for prescribing the first standard weights and measures in the United States. He had arrived in Philadelphia in September 1805 on a chartered 350-ton ship, the *Liberty,* accompanied by his wife, four children, 96 large pieces of baggage, and a company of 120 Swiss farmers, laborers, artisans, and craftsmen, whom he had recruited with the aid of a new partner, Jacques Marcel of Lausanne. They had intended to purchase a large tract of land in one of the southern States and establish a Swiss colony there. Upon arriving in America, however, Hassler

FIGURE 4.—Ferdinand Rudolph Hassler, 1770–1843.
(Courtesy Library of Congress)

learned that Marcel (who had sailed earlier) had mishandled the money for this enterprise, and lost it all.[16] Within a year Hassler himself was looking for a job. Fortunately, he had made influential federal government to undertake a complete sophical Society. They had recognized in him an outstanding and unusually gifted scientist—a type badly needed in the still immature nation. Moreover, they started a campaign to persuade the Federal Government to undertake a complete trigonometric, topographic, and hydrometric survey of the entire east coast of the nation with Hassler in charge of it. On 10 February 1807, Congress responded by appropriating $50,000 for such a survey and appointing Hassler as its first superintendent.

Before Hassler had come to this country, he had procured (with financial aid from his indulgent father) a large assortment of replicas of the best European standards of weights and measures. His possession of them, together with his thorough knowledge of their purpose and use, made him the foremost metrologist in America at that time.

On 29 May 1830 (some 31 years after the passage of the ineffective 1799 act) Senator Levi Woodbury of New Hampshire presented a resolution similar to that first one. It called upon the Secretary of the Treasury to see that a comparison would be made of the standards of weights and measures used at the principal United States customhouses.[17] Since Hassler was not then occupied with Coast Survey work, Samuel D. Ingham, President Jackson's Secretary of the Treasury, employed him to conduct that investigation.[18] During Jackson's administration, the average tenure for a Secretary of the Treasury was only one year. It was therefore a new secretary, Louis McLane, who, on 27 January 1832, received Hassler's report and forwarded it to the Senate.

Senator Woodbury's resolution, like the Act of 1799, failed to specify which weights and measures should represent the appropriate standards for checking those in use at the customhouses. Before Secretary Ingham left office, however, he had concluded that under the old 1799 act, he was vested with adequate authority to select those standards himself, and he chose those which Hassler had prescribed. Moreover, with President Jackson's consent, he actually authorized Hassler to begin making them for the customhouses. That authorization, in effect, was responsible for the establishment of the office later known as "Weights and Measures." [19] It also resulted in the first tangible progress toward solving the nation's weights and measures problem.

The standards that Hassler had prescribed closely resembled those already in effect in England, consisting of the following basic items: (1) A standard yard amounting to the 36 inches between the 27th and 63d inch graduations on a brass bar, commonly designated as an "82-inch bar," prepared for the Coast Survey by Troughton of London. Hassler had brought this bar to the United States in 1815, after he had been detained in Europe for several years by the War of 1812. (2) The avoirdupois pound derived from the troy pound of the mint according to the equivalent, 1 avoirdupois pound equals 7000/5760 pounds troy. This was the accepted relation in both this country and England. (3) A wine gallon comprised of 231 cubic inches. It represented the average of the capacity measures in use in the United States during Hassler's time. (4) A Winchester bushel comprised of 2150.42 cubic inches, for the same reason expressed above. The two volumetric standards varied just slightly from those of the British at the time Hassler made his determination. At present the American gallon is smaller than the British by about 17 percent, and the bushel by about 3 percent as a result of subsequent British legislation.[20]

Although facilities for fabricating the new customhouse standards were immediately made available to Hassler at the U.S. Arsenal (then located at what is now Greenleaf Point at the confluence of the Anacostia and Potomac rivers), actual production was slow at getting started. Plans had to be formulated for the entire operation, and drawings had to be prepared for the casting patterns as well as for each finished part. In some instances special tools and entire new machines had to be designed and built. Figure 5, for example, is a sketch from among Hassler's papers at the National Archives, showing a treadle-operated lathe presumably intended for the special purpose of machining the weights.[21]

On 10 July 1832, when Congress reactivated the Coast Survey, Hassler found himself in possession of two titles, "Superintendent of the Coast Survey" and "Superintendent of the Office of Weights and Measures." He had already been working from 9:00

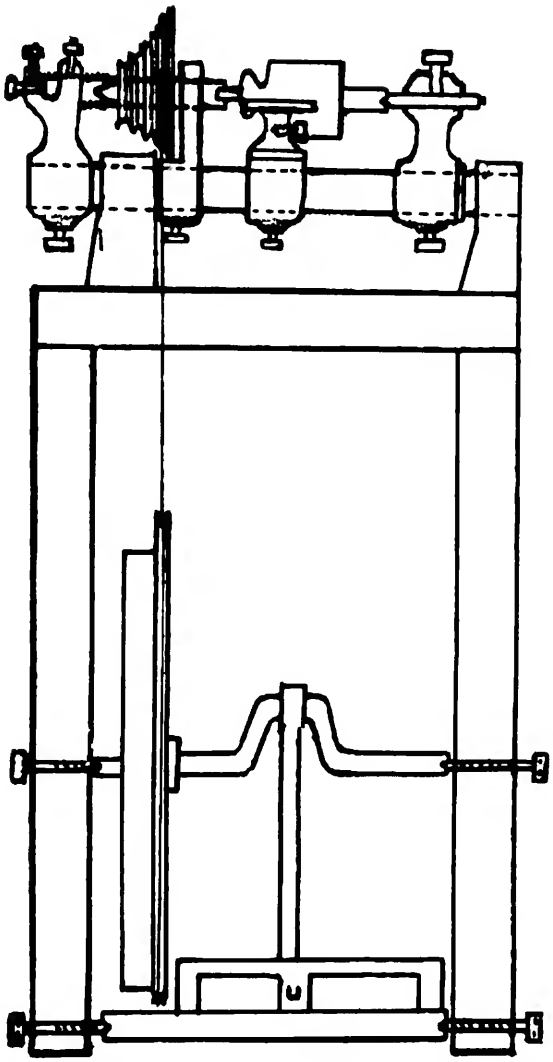


FIGURE 5.—Treadle-operated lathe, presumably drawn by F. R. Hassler, for machining the brass castings for the standard weights supplied to the customhouses. (Courtesy National Archives)

A.M. until 1:00 at night, seven days a week,[22] but with his extraordinary ego, he truly believed that he was the only person in America sufficiently competent to handle either job. As a matter of fact, he could not bear the thought of either activity being placed under the supervision of someone else. It is not surprising, therefore, that little was accomplished. Thus, three years later, in March 1835, after waiting in vain to see some tangible results from the new Office of Weights and Measures, Congress passed the following resolution:

Resolved, that it is highly expedient that the Treasury Department should complete with as little delay as practicable the fabrication of standards of Weights and Measures for the supply of the different customhouses of the United States, upon the principles set forth in the reports of the Secretary of the Treasury to the Senate, on the 3d March 1831, and 20th June 1832.[23]

Levi Woodbury, the senator who had started the customhouse investigation in 1830, had by this time been appointed President Jackson's fifth Secretary of the Treasury. Woodbury lost no time in bringing this resolution to Hassler's attention.[24] Thenceforth, events progressed at an accelerated rate. Hassler replied the very next day, asking Woodbury to appoint his son, Edward Troughton Hassler, as his assistant. Woodbury did so on the following day, 12 March.[25]

Acquisition of Shop and Office Space

During the early days of the Coast Survey, office space for the organization was limited to Hassler's famous yellow carriage, in which he "carried his wardrobe, surveying instruments, cooking utensils, and camp equipage. He frequently ate and slept in it." [26] When not in the field, his office was wherever he happened to hang his hat. With the advent of the weights and measures project, more adequate housing facilities had to be provided. Characteristically, Hassler took that responsibility upon himself, not bothering with governmental procedures. He rented an office on 13th Street, N.W., from the Bank of the Metropolis. Nobody paid attention to this until his next expense account showed $250 in rent due the bank as of 30 June 1835. When this was brought to Secretary Woodbury's attention, he wrote a sharp note to Hassler, telling him no further payment would be allowed for such rental unless an acceptable justification were furnished.[27] At the same time Woodbury took the matter up with the Commissioner of Public Buildings. Apparently the commissioner responded with alacrity, because on 18 September 1835 Hassler wrote to Woodbury:

The house procured upon Capitol Hill, by the commissioner of public buildings, will be well adapted to the whole of our operations; the repairs directed by him are just finished, and the so very necessary process of cleaning, scrubbing, and whitewashing may perhaps be finished in about two days.

I intend next Monday to begin to move the whole estab-

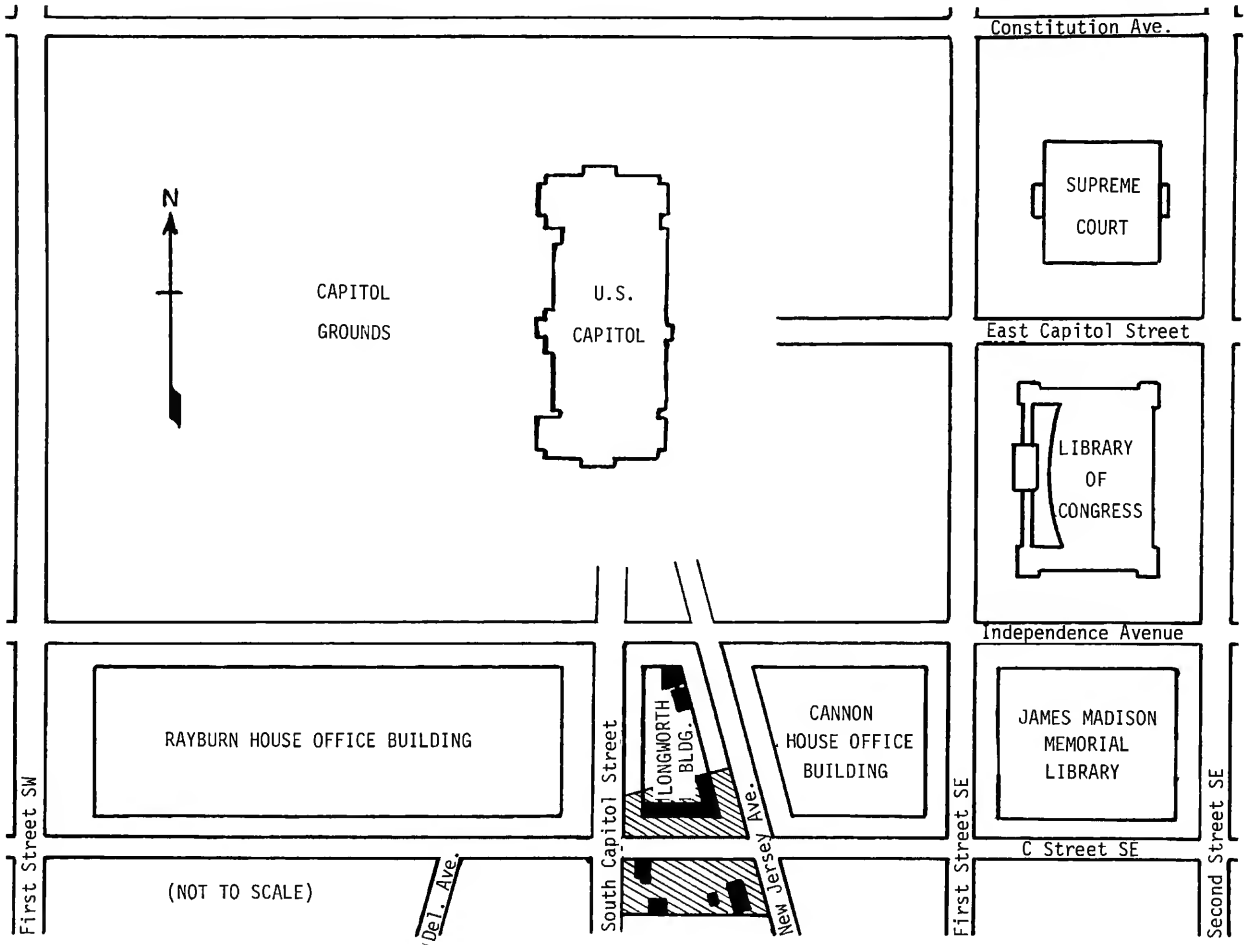


FIGURE 6.—Location of the Coast Survey and Office of Weights and Measures (cross-hatched) on Capitol Hill, Washington, D.C., ca. 1836.

lishment, which will occupy several days; the work benches are making ready to be put up there.[28]

These new quarters consisted of a three-building brownstone row-house complex on the north side of C Street, S.E., with the most easterly of the three occupying the northwest corner of C Street and New Jersey Avenue.

Less than a year after Hassler had become settled in these new quarters, he further consolidated his operations by moving the equipment and crew from the arsenal to other lots on C Street, just across from his office.[29] The cross-hatched area in Figure 6 shows the location of the entire establishment after that change had taken place.

It had apparently been a regular practice of Edward Hassler to sleep in one of the Survey office buildings. The elder Hassler also slept there between the periods when he had been in the field surveying. His explanation was that it was done for security and fire protection purposes.[30] Although no official records have been found to support it, the probability seems great that for the first six years during which Saxton succeeded Edward at the Office of Weights and Measures (1844 to 1850), he too slept there. [31]

GROWING PAINS

Federal standards of weights and measures are not items that can be mass-produced. Each one must be adjusted to the final prescribed weight, length,

or volume by the most painstaking and time-consuming handwork of a highly competent expert in that field—in this case, Ferdinand Rudolph Hassler himself. Many Congressmen of that period failed to appreciate the need for such meticulous refinement and kept demanding a faster rate of production. On 28 July 1836, the first six sets of standard weights were ready for distribution to a like number of customhouses. Each set contained one each of the following sizes of pounds avoirdupois: 1, 2, 3, 4, 5, 10, 20, 25, 50, and 1 pound troy. Those for the remaining customhouses were already in various stages of completion. At the rate of production then taking place, however, it would require a few more years before they would all be finished.[32]

As if by increasing Hassler's workload he might speed up the operations, Congress passed two more resolutions calling for additional equipment to be fabricated. The first was passed 14 June 1836, specifying that a complete set of standards be furnished each state in the Union; and the second, on 7 June 1838, called for a standard *balance* to be built for and delivered to each of them.[33]

By the time the second of those resolutions had been passed, Hassler's son Edward was in charge of all of the operations at the office except that of performing the final adjustments on the standards, a job which the elder Hassler reserved for himself. Most of the increased work accordingly fell upon the younger man's shoulders. Undaunted, however, by those ever-increasing demands, Edward ventured to almost triple the amount of work involved by offering to provide balances in sets of three, instead of one, for every state. He contended that while this change might not conform to the wording of the resolution, it was necessary for carrying out its spirit. "Experience," he explained, "has proved that [an exact comparison of weights] cannot be secured with sufficient accuracy by less than three balances." [34] And so he proceeded on that basis. The largest balance was to have a 50-pound capacity; the intermediate, 25 pounds; and the smallest, 10 pounds.

It took almost five years to accumulate sufficient parts to permit the assembly of just the first balance, and that turned out to be a special one. A devastating fire had taken place in London on 16 October 1834. It had destroyed both Houses of Parliament, and with them, the authentic British standard weights and measures. On 3 March 1843, in a gesture of sympathy and good will, Congress passed a joint resolution authorizing a complete set of the American standards and one of the large standard balances to be sent to that country.[35] The shipment left Washington on 1 June 1843. Its receipt was asknowledged in behalf of Her Majesty's government by Sir George Clerk on 24 July. The following items were contained in that shipment: one standard yard consisting of two pieces; one set of large standard brass weights, 10 pieces; one full set of ounce brass weights, 27 pieces; one full set of liquid capacity measures, with glass plates, 10 pieces; one half-bushel standard with glass plate, two pieces; and one large balance. The design and most of the assembly work on the balance had been performed by the younger Hassler, and his name, "E. Hassler," was prominently inscribed in a flat area just above the central column.[36] Some time during the 110 years or so that the balance was in Great Britain's possession, it came into the custody of the British Board of Trade Standards, and in October 1952 the board offered to return it to the United States for exhibit purposes in an American museum. Frank A. Taylor, then head curator, Department of Engineering and Industries at the Smithsonian Institution eagerly accepted the offer. The balance (Figure 7) arrived on 25 October 1954, and is presently on exhibit at the National Museum of History and Technology.

End of the Hassler Era

As it finally turned out, this was the one and only "State Balance" ever completed by the Hasslers. It is true that they had made several other balances for special testing purposes in the Office of Weights and Measures. But, when Congress decreed that each state should receive a balance, Edward Hassler designed a special model for that purpose, and the one that was sent to England was the only one which this father-and-son team completed. Edward started to assemble additional models from the parts remaining in that first lot, but due to a family tragedy, he never completed any of them. The first phase of that tragedy was the death of his father, who had gone to New Jersey in mid-October 1843 to carry on field work for the Coast Survey, and was caught in a severe hail storm, which ultimately resulted in his death. Years later, his daughter,

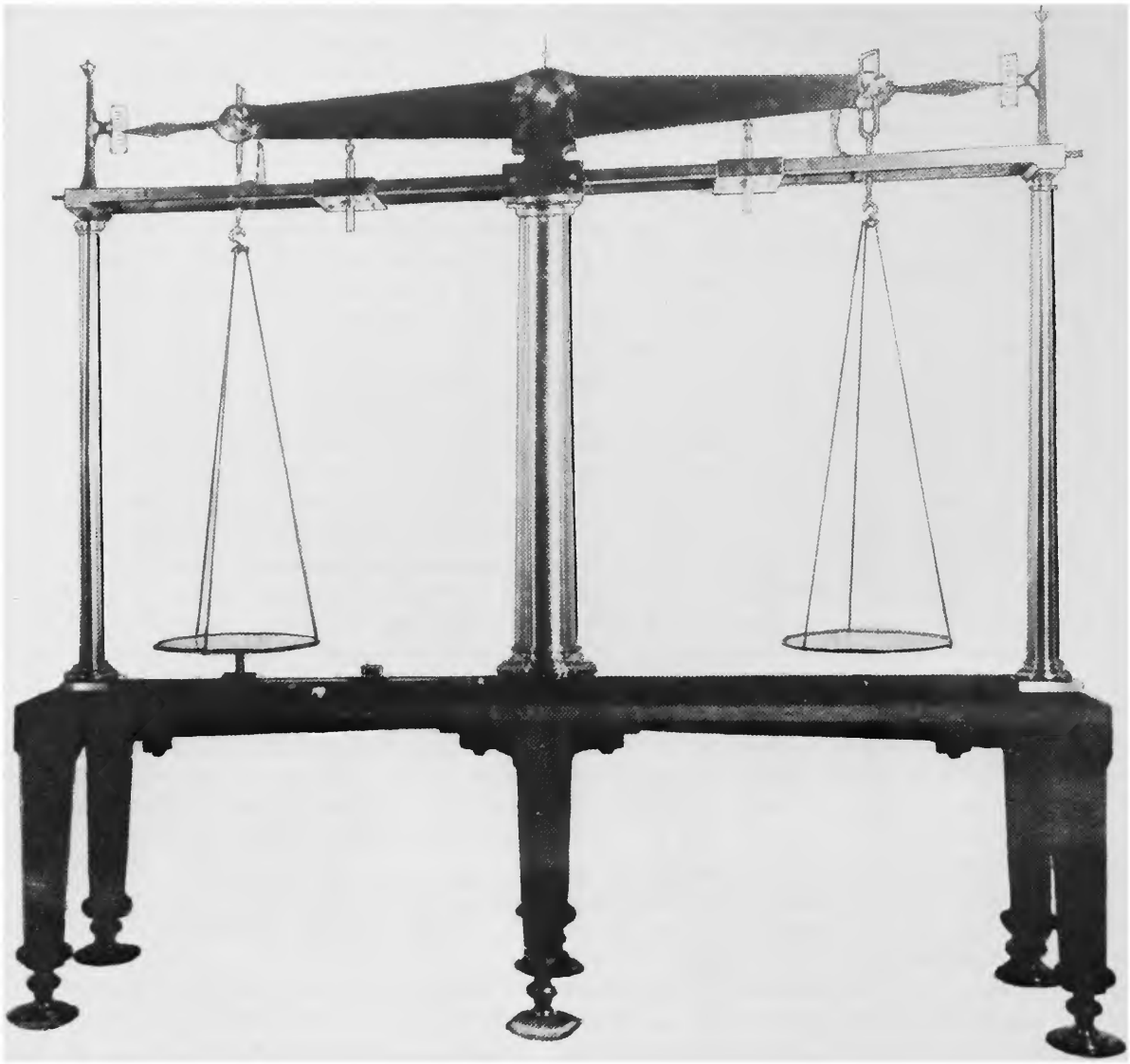


FIGURE 7.—Hassler's balance (#314,495) at the National Museum of History and Technology, Smithsonian Institution; its base is 5 feet 4 inches long by 1 foot 4 inches wide. (Photograph by the author)

Rosalie (Hassler) Norris described the circumstances. That which follows is a considerably abbreviated version of her description:

When we arrived at the Hotel in Philadelphia, we found him suffering from a very severe cold. In his effort to save his instruments from destruction when the wind took the tents off, he fell on a pointed rock and hurt his chest. Besides, he had to remain in the cold wind for several hours. The next morning at the Hotel he said he felt so oppressed that he could not breathe. It was a cold, raw, damp morning—unfit for an invalid. Yet he insisted on taking a ride in the open air in an effort to find relief. Upon his return, he looked ghastly. Despite his sufferings, he sat down to write the annual report of his work to Congress. He wrote until late in the evening. Although worse the next day, he went on writing until he said, "I have finished my report, and Congress cannot help being

satisfied with that." He sealed and dispatched it to Washington, and continued to write in his journal until within twenty-four hours of his death—until the writing was no more legible.[37]

Hassler died in Philadelphia on 20 November 1843, thereby bringing to an end his brilliant career as superintendent of both the Coast Survey and the Office of Weights and Measures.

The second phase of the tragedy centered around the internal affairs of the Office of Weights and Measures.

The Bache-Saxton Relationship

On 12 December 1843, President Tyler selected Alexander Dallas Bache, Benjamin Franklin's grandson, as superintendent of both the Coast Survey and the Office of Weights and Measures. Bache (Figure 8) entered upon his new duties at the Office of Weights and Measures in January 1844.[38] It has often been assumed that this change in administration took place smoothly, but the facts do not justify that assumption. Almost immediately

FIGURE 8.—Alexander Dallas Bache, 1806–1867.
(Courtesy Albert Stanley)

after Hassler's death, two factions emerged, each having a different view as to whom his successor should be. One was headed by no less a dignitary than John Canfield Spencer, Secretary of the Treasury, under whose jurisdiction the Coast Survey was operating. Spencer strongly favored promoting either Hassler's son or one of his other assistants to that position. The other faction was composed of several scientific organizations, such as the American Philosophical Society. They overwhelmingly endorsed Bache, and no doubt it was their influence that caused President Tyler to select Bache.[39]

The position held by Edward Hassler in the Office of Weights and Measures was next to receive attention. If any change were to be made in that position, presumably the secretary would have jurisdiction over the appointment, and there is little doubt but that he strongly favored retaining Edward. In fact, on 27 December 1843, even before Bache had taken over that office, Spencer wrote Edward, asking for a complete report of the status of his work.[40] Obviously he had become aware of Bache's preference for Saxton in that position, and Spencer was seeking ammunition with which to support Edward's retention. That report ultimately came into Bache's possession, and he included it in a progress report he submitted to the secretary on 26 February 1845.[41]

Nevertheless, Bache succeeded in getting Saxton appointed as his assistant in the Office of Weights and Measures. As a gesture of good will, Bache assured Edward that he could continue working in the office, but under Saxton. Edward, whose sensitivities and ego were probably fully equal to those of his father, and who obviously had hoped to succeed his father as the organization's superintendent, refused the offer. Becoming despondent, he went to New York to visit a brother. There, on 14 June 1844, he committed suicide.[42] His remains were buried next to his father's in Philadelphia's Laurel Hill Cemetery.

Bache and his new assistant Saxton had been friends for a long time. They complemented each other very well. Bache, a scholar, was not particularly adept as a mechanic whereas Saxton, a mechanician, was far from being a scholar. Both, however, were active and enthusiastic members of the Franklin Institute, the American Philosophical Society, and later, the National Academy of Sciences. In fact, in each of those organizations they often served on the same committees. The following are just two of the many historically interesting events which they previously had shared together.

During the late 1830s Bache was perhaps the earliest Philadelphian to have learned of Daguerre's process for taking photographs. He described it to Saxton, who promptly improvised a daguerreotype camera and, with it, took a daguerreotype of Philadelphia's first Central High School, the school at which Bache was then the principal. It is the oldest *extant* daguerreotype in America.[43]

Another joint venture concerned instruments for use at Girard College in Philadelphia which was being constructed during the 1840s. It was planned that Bache would become its president when that work had been completed. In the interim Bache had arranged for a small observatory for the study of magnetism to be built on the campus and had procured several instruments from England for use in measuring the variations in the earth's magnetic field. One of those instruments, procured from Lloyd's of London, failed to perform satisfactorily. Upon learning of that circumstance, Saxton built a new instrument for Bache. Its performance was so satisfactory that Bache took it to an American Philosophical Society meeting in January 1841 and explained its several advantages.[44]

In 1842, Bache, after having established a series of major improvements in Philadelphia's school curriculums, decided not to wait any longer for the Girard College buildings to be completed. He resigned his positions both as principal of the high school and president of Girard College, and returned to his former chair of natural history and chemistry at the University of Pennsylvania.[45] It was just a little more than a year after this that President Tyler appointed him superintendent of both the Coast Survey and of the Office of Weights and Measures.

Saxton and the State Balances

Production of the Balances

The elder Hassler's death marked the end of the Hassler era and the beginning of the Bache era at the Coast Survey. It also marked a new era in the

life of Joseph Saxton. Since balances were the main item with which the Office of Weights and Measures was then concerned, Bache, who was well acquainted with Saxton's extraordinary talent at making them, appointed him chief of that office in February 1844, a position he kept until his death in 1873. His first and most important task was to accelerate production of the state balances.

As already explained, only the model that had been shipped to England had been completed by this time. However, practically all of the parts for the first six sets (18 balances in all) had reached the assembly stage. On the basis of Saxton's past experience with building them, the temptation was great to change numerous features in their design. To do so with this lot, however, would be costly and would entail considerable delay. After consultation with Bache, it was decided that only a few changes, aimed at increasing instrumental sensitivity, would be made on the balances of these first six sets.[46] As soon as they were completed, Saxton personally delivered one set each to the following state capitals: Trenton, New Jersey, April 1845; Albany, New York, April 1846; Cambridge, Massachusetts, 1846; Dover, Delaware, April 1847; Columbus, Ohio, July 1847; and Annapolis, Maryland, March 1848.[47] Saxton also set them up and instructed the operators on how to use and care for them. Recent inquiries have revealed that none of the models delivered to New York or Ohio appear to have survived, but each of the other four states has at least one model, and both Massachusetts and Maryland have all three. Figure 9*a* shows a drawing made by Saxton of the smallest model in this first set, and 9*b* is a photograph of the one he delivered to Annapolis.

When the subsequent lots were fabricated, Saxton incorporated all of the changes he felt were needed to further increase their sensitivity, and particularly to simplify their construction. Bache referred to them in a later annual report: "In the alterations, 612 pieces were replaced by 264, which proves that Mr. Saxton's changes have simplified the construction." [48]

In 1845, the instrument shop in which the parts were machined and assembled employed twelve mechanics and laborers. It had been started simply as a shop for producing standards for the customhouses, but turned out to be the main shop for the the Coast Survey's highly sophisticated instruments. In fact, it is still a highly important facility for that organization. An example of the perfection of the work performed in the shop while under Saxton's supervision may be found in the change that he and one of his skilled mechanics made in a circular dividing engine. That device, purchased in 1841 from Troughton and Simms of London by Hassler, was intended to be hand operated. Its function was to engrave degrees and fractions thereof onto a circular disk with high precision. It was found, however, that the body heat of the operator could measurably distort the spacings between successive graduations.[49] Saxton and his assistant William Würdemann made a few changes in its design that enabled it to be driven by a remote water turbine without any operator in its immediate vicinity and with appreciably greater speed. With it, the instrument shop could produce astronomical and geodetic instruments which equalled, if not surpassed, those obtainable from England. That dividing engine is now in the custody of the National Museum of History and Technology of the Smithsonian Institution.[50] In an expression of appreciation for this and for many other of Saxton's fine achievements, Professor Bache, in an address before a scientific group, declared that he was "the greatest mechanical genius" the world had ever seen.[51]

International Recognition

Between the years 1844 and 1873, while chief of the Office of Weights and Measures, Saxton not only designed and supervised the construction of the balances that Congress had authorized his office to build for each of the states, he also built additional balances, which the Federal Government displayed at several international exhibitions.

One of his large state balances was sent to London for display at the Great Exhibition of the Industry of All Nations in 1851. It was awarded a gold medal for the "highest class that an instrument not claiming to be an invention" could receive.[52] This exposition was followed by a similar one in New York in 1853–1854.[53] Prominent among the U.S. Government displays at New York were those of the Coast Survey and its subsidiary, the Office of Weights and Measures. Here, for the first time, many of the devices designed by Saxton were assembled for American examination. Descriptions and, in some instances, illustrations of them are

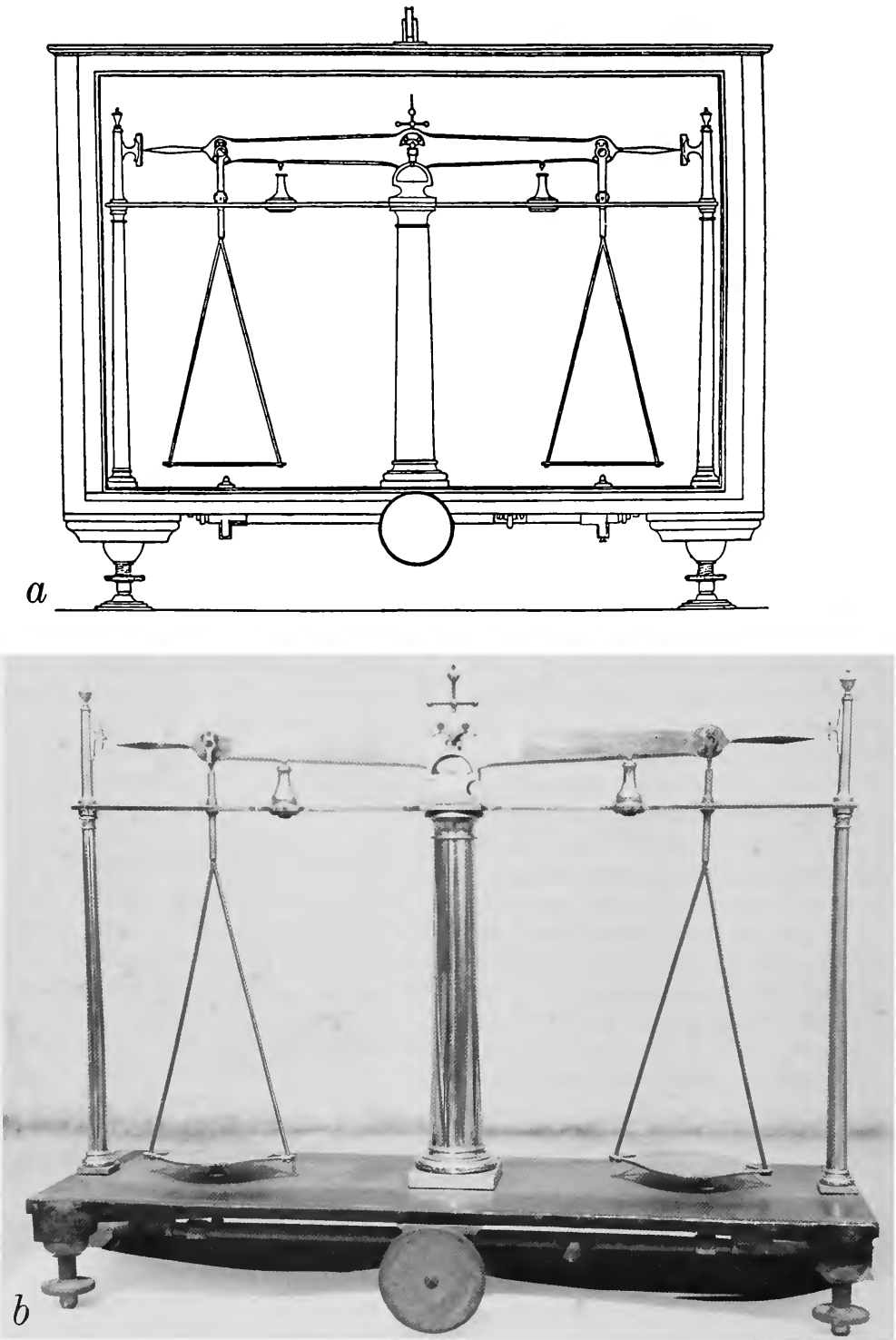


FIGURE 9.—State balances: *a*, Saxton's drawing of the smallest balance as he had redesigned it; *b*, the smallest of three balances Saxton delivered to the State of Maryland in March 1848; its base is 21 inches long by 7 inches wide.

contained in a book entitled *The World of Science, Art, and Industry Illustrated from Examples in the New-York Exhibition, 1853–54*, edited by the well-known Professor Benjamin Silliman, Jr., and C. R. Goodrich, Esq. The balances brought forth the following praise from Professor Silliman:

> The standard balances are among the finest products of American skill. Among all the tools, implements, utensils and machines in the Crystal Palace, the critical observer will hardly find anything superior in point of workmanship to the four standard comparing balances, standing in the Coast Survey space.[54]

Other items which Saxton had designed and which were on exhibit there were a reflecting pyrometer or comparator, a metallic deep-sea thermometer, and a self-registering tide gage. They, too, received high praise from Silliman.

In November 1850, one of the largest and one of the smallest state balances, together with a set of the standard weights and measures, were shipped to the Conservatory of Arts and Trades in France. J. C. Silberman, the superintendent of that establishment, was later asked to express his opinion about them. He did so in a letter dated 6 March 1852, parts of which follow:

> . . . all these articles are of irreproachable execution; the two balances particularly are the object of universal admiration . . . . In testimony of the esteem in which I hold these balances, I cannot say more than that I used the small one to adjust the platinum kilogram which was exhibited at the World's Fair in London. It is very delicate and especially most constant. I was able to make all my weighings with certainty to within half a milligram. The form adopted for these balances is at once simple, well adapted to use, and distinguished by that taste which is only to be found in instruments made by master hands. These are justly to be termed instruments of precision.
>
> What I have just said with regard to the small balance, I may repeat with still more propriety respecting the large one; it is not inferior to the former in precision. In fact, I have tested it with 10 kilograms in each scale, and it promptly indicates a difference of one half a milligramme between the two weights, that is to say, one unit in twenty millions, in each scale. I have been obligated several times to repeat this experiment in the presence of incredulous persons, and it has always given the same result.[55]

Later these balances were placed in the French Exhibition of the Industry of All Nations, and received a complimentary medal.[56]

Further international recognition of Saxton's craftmanship came when, in 1854, Commodore Matthew C. Perry, as part of his gifts to the emperor of Japan, presented him with a series of U.S. standard weights and measures and a medium-sized balance, all made by Saxton.[57]

During the 1850s Saxton reached the zenith of his career, when his balances were winning the highest awards in world-wide competition. Further proof of this recognition is seen in his portrait's inclusion in a painting by Christian Schussele of the most celebrated American inventors and industrial innovators of the times. Entitled "Men of Progress—American Inventors," there are two versions of it. The earlier (1861) is in the custody of the Cooper Union School for the Advancement of Science and Art, in New York. The later version (1862) is in the custody of the National Portrait Gallery of the Smithsonian Institution. (Figure 10). This painting, a gift from Andrew Mellon, was hung in the White House at President Truman's request in 1947, and remained there for eighteen years before it was returned to the National Portrait Gallery.[58]

Probably the crowning glory of Saxton's career occurred in 1863, when President Lincoln signed the bill establishing the National Academy of Sciences and Saxton was made one of its fifty charter members. Although he had the least formal education of any of the members, he was asked to serve on several of its special committees. In the opening remarks of Joseph Henry's biographical memoir of him, Henry pointed out that Saxton's "positive additions to the sum of human knowledge . . . will fully justify the distinction [i.e., membership in the Academy], which was confirmed upon him."[59]

Saxton suffered a partial paralysis about 1858. He made a fair recovery from it, but a second stroke about 1868 left him quite helpless. Nevertheless, he remained chief of the Office of Weights and Measures until his death on 26 October 1873. His only survivors were his wife and one daughter, both named Mary.

A major, although little publicized, success, for which the Office of Weights and Measures deserves greater recognition, was the general acceptance of the national standards by all of the states in the Union while Saxton was in charge. In 1789, when Congress had received constitutional authority to establish such standards, the difficulties involved in implementing it were too formidable for the initia-

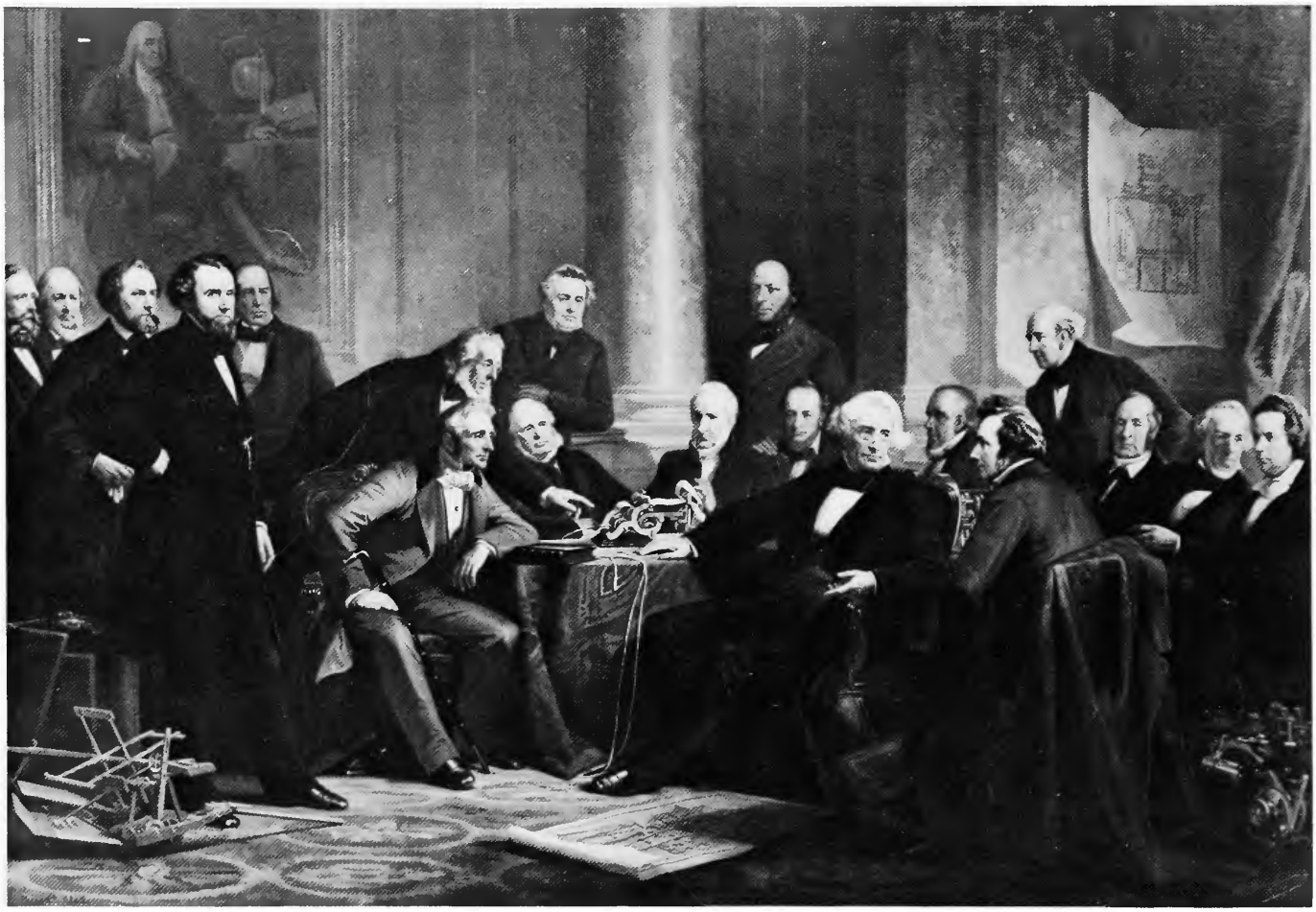


FIGURE 10.—"Men of Progress—American Inventors," by Christian Schussele, 1862, *Left to right:* William T. G. Morton (etherization), James Bogardus (iron architecture), Samuel Colt (revolver), Cyrus McCormick (reaper), Joseph Saxton (mint machinery), Charles Goodyear (vulcanized rubber), Peter Cooper (steam locomotive), Jordon L. Mott (iron and fuel), Joseph Henry (electric motor), Eliphalet Nott (management of heat), John Ericsson (caloric engines and the *Monitor*), Frederick E. Sickels (steam cut-off), Samuel F. B. Morse (telegraph), Henry Burden (horse shoe machinery), Richard M. Hoe (rotary press), Erastus B. Bigelow (carpet loom), Isaiah Jennings (friction machines), Thomas Blanchard (eccentric lathe), Elias Howe (sewing machine). (Courtesy National Portrait Gallery)

tion of any positive action. During the Bache-Saxton era, however, that goal was quietly achieved. It had been started, to be sure, with the initiative taken by Hassler, but if that had not been followed by Saxton's quiet competence and Bache's patient diplomacy, that highly difficult transition would never have been accomplished so soon nor so satisfactorily.

Notes

[1] Other technical difficulties are described in Ralph W. Smith's "The Federal Basis for Weights and Measures" *National Bureau of Standards Circular,* 593 (5 June 1958), pages 4–5.

[2] *The Public Statutes at Large of the United States of America,* volume 4, (Boston, 1846), page 278. This act remained in effect until 1911, when a "standard troy pound of the Bureau of Standards" was adopted.

[3] *The Journal of the Franklin Institute,* new series, volume 13 (April 1834), pages 302–304, contains a report by Dr. Samuel Moore, director of the mint, describing how the mint acquired the pound troy standardized by Captain Kater.

[4] Captain Kater's certificate dated 30 June 1827, London, is in Record Group 104: Records of the Bureau of the Mint, National Archives, Washington, D.C.

[5] Loc. cit. [note 3].

[6] JAMES L. WHITEHEAD, "The Mission of Franklin Peale to Europe, 1833 to 1835," *Pennsylvania History* (January 1951), pages 198–199.

[7] SISTER ST. JOHN NEPOMUCENE, "Franklin Peale's Visit to Europe in the U.S. Mint Service," *The Numismatist,* volume 71, number 12 (December 1958), page 1473.

[8] Ibid., page 1475.

[9] Ibid., page 1477.

[10] A rough draft of this letter, signed by Patterson to Saxton, 5 November 1835, is in Record Gorup 104: Records of the Bureau of the Mint, National Archives, Washington, D.C.

[11] Letter from Saxton to Patterson, 15 January 1836, Record Group 104: Records of the Bureau of the Mint, National Archives, Washington, D.C.

[12] This quotation is an abbreviated copy of the information on a card headed "Mint Balance Built by Joseph Saxton, 1838," in the same case with the balance at the Philadelphia Mint.

[13] *Journal of the Franklin Institute,* volume 1 (Philadelphia, 1841), page 268–269. Alexander Dallas Bache was also on some of these committees.

[14] Nomination No. 1074, American Philosophical Society.

[15] *Public Statutes,* volume 1 (Boston, 1845), 5th Congress, 3rd session, 1799, page 643.

[16] FLORIAN CAJORI, *The Chequered Career of Ferdinand Rudolph Hassler* (Boston: The Christopher Publishing House, 1929), page 31.

[17] *Journal of the Senate of the United States of America,* 21st Congress, 1st session, 7 December 1829 (Washington, D.C.: Printed by Duff Green, 1828), page 342 (serial 191).

[18] *Public Documents Printed by Order of the Senate of the United States,* 22nd Congress, 1st session, volume 3, document 168, page 2 (serial 214).

[19] Ibid, page 1.

[20] LEWIS V. JUDSON, "Weights and Measures of the United States: A Brief History," *National Bureau of Standards Miscellaneous Publication,* 247 (Washington, D.C.: U.S. Government Printing Office, October 1963), pages 6–8.

[21] This drawing was found among Hassler's papers in Record Group 167: Records of the National Bureau of Standards, National Archives, Washington, D.C.

[22] FERDINAND R. HASSLER, *Documents Relating to the Construction of Standards of Weights and Measures for the Custom-Houses from March to November, 1835* (New York: William Van Norden, printer, 1835), page 7.

[23] Ibid, pages 3 and 4.

[24] Ibid., page 3.

[25] Ibid., pages 4 and 5.

[26] JEANNIE TREE RIVES, "Old Families and Houses—Greenleaf's Point," *Records of the Columbia Historical Society, Washington, D.C.,* volume 5 (Washington, D.C.: Columbia Historical Society, 1902), page 59.

[27] HASSLER, op. cit. (note 22), page 20.

[28] HASSLER, op. cit. (note 22), page 24.

[29] FERDINAND RUDOLPH HASSLER, *Third Volume of the Principle Documents Relative to the Survey of the Coast and the Construction of Uniform Standards of Weights and Measures for the Custom Houses and States, from November 1835 to November 1836* (New York: John Windt, 1836), page 81.

[30] FERDINAND RUDOLPH HASSLER, *Investigation upon the Survey of the Coast of the United States, and the Construction of Standards of Weight and Measure, by a Select Committee of Congress in 1842.* (F. R. Hassler, publisher, 1843), page 39. In a letter dated 23 March 1842, which Saxton wrote to the Honorable Francis Mallory, chairman of the Select Committee of Investigation of the Coast Survey, he stated in part, "In every one of the three buildings, which connect all through with one another, two persons at least sleep; these are assistants, clerk, workmen, and I myself, so that the buildings are well watched at night."

[31] The belief that Edward Hassler and, later, Joseph Saxton slept in the Coast Survey Office buildings is supported by the fact that neither of their names appeared in the Washington city directories during their periods of residence there.

[32] Ibid., page 80.

[33] JUDSON, op. cit. (note 20), page 8.

[34] JUDSON, op. cit. (note 20), page 8.

[35] The joint resolution to which this refers is extremely difficult to find in the official documents, but the following copy thereof was located in the National Archives:

JOINT RESOLUTION OF CONGRESS NO. 46, MARCH 2, 1843.

RESOLVED by the Senate and House of Representatives: That the President be requested (if in his opinion it be expedient) to cause to be presented to the government of Great Britain a set of the U.S. Standard weights and

measures, to replace those which are understood to have been destroyed in London by accidental fire.

[36] *House Document No. 94,* 28th Congress, 1st session, 1844, page 7 (serial 442).

[37] FLORIAN CAJORI, op. cit. (note 16), page 234.

[38] *House Document No. 84,* 30th Congress, 1st session, 1848, page 2 (serial 522).

[39] BENJAMIN APTHORP GOULD, "Address in Commemoration of Alexander Dallas Bache," *American Association for the Advancement of Science Proceedings,* volume 17 (1867), pages 22, 23.

[40] *Senate Document No. 149,* 28th Congress, 2nd session, 1845, Appendix A, page 23 (serial 457).

[41] Ibid., page 4.

[42] EMIL ZSCHOKKE, *Translation from the German of the Memoirs of Ferdinand Rudolph Hassler.* Aarau, Switzerland, 1877. (Supplementary Documents, Nice, 1882, pages 552–553).

[43] ARTHUR H. FRAZIER, "Joseph Saxton and His Contributions to the Medal Ruling and Photographic Arts," *Smithsonian Studies in History and Technology,* number 32 (1975), pages 9–12. The daguerreotype is presently in the possession of the Historical Society of Pennsylvania in Philadelphia.

[44] ALEXANDER DALLAS BACHE, "Saxton's Magnetometer for Measuring the Changes in the Vertical Component of Terrestrial Magnetism" [Abstract], *Proceedings of the American Philosophical Society,* volume 1, number 14 (1840), pages 320–325. See also *Senate Document No. 97,* 28th Congress, 2nd session, 1844, volume 4 (Washington, 1845), page vii of "Preface."

[45] GOULD, op. cit. (note 39), pages 19–20.

[46] The changes Saxton made (with Bache's approval) in the first lot of state balances are described in *Senate Document No. 73,* 30th Congress, 1st session, 1848, pages 16 to 19.

[47] *Senate Document No. 6,* 35th Congress, 2nd Session, 1858. Appendix No. 8, page 257 (serial 980).

[48] *Senate Document No. 483,* 29th Congress, 1st session, 1845, volume 9, page 23 (serial 478).

[49] *Journal of the Franklin Institute,* 3d series, volume 12 (Philadelphia, 1846), pages 258–261. See also *Proceedings of the American Philosophical Society,* volume 4, number 33 (May–August 1845), page 160.

[50] This "Circular Dividing Engine—Troughton & Simms, 1841" is cataloged as number 309,643 in the records of the National Museum of History and Technology, Smithsonian Institution.

[51] "An Eminent Scientist," *Citizen and Gazette* (Urbana, Ohio), Joshua Saxton, editor, 6 November 1873, page 3, column 3.

[52] *Senate Document No. 6,* 35th Congress, 2nd session, 1858, page 243 (serial 980).

[53] B. SILLIMAN, JR., AND C. R. GOODRICH, ESQ., editors, *The World of Science, Art, and Industry, Illustrated from Examples in the New-York Exhibition, 1853–54* (New York: G. P. Putnam and Company, 1854).

[54] Ibid., subject 120.

[55] *Senate Document No. 27,* 34th Congress, 3rd session and Especial Session of 1857, 1856–1857, Appendix 17, page 139 (serial 879).

[56] Loc. cit. (note 52).

[57] ROGER PINEAU, editor, *The Japan Expedition 1852–1854: The Personal Journal of Commodore Matthew C. Perry* (Washington, D.C.: Smithsonian Institution Press, 1968), page 233. See also *Senate Document No. 6,* 35th Congress, 2nd session, 1858, Appendix no. 8, pages 257–258.

[58] FRANCES M. WILSON, "Men of Progress" (unpublished study in the files of the Department of Education, National Portrait Gallery, Smithsonian Institution, Washington, D.C., 16 August 1971).

[59] JOSEPH HENRY, "Memoir of Joseph Saxton," *Biographical Memoirs of the National Academy of Sciences,* volume 1 (Washington City, 1877), page 289.

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Illustrations must not be included within the manuscript but must be submitted separately as original art (not copies). All illustrations (photographs, line drawings, maps, etc.) can be intermixed throughout the printed text. They should be termed **Figures** and should be numbered consecutively. If several "figures" are treated as components of a single larger figure, they should be designated by lowercase italic letters (underlined in copy) on the illustration, in the legend, and in text references: "Figure 9*b*." If illustrations are intended to be printed separately on coated stock following the text, they should be termed **Plates** and any components should be lettered as in figures: "Plate 9*b*." Keys to any symbols within an illustration should appear on the art and not in the legend.

A few points of style: (1) Do not use periods after such abbreviations as "mm, ft, yds, USNM, NNE, AM, BC." (2) Use hyphens in spelled-out fractions: "two-thirds." (3) Spell out numbers "one" through "nine" in expository text, but use numerals in all other cases if possible. (4) Use the metric system of measurement, where possible, instead of the English system. (5) Use the decimal system, where possible, in place of fractions. (6) Use day/month/year sequence for dates: "9 April 1976." (7) For months in tabular listings or data sections, use three-letter abbreviations with no periods: "Jan, Mar, Jun," etc.

Arrange and paginate sequentially EVERY sheet of manuscript—including ALL front matter and ALL legends, etc., at the back of the text—in the following order: (1) title page, (2) abstract, (3) table of contents, (4) foreword and/or preface, (5) text, (6) appendixes, (7) notes, (8) glossary, (9) bibliography, (10) index, (11) legends.