JOSEPH HENRY (1797-1878)

ARCHITECT OF ORGANIZED SCIENCE

By JOHN A. WHEELER and HERBERT S. BAILEY, JR.
Princeton University

THE importance of science in the war just concluded has given the people of the United States a new and compelling interest in two questions: What kind of help do men need who are trying to advance human knowledge and control natural forces? What can and ought a national agency do to assist?

An appreciation of both problems has led the Congress and the country seriously to consider plans for a National Science Foundation. A desire prevails to support this planning with judgment and vision based on past experience. In the life of no single person is this experience so clearly visible as in that of Joseph Henry. That great man just a century ago, on December 3, 1846, at the age of 49 gave up his own scientific career to direct a kind of Natural Science Foundation of 1846, a unique institution evoked by a bequest made to the United States by an Englishman, James Smithson, "for the increase and diffusion of knowledge among men."

When Joseph Henry was invited to become the first "Secretary," which meant he would be the actual Director of the new Smithsonian Institution, he remarked to a close friend, "If I go, I shall probably exchange permanent fame for transient reputation." In a sense he was right, for going meant giving up his scientific investigation. It meant that instead of devoting himself to the pursuit of new knowledge in the laboratory, he would have to spend his time in endless details of administration, helping and directing others in the work that he loved to do. It was a difficult decision to make, and Henry accepted the new task reluctantly; he did not want to leave the congenial surroundings of Princeton where he had spent 14 happy years as Professor of Natural Philosophy. But to be true to himself, to be consistent with the strong moral compulsion that had always guided his life, he felt that he must further the "increase and diffusion of knowledge" through the Smithsonian Institution.

Fortunately, Henry did not "exchange permanent fame for transient reputation." By 1846 he had already established himself as the foremost scientist in America. The very fact that he was chosen for the new post indicates his prominence. The Board of Regents had resolved at their first meeting that "it is essential for the advancement of the proper interests of the trust that the Secretary of the Smithsonian Institution be a man possessing weight of character and a high grade of talent; and that it is further desirable that he possess eminent scientific and general requirements; that he be a man capable of advancing science and promoting letters by original research and effort, well qualified to act as a respected channel of communication between the Institution and scientific and literary individuals and societies in this and foreign countries; and, in a word, a man worthy to represent before the world of science and letters the Institution over which this Board presides."[1]

Joseph Henry more than fulfilled the requirements of the Board. Under his direction a multitude of scientific efforts were stimulated and

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their success rewarded, new discoveries were published so that other investigators could make use of the latest information, and, most important, the whole scientific effort of the nation, which had previously been uncoordinated and haphazard, took on new life and purpose through the societies, foundations, and journals that Henry fostered.

[1] From the minutes of the Board of Regents of the Smithsonian Institution, quoted in the "Address of Prof. A. Gray," in *A Memorial of Joseph Henry*, Government Printing Office, Washington, 1880.

From 1846 until his death in 1878 Joseph Henry served as Secretary to the Smithsonian Institution. His funeral was attended by the President of the United States and his Cabinet, the Chief Justice and Associate Justices of the Supreme Court, the members of the Senate and the House of Representatives, the Regents of the Smithsonian Institution, members of the National Academy of Sciences and of the Light House Board, and other illustrious personages. Henry's leadership of the Smithsonian alone deserved this tribute, but even if he had died in 1846 his immortality would have been assured by his scientific discoveries.

This man, who devoted his life to advancing knowledge and making opportunities for others, knew himself what it was to work without such opportunities. Henry's father was a day laborer in Albany, N. Y. He was poor and also suffered from bad health. He and his wife, Ann Alexander, were both of Scotch ancestry. A few years before his father's early death, and while he was still a small boy, Henry was sent to live with his grandmother in Gallway, about 40 miles from Albany. He worked in the general store of the village outside of school hours. Although he appeared to be only an average student, he became interested in reading works of fiction and in telling stories from them to a group who came regularly to the store. Once he saw a play in Albany and this excited him to join with a group of young friends in writing and acting plays. Their performances had to be fitted into the chinks between his duties, for at the age of 13 Henry was apprenticed to a watchmaker and jeweler. It was not apparent that a boy who had ended his education and who seemed destined for a small trade would ever become anything more than an obscure citizen in a provincial city.

One day, however, the 16-year old boy picked up at home a book entitled *Lectures on Experimental Philosophy, Astronomy, and Chemistry* by G. Gregory. The opening questions fired his imagination: "You throw a stone or shoot an arrow into the air; why does it not go forward in the line or direction that you give it? Why does it stop at a certain distance and then return to you? . . . On the contrary, why does flame or smoke always mount upward, though no force is used to send them in that direction? And why should not the flame of a candle drop toward the floor when you reverse it, or hold it downward, instead of turning up and ascending into the air? . . . Again, you look into a clear well of water and see your face and figure, as if painted there. Why is this? You are told that it is done by the reflection of light. But what is reflection of light?" The world opened to Henry's thought by this book appeared to him new, interesting, and important. His experience was one more step in that process of "diffusion of knowledge among men" which was to be a large part of his life work.

His reaction was decisive; he resigned as president of the dramatic organization, which had previously held his interest, and set out to get an education. He learned enough grammar to be able to earn money teaching the elements of this subject on a trip through the country districts which surrounded Albany. This experience in teaching led on to his employment as instructor in a district school. On his salary, $8 a month, raised after the first month's trial to $15, he found it possible to go on with his education by attendance at an advanced class in the Albany Academy. This combination of teaching to keep his body alive and study to satisfy his intense interests in chemistry and physiology and mathematics was continued when he became tutor for two years in the family of General Stephen Van Rensselaer.

At one time in this period Henry thought of becoming a physician, but he abandoned the idea when, at the age of 29, he was asked to take a position as engineer to survey a road across the State of New York from West Point to Lake Erie. His successful handling of this project interested him in the possibility of working on the construction of a canal in Ohio. Just when this and other opportunities were opening out to him, a vacancy developed in the staff of the Albany Academy, then one of the leading educational institutions in the country.

A way had been saved for Henry to go on with science. He now occupied one of the few positions in the United States where one could be expected to carry on advanced work in physics. The kind of opportunity available for doing scientific work in this country in 1826 can therefore be seen by looking at Henry's position. Most of his work had to be done during the summer. Through the rest of the year he spent seven hours a day teaching arithmetic and other elementary subjects to small boys. There was practically none of the intellectual companionship of the modern university, where an investigator and a group of well prepared and keen-minded students together analyze the problems of a developing subject. Nor was it easy in those days for Henry to visit investigators in other towns to gain the stimulus of new points of view. Published sources of information were inadequate in content and hard to come by. Supplies were slow in coming from New York. One group of experiments was delayed by the difficulty of getting zinc for making batteries. One or two friends, willing with their hands but helpless in planning, assisted at times with the experiments. In spite of these handicaps, Henry was able to make remarkable discoveries.

Any student of the history of science must be aware that it is a history of direct progression. There is no oscillation as there is in the history of literature where the standard of taste passes from extreme romanticism to extreme realism or from the very intellectual to the very emotional. In science there is a definite progress; by slow small steps man extends the range of his experience and reduces this experience to order.

Joseph Henry was living in an age of astounding scientific discoveries. Theories, which had been developing slowly through the years as small facts and observations were collected, were brought at last to birth when a group of discerning minds suddenly grasped the relations between the facts and the natural laws which govern them. Agassiz and

Torrey in America, Faraday, Davy, Darwin, and Wheatstone in England, Gay-Lussac in France, Gauss, Ohm, and Weber in Germany, and Oersted in Denmark were contemporaries of Henry, to name only a few. If Herman Melville had never been born, *Moby Dick* would never have been written, but it would be impossible to say that if Joseph Henry had never lived, his discoveries would have been lost to the world. The stage was set for them, but sometimes when the stage is set an irritatingly long time passes before an actor appears who is able to play the scene. Credit must be given to the quick penetrating mind and the keen powers of observation that brought the new facts to light.

Joseph Henry's scientific interests were many. The table of contents for the two big volumes of his scientific writings covers four pages in small print. The papers he wrote at Albany, Princeton, and Washington include such varied topics as: Chemical and Mechanical Effects of Steam; Topographical Sketch of the State of New York; The Production of Electrical Currents and Sparks from Magnetism; Capillary Transmission through Solids; Experiments on Phosphorescence; On the Effects of a Thunderstorm; On a new Method of Determining the Velocity of Projectiles; On Color Blindness; On the Origin and Classification of the Natural Motors; Experiment on the Magnetic Polarization of Light; On the Atomic Constitution of Matter; On the Radiation of Heat; On the Limited Perceptibility of a Direct and Reflected Sound; On the Employment of Mineral Oil for Light House Illumination. The particular contributions for which he is remembered, however, are in electricity and magnetism. In this field he made several remarkable discoveries.

The first was the discovery of the phenomenon of self inductance, the inertial property of an electric circuit. The inductance of a circuit tends to prevent the current in the circuit from changing; if a current is flowing, induction tends to keep it flowing; if an electromotive force is applied, it tends to keep the current from building up. The inductance of a circuit is determined mainly by its shape, its size, and the materials of which it is constructed. A piece of copper wire, for example, will have more inductance if it is coiled than if it is straight, and the coil will have more inductance if a soft iron core is placed in its center. Joseph Henry is immortalized in the name of the electrical unit of inductance, which is called the henry. [A coil has an inductance of one henry if a rate of change of current of one ampere per second through it produces an electromotive force of one volt across its terminals.]

Henry discovered self inductance when he noticed that by disconnecting a circuit constructed with long wires, he could produce a spark where the connection was broken, but no spark was observed when a short circuit was suddenly disconnected. He wrote that "the effect appears somewhat increased by coiling the wire into a helix; . . . . I can account for these phenomena only by supposing the long wire to become charged with electricity, which, by its reaction on itself, projects a spark when the connection is broken."

The initial discovery was Henry's, but it remained for Faraday, with his pictographic mind, to visualize the magnetic lines of force in which the energy is stored. Faraday's work in England ran parallel to Henry's. It is quite probable, for example, that Faraday's discovery of mutual inductance, of the effect of one current-carrying wire on another, was previously observed by Henry. It is appropriate that we measure in farads the value of the electrical capacitor, which is so often connected in circuits with coils whose inductance is measured in henries.

At the time when Henry was experimenting with self inductance he was building more powerful electromagnets than had ever been built before. He did not use any new principle. Oersted (1820) had observed the effect of a current carrying wire on a magnetic compass needle. Schweigger (1820) looped several turns of wire around the magnetic needle thus increasing the effect and making the first fixed-coil galvanometer. Sturgeon (1825) looped 18 turns of uninsulated wire around a horseshoe of soft iron which was insulated from the wire by a coat of shellac. At the time, Sturgeon's electromagnet, weak though it was, was the most powerful in the world. In 1828 Henry built a small electromagnet of soft iron wound with many turns of silk-insulated copper wire. This was the first modern electromagnet, and was certainly far more powerful than Sturgeon's. Henry continued experimenting with larger and larger magnets, and in 1831 he built a magnet for the Yale College laboratory which weighed 82½ pounds and could lift 2,300 pounds.

Henry utilized these larger magnets in his experiments on self induction. The greater inductances permitted him to produce larger sparks when he interrupted their circuits. At Princeton, in his laboratory in Philosophy Hall (which stood on the present site of the Chancellor Green Library), he produced a spark so strong that its crack could be heard outside the room through a closed door.

Perhaps the production of sparks and the discovery of self induction seems less important than the building of the world's first modern electromagnet. But in discovering self induction Henry added to our basic knowledge of the physical world. Using already existing knowledge, he adopted a new technique and produced the first multi-turn multi-layer coil. He called this type of coil an intensity coil. No power line, radio, telegraph, electric motor, generator, telephone, or television apparatus can be constructed without the use of Henry's discovery of induction, nor could these devices exist without the use of multi-turn coils. It may well be asked why Sturgeon did not discover inductance before Henry. Surely his electromagnet of 18 turns produced a spark when he opened its circuit. The phenomenon must have occurred before his eyes, but he was not keen enough to see it or, if he did see it, to wonder.

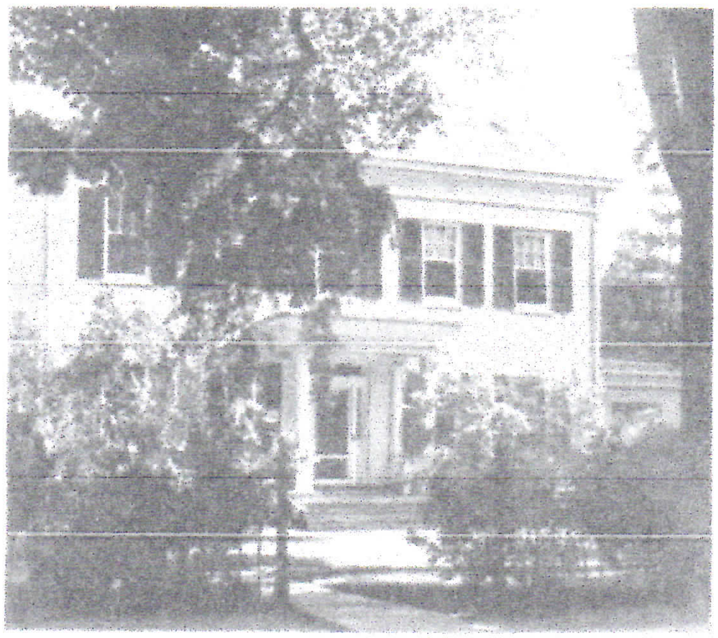
In 1831, the year before he came to Princeton, Henry suspended a little more than a mile of wire around the walls of a lecture room in the Albany Academy. At one end of the wire was a battery and at the other end an electromagnet. Close to the end of the electromagnet was a permanent magnet arranged on a pivot so that it could swing, and near one end of this permanent magnet was a small bell. When the circuit was closed, the electromagnet was energized, repelling the end of the pivoted permanent magnet, which swung against the bell, thereby ringing it. This was a form of electromagnetic telegraph, but Henry did not see the commercial possibilities because he was not interested in the experiment for that purpose. To him it was a philosophical experiment, designed for demonstrating and investigating the laws of nature.

Other telegraphs had been devised before, using electrolytic or swinging needle indications. Henry's was the first telegraph with the great advantage of an acoustic indication, and was by far the most practical yet invented. Samuel F. B. Morse is credited with the invention of the telegraph in 1837. It is true that Morse first produced a practical telegraph and had the foresight to get it patented, but he acknowledged in 1848—he was writing to Professor S. C. Walker—that "justice has not hitherto been done to Professor Henry, either in Europe or this country, for the discovery of a scientific fact which in its bearing on telegraphs, whether of the magnetic needle or electromagnetic order, is of the greatest importance . . . . To Professor Henry is unquestionably due the honor of the discovery of a fact in science which proves the practicability of exciting magnetism through a long coil or at a distance, either to deflect a needle or magnetize soft iron."

The fact referred to in Morse's letter is Henry's discovery of "quantity" and "intensity" cricuits. This discovery was related to his multiturn coil, which he called an intensity magnet. Morse's first telegraph could not operate over more than a few feet because he used a quantity magnet. Morse's friend, Dr. L. D. Gale, Professor of Chemistry at New York University, suggested to him that he use a coil of many turns. Gale later wrote to Henry: "At the time I gave the suggestions above named, Professor Morse [of the Art faculty] was not familiar with the then existing state of the science of electro-magnetism. Had he been so, or had he read and appreciated the paper of Henry, the suggestions made by me would naturally have occurred to his mind as they did to my own."

Morse's invention of the telegraph, then, rested directly on Henry's discovery of the intensity magnet. But the general principle that Henry observed in operation here has since found even wider use. Henry found that in order to produce maximum effect it was sometimes necessary to connect cells in series and sometimes in parallel. Which connection was preferable depended on the type of circuit to which the cells were to be connected. He classed circuits as quantity circuits and intensity circuits, which we now recognize as low impedance and high impedance circuits. In order to get maximum power transfer, it was necessary to match the impedance of the source and that of the load, and Henry did this, without fully understanding why, by changing the connection of the batteries. This was an important practical observation. The theory behind it could have been deduced from Ohm's law, but Ohm's book, published in Germany in 1827, which would have been so helpful to Henry and Faraday, was unknown in England and America at the time.

In 1832, at the age of 35, Henry came to Princeton as the first Professor of Natural Philosophy in the College of New Jersey. At Princeton he built a house, now known as the Joseph Henry House, which has since become a landmark on the campus. It was originally near the



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present site of Reunion Hall, but it has been moved three times. It now stands between the Chancellor Green Library and Nassau Street and is the official residence of the Dean of the College.

At Princeton Henry continued his studies of electromagnetism. He built a magnet more powerful than the one he had constructed for Yale College; this one was able to lift 3,500 pounds. For his convenience he erected a signal system across the front campus between his laboratory in Philosophy Hall and his house. This was a telegraph similar to the one he had used as a demonstration at the Albany Academy, with one new and important refinement. The circuit which carried the signal was an intensity circuit, and the magnet which it activated did not have much lifting power. Henry arranged the receiving end of the circuit so that the intensity magnet pulled a bar which closed a circuit connecting a cell and a quantity magnet. The quantity magnet was then powerful enough to produce any desired effect, such as lifting a heavy weight. The important thing to notice is that Henry had constructed the first magnetic relay, a device which is now very widely used in telephone, telegraph, and all kinds of control circuits.

Another discovery made by Henry at Princeton must be mentioned. In magnetizing a large number of steel needles by placing them in a spiral coil of wire through which current was flowing, he noticed that if the circuit was suddenly broken, some were magnetized with one polarity and others with the opposite polarity. He pondered over the phenomenon, considering the now-familiar spark which occurred when the circuit was broken, and he concluded that the spark was a damped oscillatory discharge, a fact since borne out by further investigation.

In another experiment Henry demonstrated the phenomenon of mutual induction through the enormous distance of 220 feet. In this case his primary wire was stretched across the campus in front of Nassau Hall, and his secondary wire, with both ends buried in the ground, was stretched behind Nassau Hall, obscured by the building. Steel needles placed close to the secondary wire served as indicators. These became magnetized when the primary was excited by a spark from an electrical machine. This experiment foreshadows the invention of radio, though it should be noted that the phenomenon was one of magnetic induction rather than electromagnetic radiation.

Although Henry's main field of inquiry was electricity and magnetism, he also continued other studies while at Princeton. With his brother-in-law, Professor Stephen Alexander, he investigated sunspots and solar radiation. He studied meteorology with Professor Guyot and recommended to the American Philosophical Society the establishment of meteorological observation stations. When Professor John Torrey went to Europe in 1833, Henry taught his courses in Chemistry, Mineralogy, and Geology. He also found time to investigate capillarity, molecular physics, phosphorescence, and various phenomena of light and heat. Henry's scientific work shows that he had sound judgment in drawing conclusions from his observations. In the complex subject of electromagnetism, however, he did not have quite the ability of Faraday to make far reaching generalizations. This deficiency is related perhaps to his failure to make adequate use of mathematics as a tool. His collected papers contain little mathematics and no calculus. He is reported to have studied, in his early years, the famous *Mécanique Analytique* of Lagrange, but there is little evidence that he ever taught this or any other advanced mathematical subject. Association with others as interested in mathematics as he was would undoubtedly have been of benefit to his research.

Henry himself recognized the advantages of association and consultation. He visited Europe twice, once while on leave from Princeton and again as emissary from the Smithsonian Institution. On his first trip to England he exchanged scientific knowledge with Wheatstone and Faraday. When he showed Faraday the production of a spark from a circuit containing an intensity magnet, Faraday capered in boyish enthusiasm and cried, "Hurrah for the American Experimenter!" Faraday took a warm interest in Henry's work on electromagnetism, and a more active part than anyone else in attempting to secure for Henry the priority which he sometimes lost through incomplete or tardy publication.

During his visit to London in 1837, Henry learned from Richard Rush of a chancery suit in progress, the outcome of which was nine years later to change his entire career. In 1829 an Englishman, James Smithson, had died, bequeathing his fortune to the government of the United States in trust for "the increase and diffusion of knowledge among men." It was not until 1835 that the United States officially learned of the existence of the will, and it was a full year later before Congress, against some party opposition, put in its claim. In 1838 the suit for the money succeeded and Congress began an eight year debate on the way in which the fund should be administered and used. Finally, on August 10, 1846, Congress agreed upon an Act of Establishment and created a distinguished Board of Regents to bring into being the new Smithsonian Institution. This board included the Vice-President of the United States, Chief Justice Roger B. Taney, Senator Jefferson Davis, and the great lawyers and diplomats, Rufus Choate and Richard Rush.

The first and most important task of the Smithsonian Board of Regents was to select a distinguished man for Secretary and director of the new national science foundation. It was clear to them as to others that Joseph Henry was the greatest scientist in America. As early as 1832, when Henry was appointed to the chair of Natural Philosophy at Princeton, Professor Benjamin Silliman at Yale, himself a scientific leader, had written, recommending him, "Henry has no superior among scientific men of the country." His position in science, joined to his integrity of character, caused the Regents to vote unanimously to ask Henry to take the new position.

Reluctantly Joseph Henry accepted the call and embarked upon a new phase of his career. It must have been doubly hard to leave Princeton because, though he had many devoted pupils, he had developed no famous disciples to carry on his work. Yet the new task, though it prevented him from giving as much time to research as he would have liked, was probably of greater importance to the development of science than any discoveries he could have made.

Henry's interest in the Smithsonian Institution was intense, and once he had made up his mind to accept the responsibility, he gave himself wholeheartedly to his new tasks. It had cost him many pangs to leave his friends, his home, his laboratory, and the congenial atmosphere of Princeton, and he was determined to make the sacrifice worth while. As a teacher and an investigator, Henry had already devoted the major portion of his life to the very ideas which Smithson specified in his bequest, "the increase and the diffusion of knowledge among men." His new position did not change the purpose of his life, rather it allowed him to pursue his ideal in a different way. Henry always kept the purpose of the Institution before him, and he interpreted Smithson's wishes strictly. "There is," he said, "another division with regard to knowledge which Smithson does not embrace in his design; *viz.* the application of knowledge to useful purposes in the arts. And it was not necessary he should found an institution for this purpose. There are already in every civilized country, establishments and patent laws for the encouragement of this department of mental industry. As soon as any branch of science can be brought to bear on the necessities, conveniences, or luxuries of life, it meets with encouragement and reward. Not so with the discovery of the incipient principles of science. The investigations which lead to these, receive no fostering care from Government, and are considered by the superficial observer as trifles unworthy the attention of those who place the supreme good in that which immediately administers to the physical needs or luxuries of life. If physical well-being were alone the object of existence, every avenue of enjoyment should be explored to its utmost extent. But he who loves truth for its own sake, feels that its highest claims are lowered and its moral influence marred by being continually summoned to the bar of immediate and palpable utility."[2]

Congress, which had the responsibility of administering Smithson's bequest, tended to be more interested in impressive libraries, buildings, and exhibits than in the stimulation of research. But Henry held firm to the letter and the spirit of the bequest. He stalwartly opposed unnecessary expenditures on grounds and buildings and other equipment. He was determined that the funds of the Smithsonian should be devoted to projects that would actually increase and spread human knowledge. In order to carry out Smithson's instructions, Henry set up an elaborate program, which he presented to the Board of Regents in his First Annual Report. The main points are listed in Section I:

> *To increase knowledge:* It is proposed—
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> 1. To stimulate men of talent to make original researches by offering suitable rewards for memoirs containing new truths; and,
> 2. To appropriate annually a portion of the income for particular researches, under the direction of suitable persons.
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> *To diffuse knowledge:* It is proposed—
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> 1. To publish a series of periodical reports on the progress of the different branches of knowledge; and,
> 2. To publish occasionally separate treatises on subjects of general interest.

[2] Smithsonian Annual Report for 1853.

In the remaining part of the program these points are explained and illustrated in considerable detail.

The Smithsonian under Henry promoted research without actually proposing specific projects or carrying them out with its own personnel, except in special circumstances. Projects were proposed from outside, and the financial support of the Smithsonian was granted according to the merit of each case. This policy guaranteed diversity. No matter how wide his interests might be, no director, even such a one as Henry, could have the wide vision necessary to see all the research that needed to be done, nor to assess all the projects proposed. Accurate evaluation of the ideas of others might have been difficult if the Smithsonian had been carrying on extensive research projects of its own.

Henry's policy of helping others to do effective work was early seen to accomplish more than the Smithsonian could have done by using the same funds itself. Grants-in-aid of a few hundred dollars made the difference between no and yes for projects to which others were prepared to devote thousands of dollars worth of time and effort. These investigators, working independently or in local institutions and colleges, built up scientific knowledge throughout the Union, quietly, steadily, and effectively.

It is beyond the scope of this account to relate all the activities that were stimulated by the Smithsonian Institution under Henry's direction. A few, however, are particularly notable. In his first report to the Board of Regents, Henry suggested that a system of meteorological stations be set up; the observers were to report their data by telegraph so that early storm warnings could be obtained. This suggestion was later carried out, and the organization soon became so important that it no longer needed the support of the Smithsonian; its new name was the United States Weather Bureau.

The genesis of the Weather Bureau illustrates a principle that Henry always applied in the administration of the Smithsonian. As soon as any project was strong enough to stand on its own feet, it was cut loose from the Institution. This relieved the Smithsonian of long-standing financial obligations and freed its funds for supporting new investigations. This policy, and that of not undertaking any work which might be financed by another agency, enabled the Smithsonian to support scientific work that otherwise could never have been carried on.

Another project suggested by Henry was the publication of *Smithsonian Contributions to Knowledge*. Henry himself edited the 21 volumes of the series. This publication encouraged men of science by providing an outlet for their findings, and at the same time spread new knowledge throughout the world.

By exchanging publications with associations and institutions in foreign countries, the Smithsonian was able to keep abreast of scientific developments everywhere. The system of exchanges, set up by Henry to aid in the "diffusion of knowledge among men," was not so simple to arrange as one might suppose; there were problems of local restrictions and transportation difficulties to be overcome. It was necessary to appoint agents in every corner of the world to procure and forward books and documents. The amount of material sent abroad steadily increased under Henry's direction; in his tenth year at the Institution, 14,000 pounds of publications were sent abroad; in his twentieth year the figure had risen to 22,000 pounds; and in 1877, the year before Henry's death and his thirtieth at the Smithsonian, 99,000 pounds of literature were shipped abroad. At that time there were more than 2,000 foreign recipients of Smithsonian publications in cities from Iceland to Cape Town and from Tokio to Algiers. By an international agreement all publications sent to and from the Smithsonian were passed free of duty. Henry repeatedly pointed out that when James Smithson, an Englishman, had left his bequest dedicated to the "increase and diffusion of knowledge among men," he had not specified any particular men.

At Princeton Henry had been known as a mild-mannered professor who concerned himself with affairs very remote from the practical world, and when he foresook his life of secluded experimentation for one which entailed administration and the management of sizable sums of money, there were some who doubted his ability in the new field. But apparently Henry's scientific activities had concealed another talent. In 1846, when he was about to leave Princeton, Henry wrote to his friend, the Rev. Dr. Eliphalet Nott, President of Union College:

> The income of the Institution is not sufficient to carry out a fourth part of the plans mentioned in the Act of Congress, and contemplated in the Report of the Regents . . . You will readily perceive that unless the Institution is started with great caution there is danger of absorbing all the income in a few objects, which in themselves may not be the best means of carrying out the design of the Testator. I have elaborated a simple plan of organization, which I intend to press with all my energy. If this is adopted, I am confident that the name of Smithson will become familiar to every part of the civilized world.

Smithson had intended that the Institution be established for all time, and Henry was determined that the substance of Smithson's bequest be not all consumed in a few projects in a few years. The management of the fund by Henry and the Regents speaks for itself. The total bequest was $541,379.63. In 1878, at Henry's death, the Smithsonian fund had increased to $1,468,000.

But Henry did not devote all his energies to the Smithsonian Institution. While he was in Washington he engaged in many other activities. Prominent among these was the Light House Board, on which he first served as chairman of the committee on experiments and later as chairman of the Board itself. He devoted considerable time to it, and conducted several scientific investigations to further its work. He experimented with illuminating oils for lighthouses and examined the phenomena of "dead" spots or null regions in the neighborhood of fog horns.

Henry was a member of many committees and associations. He was a Trustee of Princeton College, of Columbia University, and of the Corcoran Gallery of Art. He had been elected to the American Philosophical Society in 1835. He helped to organize the American Association for the Advancement of Science, which was evolved in 1847 from the Association of American Geologists and Naturalists. At its second meeting he was elected president. He assisted in founding the Philosophical Society of Washington and served as its president until his death. He took part with Lincoln in planning the National Academy of Sciences, was an original member of this body, was elected vice president in 1866, and was president from 1868 until his death. In the year of his death he was made a member of the American Electrical Society, and his last scientific paper, "Observations in Regard to Thunderstorms," was a contribution to its Journal.

During the Civil War the Federal Government made great demands upon the Smithsonian for advice and assistance. This work brought Henry into close relation with Lincoln. The President took up with him the problems created by the Confederate destruction of lights and signal stations along the southern coasts. He participated with Henry in experiments to test new signalling devices. The contacts gave Lincoln an appreciation of Henry as a man as well as a scientist. "He is so unassuming, simple and sincere. I wish we had a few thousand more such men." Henry in turn said of Lincoln, "He is producing a powerful impression on me. It increases with every interview. I think it my duty to take philosophic views of men and things, but the President upsets me. If I did not resist the inclination, I might even fall in love with him."

This account has considered the achievements of Joseph Henry as an investigator and as administrator of the Smithsonian Institution, but it is impossible to close without saying a few more words about his personality. He was a serious and friendly man. An apparently slow and unruffled exterior concealed the energy that drove him in pursuit of his ideals. He believed in the unity of all knowledge, and felt that facts meant little without insight. In an era when Darwin's theory of evolution shook the religious faith of many, this great scientist accepted the new while retaining the old. He was an accomplished linguist, had an ear and memory for poetry, and was well read and keenly interested in political science.

Near the end of his days, speaking of his career, Henry modestly summed up the aim and purpose of his life: "[It] . . . has been principally devoted to science, and my investigations in different branches of physics have given me some reputation in the line of original discovery. I have sought, however, no patent for inventions and solicited no remuneration for my labors, but have freely given their results to the world, expecting only in return to enjoy the consciousness of having added by my investigations to the sum of human knowledge and to receive the credit to which they might justly entitle me."

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through sheer ignorance and irresponsibility the population is increasing 5,000,000 a year—and all hungry. It may be expecting too much that such numbers of illiterate people can be taught to handle soils with such scientific precision that they can ever hope to avoid hunger; their unchecked population seems destined to keep ahead of the food supply. China's population, although one of the most dense, has remained almost stationary for 75 years. When recently I asked a Chinese visitor in this country how many people China has lost through the war, he replied, "About 20,000,000." But he went on, "That's not such a high percentage, after all." Let us remember that all this loss of life is unnecessary. If the world population could be held at anything like its present levels, we have the knowledge, even at the present time, were it only properly applied, to give "every Hottentot his bottle of milk" and every civilized human his balanced diet, and thus soon place the population figure many laps behind in the race with food supply.

In the final analysis, it must be granted that many of our practical soils problems are yet unsolved, and that the knowledge in our possession is inadequately disseminated and very unequally distributed and utilized in different parts of the world. One can only hope that time may erase these inequalities. The more technical and fundamental aspects of soils research are going on at a rapid pace and, with additional help from new investigators, will be of importance not only in the solution of the world's food problems and the keeping of the peace, but also may underwrite our political and social security of the future.

Joseph Henry

(Concluded from page 632)

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Note by the Editor.—The article on Joseph Henry is from a manuscript entitled *The Lives of Eighteen from Princeton,* which is to be published in November 1946 by the Princeton University Press, under the editorship of Willard Thorp.