The remaining possible solution of the problem of utilizing the radiant energy of the sun for the production of mechanical work is the application of reversible photochemical reactions which proceed in such a manner that the absorbed radiant energy may be converted into a usable form such as electrical energy. If the reversibility of such photochemical reactions is nearly quantitative in character, the photosensitive system of substances will then, in respect to solar radiation, play a rôle analogous to that of the lead accumulator in respect to electric energy. We might term such instruments "radiation accumulators"; they would be exposed during the day to the solar radiation which would cause a certain photochemical reaction, and then at night when left in the dark this reaction would reverse, the materials would return to their original condition, and the radiant energy absorbed during the day would be set free and stored up for mechanical uses.

It has long been known that such reversible photochemical processes really exist. For example, if a solution of mercuric chloride and ferrous chloride in water is exposed to light radiation, a reaction takes place in which certain amounts of mercurous chloride and ferric chloride are formed, a chemical equilibrium between the four salts being finally reached. If now this solution is placed in the dark, the substances will revert to their original form, and during this inverse reaction the radiant energy absorbed will be completely set free in the form of electrical energy. It is possible to obtain a tension of 0.17 volt by means of such a photochemical cell; consequently a dozen such cells joined in series will yield the current furnished by an ordinary lead accumulator.

Again, such a photochemical cell can be made by placing two platinum electrodes to an acidulated solution that contains potassium iodide and ferric chloride. When this cell stands in the dark, ferrous chloride and a certain amount of free iodine will be formed, the iodine remaining dissolved in the excess of potassium iodide. On exposing this cell to the action of light, the chemical equilibrium is displaced in the opposite direction, and potassium iodide and ferric chloride are regenerated. As with the previous cell the absorbed radiant energy is set free as electric energy.

Another remarkable example of a phenomenon of this nature is described by Rigollot. Two plates of red copper, each of them superficially covered with a thin layer of cuprous oxide, are placed in a saturated solution of sodium chloride. If now one of these plates is exposed to light radiation and the other is kept in the dark, an electric current passes through the wire that connects the two electrodes. This current continues as long as the exposure lasts. The whole system returns to its original state in the dark. If the other electrode is illuminated, the electric current produced in the circuit flows in the opposite direction.

These various experiments furnish definite proof that it is possible to convert radiant energy into electrical energy by means of reversible photochemical processes.

There is, however, one great drawback to the practical application of such a method, and that is the very low intensity of the electrical current that is produced. The electrical work that can be done, which is a product of the voltage and current intensity, is, therefore, in all cases only extremely small. The explanation lies in the fact that the reversible transformations which take place in these cells are characterized by very small reaction velocities, and consequently the energy that is carried off can not be resupplied by the photochemical reactions with sufficient rapidity. The photochemical effect appears in general to be the strongest in those cases of reversible processes in which the oppositely directed reactions are slowest, and because of this fact, some investigators are inclined to doubt whether the utilization of such radiation accumulators can ever be of practical value. This opinion may, however, prove to be unduly pessimistic. The construction of such cells is wholly a problem of reaction-kinetics. If it should prove possible to devise radiation accumulators or Volta-cells in which reversible and very rapid photochemical changes take place when radiation of such wave-lengths as are contained within the solar spectrum is employed, the problem of using solar radiation as a source of energy might be regarded as definitely solved.

We are, however, still far distant from this goal. Photochemistry is still in its infancy and it has not yet outgrown the stage of mere empirism. It is quite possible, however, that when man's existence becomes seriously menaced because of a shortage of energy, photochemistry will rescue him from his distress.

The protection of mankind from this danger rests chiefly upon the physicist and the chemist, and they must ever be on the alert to find solutions for these intricate problems that involve the very existence of our race.

F. M. JAEGER

ITHACA, N. Y.

A MASTER MUSEUM BUILDER

FREDERIC AUGUSTUS LUCAS, 1852–1929

IN presenting some account of the scientific activities of Frederic Augustus Lucas we seem to be justified in giving him the rather old-fashioned title of naturalist, rather than that of zoologist or anatomist. His almost life-long connection with museum work in four celebrated institutions gave him an unusually wide knowledge in the field of natural history. Many voyages in boyhood to far-away countries with his master-mariner father were, in his case, good preparation for the work he was to do, and to which, in fact, he was very early inclined.

It is fifty years since I found him in charge of the extensive work of preparing museum exhibits then going on in Ward's Natural Science Establishment. Whether the French preparateurs were engaged in osteological, taxidermal or other lines, they all submitted loyally to his judgments, as he explained his criticisms in their own language.

A score or more of well-known naturalists who found their way to Rochester at different times as amateurs are indebted to him for useful training in museum methods.

His genius in that direction was strongly developed. Although most of them, like Lucas himself, had common-school education only, they eventually secured recognition in the field of natural science.

While college training undoubtedly has its advantages, the young man who knows what he wants to do and is persistent can make headway without it. Lucas believed in manual training. His skill with small tools and his drawing were excellent. Angling was his favorite outdoor recreation, and the rods he made himself were the equals of those sold in the shops. He helped me mount my first tortoise, and for separating carapace from plastron, quickly riveted a small saw blade in the handle of a toothbrush, making an instrument that has been serviceable for light sawing purposes ever since. Humorous and kindly as he was, those who worked with him can not forget his ever-ready helpfulness.

He went to the National Museum in 1882, where notable exhibits in osteology, paleontology and the results of other labors as curator remain as his monuments. His work as curator-in-chief of the Brooklyn Museum, to which he was called in 1904, was distinctly that of an up-builder.

Recognized as an ideally equipped museum officer by reason of his curatorial successes, he was called in 1911 to the directorship of the American Museum of Natural History, where many instructive installations bear witness to his scientific knowledge and good taste. It is important to note that his associates everywhere greatly valued his opinions.

There was another side to the character of Dr. Lucas which we find of greater interest than the official positions he so ably filled. Stevenson says—to quote from memory—if a man love the occupation that supports him, the gods have called him. Intensely devoted to his daily work and his natural history studies, Dr. Lucas dwelt under a happy star. Since he had a taste for the best literature and was naturally studious and decidedly gifted as a writer, his published papers remain as permanent contributions to the subjects he strove earnestly to elucidate.

He took many an effective shot at scientific errors as they flew, without anybody's feelings being hurt by his marksmanship. He had a genial way of winning out in his controversies.

During the late nineties, while he was my neighbor in Washington, his regular evening occupation was the preparation of zoological articles for Johnson's "Universal Cyclopaedia," then being published in eight volumes. Having had this work within reach ever since, I find it easy to testify to the value of his contributions thereto.

While his writings are to be found chiefly in scientific journals and government documents, he provided two books for the publisher—"Animals of the Past" and "Animals Before Man in America."

We were associated in the fur-seal investigations of 1896–97 in Bering Sea, where Dr. Lucas undertook anatomical studies having an important bearing on certain matters of international controversy, with the result that vital claims made on the American side were substantiated.

He greatly enjoyed the prolonged struggle over the Bering Sea question, and exclaimed again and again, "We shall beat them on that point." Commenting on the way that matters already well disposed of wouldn't stay put, he quoted, "Per aspera ad astra," and provided an additional demonstration.

We have known no more gifted critic in the field of museum effort. Few curators can point to more illuminating labels than those he wrote by the hundred.

Since these lines are written at sea, with no opportunity to look up his scientific papers for comment, it is impossible to make this sketch what it should be.

CHAS. HASKINS TOWNSEND

NEW YORK AQUARIUM

SCIENTIFIC EVENTS

SOIL EROSION

MR. HUGH HAMMOND BENNETT reports to the U. S. Department of Agriculture that more than 513,000,000 tons of soil are being washed out to sea each year from the farms of the United States, and the Mississippi River system alone is responsible for 428,000,000 tons.

Mr. Bennett states that this is a minimum estimate for the Mississippi. More comprehensive methods of measurement devised recently indicate that