not yet begun to utilize the solar energy that is available to us, and we shall do it better with the knowledge that it is probably all we have.

If you belong to the group represented by the Bishop of Ripon which fears the too rapid advance of science and lives in dread of the day when some unscrupulous, or careless, Dr. Faust may touch off the stupendous subatomic powder magazine and blow this comfortable world of ours into star dust, you may henceforth banish your hobgoblin and sleep in peace in the consciousness that the creator has realized the wisdom of introducing some fool-proof features into his machine. If, on the other hand, you belong to the group represented by Lord Birkenhead which anticipates that one fine day the scientist will transform this earth into a Lotus Land in which the atoms will do all our work for us while we lie in bed and keep our digestions good by ordering two atoms worth of massage between meals, then you may wake up, banish your idle Utopian dream, and get back to your job, reflecting that the best of life is in the striving, and that there is infinitely more fun in learning how to smash a resistant atom than there could be in lying on your back and watching it explode.

Michelson's economic value! In the last analysis there is nothing that is practically important at all except our *ideas,* our group of concepts about the nature of the world and our place in it, for out of these springs all our conduct. There is not an idea that I have advanced to-night, a conclusion that I have drawn from Einstein's equation, from Aston's curve, from cosmic ray data, that would have been possible had not somebody driven to the limit the precision of physical measurement, and much of it became possible because of Michelson's own super-refined experiments—so true has it been proven to be that human progress "grows out of measurements made in the sixth place of decimals." Not he, nor anybody else, saw at the time what bearings the results would have. He merely felt in his bones, or knew in his soul, or *had faith to believe* that accurate knowledge was important. But some of the bearings have already appeared and others will continue to be found for ages yet to be.

I personally owe *everything* to the fact that thirty-two years ago Mr. Michelson took me into his nest at the University of Chicago, and I personally believe that the United States has not had in this generation a greater economic asset than Albert A. Michelson.

ROBERT A. MILLIKAN
CALIFORNIA INSTITUTE OF TECHNOLOGY

METEOR CRATER EXPLORATION

IN its genesis, characters and relations the Arizona meteoric bowl is unique, unless the pittings in Siberia made by a meteor fall in 1908 are comparable. The Meteor Crater with its association of iron meteorites is one of the scientific marvels of the world, but not yet properly appreciated by the public or by the scientific fraternity. Unfortunately the subject is involved in unhappy personalities.

A recent article (June, 1928) in the *National Geographic Magazine* gives a popular description of the crater, but is faulty in omission and in implication. It fails to give the proofs of meteor-impact origin; it omits the very interesting story of its exploration and study, and, most important, fails to give proper credit for discovering and publishing the evidence of its impact origin. On the contrary, the article by implication and by the photographs appears to give the credit for discovery to G. K. Gilbert and the U. S. Geological Survey. Naturally any account of the crater exploration and the discovered evidence would have required the name of Daniel Moreau Barringer, which was entirely suppressed.

Naturally and properly the implication in the article has been resented by Barringer, who at great cost in time, effort and money explored and probed the crater, marshaled and first published the facts, and so proved beyond any reasonable doubt the meteor-impact genesis. A very spirited correspondence, involving a number of friends of Barringer, has not yet obtained the *amende honorable.* There is here a question of scientific and journalistic ethics. The purpose of this writing is to tell the true story of the crater study and to establish the credit for the discovery and publication of the truth.

The masses of nickeliferous iron, known as Canyon Diablo siderites, have been found in great numbers, and of size up to 1,400 pounds, scattered over the Arizona desert a few miles south of Sunshine station on the A. T. and Santa Fe Railroad. During the late eighties or early nineties of the last century two parties, F. W. Voltz, at Canyon Diablo, and the Williams Brothers, at Winslow, made a business of collecting the meteorites, with the aid of Mexicans, and of selling them to institutions and collectors all over the world. In consequence the Canyon Diablo siderites are the most widely distributed of all meteorites. They were also the first to yield minute diamonds, described by A. E. Foote in the *Proceedings* of the American Association for the Advancement of Science, Vol. 40, 1892, pp. 279–283.

In the midst of the desert area over which the irons were distributed is the great crateriform pit, four fifths of a mile across at the top and about 450 feet deep below the surrounding plain. With the elevated rim of quartz dust and rock fragment it has, from the inside of the bowl, a vertical relief of 570 feet.

This association of the crater, then bearing the absurd name of Coon Mountain or Coon Butte, with the

meteoric irons that were scattered concentrically around the hole for a radius of four and five miles, was long ago examined by a party from the U. S. Geological Survey, headed by G. K. Gilbert. His reports, published in the thirteenth and fourteenth annual reports of the survey for 1892 and 1893, briefly refer to his visit to the locality and note the two hypotheses of origin of the crater, one that it was essentially volcanic or an explosion of steam, and the other that it was produced by the fall of a very large mass of meteoric iron. The latter report states that he had partially prepared a report of conditions as to the structure and origin of Coon Butte but it had not yet received final form for publication.

Upon invitation of the writer, and under the auspices of the Rochester Academy of Science, Mr. Gilbert made an address on August 22, 1892, before the American Association for the Advancement of Science at its summer meeting in Rochester, New York, devoted to discussion of the Coon Butte problem and favoring the volcanic theory. The relief map which he used on that occasion he presented to the writer. Later came his quite famous address before the Geological Society of Washington (read on December 11, 1895, and printed in SCIENCE, 3: 1–13, 1896, entitled "The Origin of Hypotheses Illustrated by the Discussion of a Topographic Problem." In this address he considered the theory of impact origin of the crater, but favored a volcanic genesis or some sort of steam explosion. The lack of any magnetic effect from a supposed buried mass of iron, under the meteoric theory, appears to have been a determining factor.

And there the matter rested for several years.

In 1902 Mr. S. J. Holsinger, an employee of the U. S. Land Office, mentioned the crater, in a casual conversation at Tucson, Arizona, to Mr. D. M. Barringer, a mining engineer and geologist of Philadelphia. Holsinger had not at the time visited the crater but had heard of it from Voltz, the trader at Canyon Diablo. Mr. Barringer was greatly interested, and the outcome was that Barringer and B. C. Tilghman, also of Philadelphia, to whom Barringer had communicated his suspicion that the crater was formed by a meteoric mass, organized a mining company to take title to the property and secured a patent from the U. S. government to the square mile which includes the crater. This patent bears the date of December 24, 1903.

With scientific curiosity and commercial enterprise exploration of the crater began in 1903 to locate the supposedly buried meteorite. An attempt was made to sink a shaft in the center of the crater, but at 200 feet quicksand was encountered and the attempt abandoned. Twenty-four holes were drilled in the central area of the crater, even to a depth of over one thousand feet. These failed to discover any meteoric mass but did discover oxidized meteoric iron and proved the continuity in undisturbed position of the deeper rock strata, with the non-existence of any volcanic chimney. No evidence of volcanism has ever been found in or near the crater.

With the efficient aid of Mr. Holsinger, who was put in charge of the exploratory work and continued in the employ of the company as superintendent until his death at the crater in 1911, Mr. Barringer collected a great amount of very interesting information. The evidence of genetic association of the crater and the siderites was so conclusive that Barringer and Tilghman had announcement of the impact origin of the crater made by the president of the Academy of Natural Sciences of Philadelphia on December 5, 1905. And in the *Proceedings* of the academy for that month Barringer and Tilghman published the first articles marshaling the facts for the impact origin of the crater. This volume of the *Proceedings* was issued in March, 1906. The money which was spent in proving the crater to be an impact crater was advanced by Messrs. Barringer and Tilghman.

In June, 1906, Professor J. C. Branner reviewed the publications by Barringer and Tilghman before the Geology Section of the American Association for the Advancement of Science in session at Ithaca, New York, but did not commit himself.

In August, 1906, the writer examined the crater and studied its associations, and in September, at the tenth session of the International Geological Congress, in the City of Mexico, exhibited the meteoritic and rock materials and affirmed the meteoric origin of the phenomena. (*Compte Rendu X Session,* 1906, page 144). Another paper read before the Geological Society of America at New York in December was published, with illustrations, in the *Bulletin* of the society, Vol. 18, 1907, pages 493–504.

In 1907 Dr. George P. Merrill also visited the crater and printed a description in the *Smithsonian Misc. Coll.* (Quarterly Issue), Vol. 50, part 4, 1908.

Subsequent to the publications noted above Mr. Barringer published other papers with further facts and convincing illustrations, principal among which is his paper read before the National Academy of Sciences at its autumn meeting at Princeton in 1909. This was privately published but was widely distributed among scientists. His later papers on the subject, in each of which he brings forward additional convincing proofs of the meteoric theory of origin, are as follows: "Further Notes on Meteor Crater, Arizona," *Proc. Acad. Nat. Sciences of Phila.,* September, 1914; "A Possible Partial Explanation of the Visibility and Brilliancy of Comets," *Proc. Acad.*

Nat. Sciences of Phila., August, 1916; "Further Notes on Meteor Crater in Northern Central Arizona (No. 2)," *Proc. Acad. Nat. Sciences of Phila.*, 1924.

These thorough studies prove beyond the slightest doubt the meteor-impact origin of the crater. No feature is wanting that might reasonably be expected under the impact theory. And, on the contrary, not the slightest suggestion of any volcanic action has ever been found. The impact origin of the crater must be accepted as fact, no longer as theory. But this does not determine the fate or disposition of the colliding body or its mass.

In the *Scientific American* for July, August and September, 1927, is an interesting summary of the discoveries at Meteor Crater by D. M. Barringer, Jr.

From 1893 to the present time the U. S. Geological Survey has by its silence tacitly held to the volcanic or steam explosion hypothesis, by entirely ignoring all the work of geologists since Mr. Gilbert's report, while the negative attitude of some members of the survey toward the impact origin is well known.

This attitude of the survey deserves criticism. The scientific evidence is before the court of scientific men. The writer as mutual friend of all the parties, and especially as a close friend of Dr. Gilbert, will now assume the unsolicited and delicate task of summing the case and of pronouncing verdict.

The cause or reason for the unscientific and unfair attitude of the Geological Survey is probably of a personal nature. It is possible that Mr. Barringer is *persona non grata* to some on the survey. Also it may be that the personal ownership of Meteor Crater by Mr. Barringer and its exploration as a quasi-commercial enterprise is made an excuse for not recognizing and publishing the dramatic truth. Of course that would advertise the property. But the survey gives attention to mines and other exploitations which are wholly commercial and in private ownership.

Another reason, and perhaps the chief one, for the survey's silence is that the history and the facts show that a mistake was made by an eminent and beloved member of the survey. Dr. Gilbert certainly did form an erroneous opinion. Such a reason for the attitude of the survey implies either that the workers on the survey are considered infallible, or if fallible, that the survey never admits an error.

The writer had intimate personal and scientific relations with Dr. Gilbert and yields place to no one in regard and admiration for him as a man and geologist. It is difficult to understand how he came to favor volcanism as the cause of Meteor Crater. Most certainly he later knew his mistake. During the years following the publications by Barringer and myself he never questioned the impact theory, as he surely would have done had there been any doubt in his mind. Subsequent to his report on the crater he made a study of the moon's craters and found evidence of their origin by impact.

No luster is added to Gilbert's fame by neglecting to admit the evident truth. Nor would admission of this error hurt his reputation. It is human to err. After twenty-three years of implied acceptance of Gilbert's findings by official silence, confession by the survey will of course be painful. The public as father-confessor is waiting. And, really, a little evidence of humility and admission of fallibility by a great bureau of the government would be something new. It might awaken more generous feeling on the part of the public.

As a great bureau of the people's government, and supported by public money, the survey has no ethical or legal right to suppress or withhold any geologic truth, for personal or any other reason. The silence of the survey on the important feature works an injustice against (1) Mr. Barringer, who has made sacrifices to discover and publish the facts; (2) the scientific world, which looks to the survey for geologic information, and (3) the general public, which is morally and legally entitled to the latest and best information on all scientific matters considered by the survey.

HERMAN L. FAIRCHILD
UNIVERSITY OF ROCHESTER

SCIENTIFIC EVENTS

AGRICULTURAL RESEARCH BUREAUS IN GREAT BRITAIN

PROGRESS has been made in bringing into effect the scheme submitted last December to the governments of the empire to establish eight bureaus for the collection and interchange of information in eight branches of agricultural science. It was then announced, according to the London *Times*, that, as a result of a representative conference held in London, detailed proposals had been made for attaching these bureaus to recognized research institutes and for financing them from a common fund formed by contributions from governments of the empire and controlled by an executive council representative of the governments.

The governing bodies of the institutes which were approached have all accepted the scheme. The proposals have received the wide approval of the governments of the empire. The executive council at a meeting held at the end of March was thus able to authorize the opening of three bureaus from April 1, of a fourth from May 1, and to contemplate the opening of the remaining four during the summer months.