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CONTENTS

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EDWARD CHARLES PICKERING

BY the death of Edward C. Pickering American science has lost one of its most distinguished figures, one of the most noteworthy contributors to its progress during the past forty years, and one of its most inspiring and influential leaders. A full account of his long and active career would demand far more space for its presentation and time for its preparation than are at the moment available; only the main events and achievements of an exceptionally productive life can be touched upon in these few words of appreciation.

Born at Boston, in 1846, of an old New England family, and a graduate of Harvard of the class of 1865, after two years as instructor in mathematics, he became professor of physics at the Massachusetts Institute of Technology, where he established the first laboratory in America in which students were instructed by actual contact with physical instruments and measurements. Upon the death of Professor Winlock, the youngest physicist was called, in 1877, at the age of thirty-one, to the directorship of the Harvard College Observatory, which he held for nearly forty-two years, continuing the tradition of the institution, all of whose directors have died in office.

At this time most observatories were devoting themselves mainly to the old "astronomy of position"—the determination of the apparent positions of the stars and other heavenly bodies upon the celestial sphere, and of those constants of nature which can be derived from such observations—and the "new astronomy" (now bet-

ter known as astrophysics) was in its infancy. It is characteristic of Pickering that he realized at once in what direction the greatest opportunities lay, and set to work to employ the full resources of the observatory in fundamentally important work. Harvard had always been sympathetically inclined towards the newer developments of astronomical science, and considerable photometric work had been done under Bond and Winlock; but, when the new director began to devote the main portion of his own time, and that of the fifteen-inch telescope (then one of the greatest in the country) to photometric researches, considerable criticism was aroused. "Why," said these critics, "should observations with the meridian circle and micrometer, which yield results accurate almost to one part in a million, be neglected in favor of measures in which differences of five, or even ten per cent. habitually occur? Can such inaccurate observations be of any value in an exact science?"

Undaunted by these cavils, he continued in his chosen course—with what abundant reason the nearly eighty volumes of the "Harvard Annals" which appeared during his directorate may testify. The "old astronomy" was not neglected—in fact, twenty years' time was spent by several members of the staff in preparing each of the two Harvard zones of the Astronomische Gesellschaft's scheme of international cooperation in star-cataloguing—but the astrophysical work accomplished under Pickering's directorship, and bearing the marks of his genius, is of incomparably greater volume and importance. He was a pioneer in several fields, in each of which he has had many followers.

He was never contented with the unthinking adoption of the methods and instruments of investigation which he found in use, but was always designing new ones, with a view to increasing the accuracy of observation, and, above all, to obtaining rapidity without sacrificing accuracy. In the latter particular he was indeed a master. He possessed a genius for organization which would undoubtedly have brought him both wealth and fame in the world of business: but he preferred to devote these talents to the service of science, and, because of them, enjoyed work of a sort which most other men would have regarded as drudgery. He once said to the writer, "I *like* to undertake large pieces of routine work." In the great masses of such work done under his direction, the principles of "scientific management" were fully applied. All that could be done by assistants of moderate capacity was left to them, and the whole working time of the experienced specialists was devoted to such parts of the work as they alone could do. To extend the study to the stars of the southern hemisphere, a station was established at Arequipa, Peru, in 1890, and has been actively maintained ever since, and another has more recently been set up in the island of Jamaica.

The results of these carefully reasoned plans have been so extensive that only the principal features can be mentioned here, leaving a host of minor but highly interesting investigations undescribed.

In *visual photometry,* Pickering started almost *de novo,* devising new measuring instruments, with which observations of all the accuracy necessary for his purpose could be made with great rapidity—notably the meridian photometers, with which the brightness of stars is measured, as they cross the meridian, by comparison with some circumpolar star which is always available as a standard. With these instruments more than 45,000 stars have been observed at Cambridge and Arequipa, and the resulting system of visual stellar magni-

tudes has been generally adopted as an international standard. When to these observations, most of which were made by Professor Pickering himself, are added his numerous measures upon variable stars, satellites and other objects, the whole number of photometric settings which he personally made rises to the amazing total of more than a million and a half.

He was also a pioneer in *stellar photography*, and especially in the use of the doublet lenses which combine great light grasp with a wide angle of field, and can with an exposure of an hour or two, record on a single plate the positions and magnitudes of a number of stars which may run into the hundreds of thousands. The Harvard equipment includes instruments of this type ranging from the 24-inch Bruce telescope at Arequipa and the 16-inch Metcalf instrument at Cambridge to the little lenses of one inch aperture which are used to photograph as large a portion of the visible heavens as possible on every clear night. The plates are developed, indexed, and filed in the great "Harvard Photographic Library," which its creator described as "a library of 250,000 volumes, every one unique, and with but a handful of readers to work in it." The very magnitude of the mass of information stored in this vast collection makes it impossible to extract it all; but whenever an object of unusual interest is discovered, it is only necessary to refer to the Harvard plates to find out just where and how bright it was on some three or four hundred dates during the last thirty years. Among the most notable examples of this may be mentioned the recognition of images of the asteroid Eros upon plates taken two and four years before its discovery, and the recent tracing of the history of the brilliant new star in Aquila through an interval of thirty years, up to the very day before the great outburst.

The third principal field of work is in *stellar spectroscopy*. Pickering led again in the photography of stellar spectra with the objective prism, and in the more precise classification of stellar spectra which this made possible. Assisted financially by the liberal aid of the Henry Draper Memorial, he and his very distinguished assistants, Mrs. Fleming and Miss Cannon, studied these spectra, devised the empirical classification of the original Draper Catalogue, and improved upon this by omitting some of the original classes and rearranging others, until the resulting classification proved so convenient, and so remarkably representative of the actual facts, that it was adopted without a dissenting voice by the International Union for Solar Research as a universal standard. The fact, which was first brought out by this investigation, and served as the basis of the final classification, that the spectra of almost all the stars fall into a single sequence, along which each type grades almost imperceptibly into the next, is now recognized as the very foundation of modern astrophysics, and the progress of discovery serves steadily to emphasize the importance of classification according to spectral type in the most diverse problems of sidereal astronomy. In this field, too, the Harvard work is of imposing extent, culminating in the "New Draper Catalogue" containing the spectra of about 215,000 stars, classified by Miss Cannon. Professor Pickering took the liveliest interest in this monumental work, and in the admirably arranged plans for its production; and it is cause for gratification that the first volume saw the light while he was alive to enjoy it.

One other series of investigations that should not be passed over deals with *photographic photometry*. This was one of the chief interests of his later years, and an increasing part of the work of the observa-

tory was devoted to it. The establishment of a standard system of photographic magnitudes proved a difficult and intricate problem, but again the results are of primary importance, for the color of a star, which is best measured by the difference between its visual and photographic magnitudes, proves to be almost as important as its spectral type, to which it is very intimately related. Here again the principal work of observation was done by others—Miss Leavitt, Professor Bailey and Professor King—but the unifying guidance was Pickering's. Closely related to this is the discovery of variable stars, which, previously largely a matter of chance, was reduced to a system, whether by the comparison of plates of the same field taken at different times, or by means of certain spectral peculiarities. The new methods were so successful that the number of variable stars discovered at Harvard within a few years was three times as great as that of all those detected by all the astronomers of the world during the previous history of the science.

Finally, and by no means least, should be recorded his deep interest in, and support of, cooperation between the whole fraternity of astronomers, whether in this country or abroad. There was hardly an organization for the furtherance of any specific astronomical aim, such as the Committee on the "Carte du Ciel" or the Solar Union, in which he did not take an active part, and his counsel and advice were always of weight. But equally influential, though less conspicuous, was his ever generous aid to individual investigators, to whom he was continually transmitting invaluable material from the treasures under his charge, sometimes observations already made, but unpublished, and again data concerning stars which had been put upon his observing lists for that especial purpose. His abiding willingness to use his powerful influence to aid other astronomers in obtaining instruments for the expansion of their researches, or funds to provide assistance in the reduction and publication of their observations, is known to all.

It may be pardonable to speak of one or two instances. In conversation, referring to the Metcalf Telescope, for which he had found the funds to purchase the glass disks for the lens, and provide the mounting, while the figuring of the lens was done, as a labor of love and in his spare time, by the distinguished amateur whose name it bears, "I felt as if a great artist had said to me 'If you will buy the canvas, and the brushes and paint, I will paint you a picture.' "

If a more personal allusion may be excused, it may be recorded that, shortly after the writer's first interview with Professor Pickering (during which he had described his first serious astronomical work, on stellar parallax) a letter arrived from Harvard, saying in substance "I think that it would be useful to determine the magnitudes and spectra of all your stars. If you will send me a list of them, we will have them observed, and send you the results." This involved the photometric and spectroscopic observation of some three hundred stars (the photometric settings being made by Professor Pickering himself) and was offered as an unsolicited contribution to the work of a young and unknown instructor!

The Harvard Observatory never admitted graduate students of the ordinary sort; and doctoral theses are absent from the long list of its publications. But, under Pickering, it was an educational center of the first rank, and its pupils were not the immature students, but the working astronomers of the country. Who among us has not gone to Harvard, enjoyed the delightful hospitality and finished courtesy of the director, and returned, loaded down with

data for investigations new or old, and inspired by his experience with new enthusiasm alike for the magnificent researches of the great observatory, and for his own humbler work?

Such a career deserved unusual recognition, and received it in a merited degree. Almost all the honors of the scientific world fell to his lot, and the list of these distinctions is too long to detail here. But those who knew him will mourn less the disappearance of the distinguished leader of science than the loss of a warm and loyal friend, one of the kindliest and most generous of men.

HENRY NORRIS RUSSELL

PRINCETON UNIVERSITY OBSERVATORY,
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SOME RECENT CONTRIBUTIONS TO THE PHYSICS OF THE AIR[1]

THERE has come to us from ancient times the story of a foolish man who sold his birthright for a mess of pottage, and that story to-day is right applicable to us physicists, except in one important particular—we haven't even got the pottage. No department of learning has a richer birthright than has the department of physics in meteorology—the physics of the air. And yet the few institutions that even profess to teach this subject in any form offer it through the department of geology, or, more frequently still, that omnivorous department which, for want of a better name, is called the department of geography. Statistical meteorology, if such expression will be permitted, or climatology, is of course of great interest alike to the geologist and the geographer and this they should teach and in great measure do teach, but climatology is no more meteorology than descriptive geography, for instance, is geology. Its value is great and unquestioned, but its function, like the function of geography, is merely to describe and not to explain.

Meteorology, on the other hand, is concerned with causes, it is the physics of the air, a vast subject of rapidly growing importance upon which peace and war alike are becoming more and more dependent. Only yesterday we

> Heard the heavens fill with shouting, and there rained a ghastly dew
> From the nations' airy navies grappling in the central blue;

and to-day

> Saw the heavens fill with commerce, argosies of magic sails,
> Pilots of the purple twilight, dropping down with costly bales.

It is, therefore, no longer an opportunity, a shamefully neglected opportunity, that invites, but an imperative duty that commands our leading institutions to add to the various subjects taught, studied and investigated in their departments of physics that eminently valuable and fascinatingly difficult branch of geophysics—the physics of the air.

No doubt the great majority of colleges and universities would find it highly impracticable to add a proper course in meteorology to their present long list of electives. Neither is it practicable nor desirable for all of them to teach anthropology, say, despite its fascination, nor even any whatever of the a-to-z kinds of engineering. But it is insisted with all possible emphasis that if taught at all it be taught right—taught as a branch of physics. It is also insisted that there is a growing need, especially in connection with both the science and the art of aviation, for young men who understand the phenomena of the atmosphere. Nor should it be forgotten that when our army called for men trained in meteorological physics it called in vain—they did not exist. Furthermore, it would be a godsend to our national Weather Bureau if in the future it could secure a larger portion of its personnel from among university gradu-

[1] Address of the vice-president and chairman of Section B—Physics, American Association for the Advancement of Science, Baltimore, December, 1918.