bodiment and successful conclusion. It called for boldness and faith and persistence to a degree rarely matched.

In the magnetic resonance accelerator, or cyclotron, which Dr. Lawrence has created and developed, positively charged particles are accelerated so many times, as they circle about in a strong magnetic field, that they acquire energies of millions of electron volts, even though the actual accelerating potential difference is only a few tens of thousands. Not only this, but the limit to the particle energies which can be generated in this way is not yet in sight.

Many serious difficulties have arisen and been successfully overcome. There has been, for example, the very vital problem of protecting human beings in the neighborhood from the extremely penetrating and dangerous radiations produced by the cyclotron discharge. Without much intelligent care many workers might well have been seriously injured. The value of the new tool is attested by its world-wide adoption and by the variety of scientific uses to which it is being put.

Dr. Lawrence has not only created and developed the cyclotron, but, in addition to this, he has been in the forefront of those actually using high energy particles in the assault on the nucleus. With high energy deuterons he has bombarded various elements, nearly all of which have been disintegrated by these particles, in most cases giving rise to new radioactive isotopes. These new artificial radioactive elements, which will soon be available in large quantities, can be used to investigate not only other nuclear phenomena, but also the mechanism of chemical and biological processes. They may also find important therapeutic uses.

By the bombardment of beryllium with deuterons Dr. Lawrence has been able to produce neutrons at a rate which is enormous compared with the output which had previously been obtained, thus greatly extending the possibilities of their use in both nuclear and biological research.

He has accelerated doubly charged helium ions to energies greater than those available from natural alpha particle sources and with intensities thousands of times greater. The results indicate that the field of alpha particle disintegration can be expanded indefinitely with such artificial sources.

We must credit him not only with his own brilliant work in nuclear research but also with the inspiration and assistance which he has given to collaborating physicists, chemists, biologists and radiologists.

In making its recommendation to the academy, the committee has found itself in the favorable position of being able to do so on the basis of only a fraction of Dr. Lawrence's important pioneering work. I am referring by inference to such of his work as that with Dr. Sloan, in creating and developing a combination high voltage generator and x-ray source, in which a million volts or more is generated and used inside of an evacuated grounded metal tank.

While consideration was given to the names of other men who are doing work of a high order of merit, Dr. Lawrence's work was so outstanding as to make him unmistakably the committee's choice. It then became a pleasure to make the recommendation, which we know will meet with favor both from Dr. Lawrence's colleagues and from the scientific world generally.

In closing, may I express for the committee the hope that with his youth, enthusiasm and joy in scientific work, and stimulated by the richly earned recognition which his work has received, he may continue for many years his epoch-making investigations in physical science.

WILLIAM D. COOLIDGE
GENERAL ELECTRIC COMPANY,
SCHENECTADY, N. Y.

RESPONSE BY PROFESSOR ERNEST O. LAWRENCE

WORDS fail me in expressing my deep appreciation of this great honor. You all know from your own experience that scientific advances are rooted in the past and always involve, directly or indirectly, the work of many contemporaries—that no individual is alone responsible for a single stepping stone along the path of progress. In my own endeavors this has been particularly true, for from the beginning it has been my good fortune to be associated with men of outstanding ability and devotion to science, a circumstance which has indeed been as much a source of joy as the satisfaction of contributing a little to scientific progress.

In 1930, three splendid students embarked with me on the voyage of experimental research that has reached the destination you have seen fit to recognize so magnificently this evening. In the spring of that year, Niels Edlefsen built the first model of the apparatus which has come to be known as the cyclotron, and although it was very crude, the indications of its performance were encouraging. Perhaps some of you will remember that we presented a paper on these first experiments before the meeting of the Academy in Berkeley. In the fall, Stanley Livingston carried forward with unusual ability and enthusiasm the experimental development begun so well by Edlefsen. Livingston being an untiring worker, it was not long before a model of the cyclotron was evolved, which worked well enough to assume a significant place in nuclear research. He had a prominent part in our work for two years more and all of us in the laboratory greatly regretted his leaving, for he contributed so much to our joint endeavors. A third student of those early days was David Sloan, an experimenter of rare genius. Although he was not primarily concerned with the cyclotron, he did, in fact, contribute a great deal to its development and to the general technique of the laboratory. Following these young pioneers, our laboratory has been blessed with a succession of fine men, and I wish there were time here to pay proper tribute to them all. May I at least acknowledge my appreciation of a great friend and valued scientific colleague, Donald Cooksey, who during the past three years has played an important part in the work of the laboratory and especially has been largely responsible for the improvement of the cyclotron. In thanking you for this greatly appreciated honor, I do so with the happy thought that I am the representative of these valued associates and intimate friends.

Perhaps I may be permitted to add a few remarks in the nature of a prognosis, for it seems clear that we are now on the threshold of a new scientific epoch, having much the same character as that which followed the discovery of x-rays and radioactivity. I need not recall the development of modern atomic physics and the benefits to the medical sciences that came from these discoveries. The recent discoveries in the domain of the atomic nucleus—notably neutron rays and artificial radioactivity—have similarly opened up new vistas of incalculable importance. Although I might more properly speak of the problems of the physical sciences that have come to view, with your permission I should like to call particular attention to the bearing of these recent advances in nuclear physics on problems of the biological and medical sciences; for there are grounds for the view that the fundamental problems of biology are at the moment of greater importance than those of physics.

From the moment of discovery it was apparent that neutron rays might have important applications in medical science, for although they are similar to x-rays in their penetrating power, the mechanism of their absorption in matter is quite different. Recent experiments indicate that neutron rays do indeed produce quite different biological effects from those produced by x-rays, shedding fundamental light on certain biological processes induced by ionization and giving strong hopes that for certain therapeutical purposes the neutron ray may be extremely valuable.

The discovery that it is possible to produce radioactive forms of the common elements is also of tremendous importance for biology. These artificial radioactive substances, which apart from their radioactivity are chemically and biologically indistinguishable from the ordinary elements, conveniently manifest their presence by the powerful radiations they emit. They are tagged atoms which are easily traced through a complicated biological system. During a visit in our laboratory last year, Professor A. V. Hill, the distinguished physiologist, emphasized his view of the importance of the artificial radioactive substances as tracer elements in biological research by predicting that future history will rank this technique of equal importance with that of the microscope. It will be said that the microscope revealed the cells while the artificial radioactive substances permitted the biologist in effect to see the atoms themselves. It seems clear that the biologist has at hand a powerful new technique and that we may look forward to significant advances in this field which otherwise would have been impossible.

It is a tremendous source of satisfaction that valuable contributions to biology and practical medicine are emerging from researches on the fundamental problems of atoms. Although the history of science records a convincing story of the great practical benefits that always accrue to humanity from fundamental research, nevertheless those of us engaged in pure science can not help but entertain occasional thoughts that possibly our efforts in solving some puzzling scientific problems may not be of greater significance than a fascinating game of chess. In this distinguished gathering it is not necessary to point out the essential unity of science or a justification for fundamental research, but may I confess that close association with these developments in nuclear physics having bearing on the medical sciences has made me appreciate more fully the fact that an advance of the horizon of knowledge in any direction uncovers territory of all the sciences.

In closing, Mr. President and members of the academy, may I reiterate my deep appreciation and thank you for myself and in behalf of my colleagues, who share with me this great honor.

ABSTRACTS OF PAPERS

The Volcano Tarawera in 1886: ARTHUR L. DAY. In any comparative study of hot-spring activity in the North Island of New Zealand and our own Yellowstone National Park one fact stands out in dominating relief. Primary volcanic activity in Yellowstone Park ended in quiet rhyolite flows in the Pliocene epoch, while at least two volcanoes in the New Zealand group are still intermittently active. Tarawera in 1886 was violently explosive, and out of the nine-mile rift which opened during this eruption there broke forth in 1902 the greatest geyser (Waimangu) of which we have a historic record. Three years later the geyser had, apparently, exhausted itself and no trace exists to-day of its point of emergence. This eruption of Tarawera and some of its consequences was described (with illustrations).

The University of Rochester–Bishop Museum Geological Expedition to Lau (Eastern Fiji): J. EDWARD HOFFMEISTER and HARRY S. LADD (introduced by T. Wayland Vaughan). In January of 1934, the writers left Rochester for several months of geological work in the Lau Islands (eastern Fiji). Twenty-six islands were studied and nine geologic maps were prepared of the most im-