the emission of a (virtual) γ-quantum by the electron, the absorption of this quantum by a nucleon, and the subsequent emission of a meson. Hence, we have $a = 2$, $b = 1$, and

$$\sigma_B = \pi\lambda_t^2 \ (e^2/hc)^2 \ (g^2/hc) \ \varepsilon^{7/2}. \qquad (3B)$$

(C) In the final case, where we have the photomesic effect, we get for c the value 5/2. (The volume in momentum space reduces to $\int dp_n' \ dp_n$.) Since the reaction consists of the absorption of the photon and the emission of a meson, we have $a = b = 1$, and

$$\sigma_C = \pi\lambda_t^2 \ (e^2/hc) \ (g^2/hc) \ \varepsilon^{5/2}. \qquad (3C)$$

We may remark here that the exponent of ε is different from that obtained by Nordheim and Nordheim or Yukawa (*Phys. Rev.*, 1938, **54**, 254; *Proc. phys. math. Soc. Japan*, 1938, **20**, 720; cf. also P. Urban. *Acta Phys. Austr.*, 1947, **1**, 167). This is due to the fact that these authors did not take into account the momentum of the nucleon in the Fermi gas.

In order to get an idea as to the absolute value of the cross sections for bombarding energies well above the threshold, we can calculate the cross sections for $\varepsilon = 1$. Using $g^2/hc = 1/6$, we get:

$\sigma_A = 2.10^{-4}$ barns, $\sigma_B = 4.10^{-7}$ barns, $\sigma_C = 6.10^{-5}$ barns.

We must remind the reader here that if nuclei of atomic weight A are bombarded, the cross sections have to be multiplied by A.

Comparing equations (1) and (2), it seems that one may expect an optimum energy for the creation of mesons to exist somewhere in the neighborhood of 300 Mev ($2 \mu c^2$).

We may refer to McMillan and Teller's paper for a discussion of the various effects which they and we neglected. It should be remarked here that in cases B and C it is always possible to satisfy the law of conservation of momentum.

I should like to express my thanks to H. M. James and J. A. Wheeler for clarifying discussions on the subject of this note.

D. TER HAAR

Department of Physics,
Purdue University

The Use of Chemicals to Prevent Molding of Herbarium Specimens

Recently Fosberg (*Science*, September 12, 1947, pp. 250–251) discussed the use of formaldehyde to prevent molding of herbarium specimens. Johnson (*Science*, March 19, p. 294) found that this type of chemical treatment is without value in preparation of specimens of *Tsuga* and *Picea.* It is of interest to note that certain chemicals were used effectively by a botanist as early as 1854 to inhibit mold.

In a recent book (*A scientist with Perry in Japan.* Chapel Hill: Univ. of North Carolina Press, 1947), James Morrow recounts in his diary the difficulties experienced in preserving herbarium material collected mostly in Japan. On page 212 there is a statement that Morrow found some of the specimens beginning to mold, and also signs of insects working among them. He therefore painted the dried plants and flowers with a preparation of corrosive sublimate, strong spirits of wine, and camphor.

In a memorial presented to Congress after the return of the Perry expedition it is stated on page 264 that Morrow collected plants at different ports and that by painting with a chemical preparation he was so fortunate as to bring them to the U. S. without injury to a single plant.

IRA J. CONDIT

University of California,
Experiment Station, Riverside

The Robert H. Goddard Rocket Project

The Robert H. Goddard Memorial exhibit sponsored by the Daniel and Florence Guggenheim Foundation, which was opened at the American Museum of Natural History on the afternoon of April 21 (*Science*, April 23, p. 420), is an admirable expression of appreciation of the late Dr. Goddard's scientific work. This exhibit is to be shown in other cities and later placed in some public institution for permanent display.

All who have been associated with the rocket project feel a deep sense of appreciation for the generous support which the Guggenheim Foundation has given to this scientific work during its later years and for the kind words regarding Dr. Goddard, expressed by Harry F. Guggenheim and Lt. Gen. James H. Doolittle at the exercises associated with the formal opening of the exhibit.

The conception of a rocket to be flown at terrific speed by jet propulsion and the earlier stages in this great adventure of a remarkable scientist, when much of the creative thinking was done, were not adequately covered in the addresses made at the Museum. Many institutions and individuals have contributed to this enterprise.

In his biographical sketch, Gen. Doolittle stated that Dr. Goddard was born in Worcester and graduated with a B.S. degree from the Worcester Polytechnic Institute in 1908. That is correct. No mention was made of the fact that Dr. Goddard transferred to Clark University for his graduate studies in physics and from that institution received his Master's degree in 1910 and his Ph.D. in 1911. He received the D.Sc. degree, *honoris causa*, from Clark University in May of 1945.

For a brief period (1912–13) Dr. Goddard was at Princeton, where he held a Research Fellowship. While there, he worked on the mathematical theory of rocket propulsion. He returned to Clark in 1914 as a member of the faculty and continued as a member of that staff until 1943, when he voluntarily resigned his professorship in physics to accept full-time employment in the laboratories of the U. S. Navy at Annapolis.

From the time Dr. Goddard joined the faculty of Clark University he gave most of his research time to the laboratory problems associated with jet propulsion and rocket flight. In this he was supported by the University and encouraged from time to time by special appropriations made by the Board of Trustees.

When I came to Clark in 1920, Dr. Goddard told me that he had proved, both mathematically and by actual tests, that the rocket would work in a vacuum. The rocket was to be propelled by the thrust produced by expelled gases created by the combustion of liquid fuels. Basically, it would be much like an ordinary Fourth of July sky rocket. Propulsion would be produced not by a push against air but recoil due to the sudden formation of gases. He knew that it did not need air or any other substance to push against. This led to the idea that such a rocket might go to the moon, and that brought a large amount of publicity. It is reported that a New York City policeman volunteered to be the first passenger to the moon.

Over and over again in those early years of the '20s, Dr. Goddard told me, as we worked together for additional appropriations, that his remaining problems were largely mechanical. He was endeavoring to overcome friction in the mechanism of his rocket and give strength to the structure where needed.

It was while Dr. Goddard was at work in the laboratories of Clark University that he proved that liquid fuels could be used in rocket propulsion. This antedated the use by the Germans of liquid fuels in a rocket by nearly 18 years. He also perfected a plan for cooling the rocket or avoiding excessive heat, which was of primary importance. He had developed the basic idea of the "bazooka" during World War I. That weapon, however, was not used until World War II.

Gen. Doolittle was right in pronouncing Dr. Goddard "one of the most remarkable men in the history of modern technology." He called him "founder of a whole new field of engineering," and said that "he fathered the basic research and development which led to the great expansion of rocket activity in World War II and which we may presume will give us the long-range control air weapons of the future." We should like to add that he was not only a skillful engineer; he was a man of vision and creative imagination.

In 1919 Dr. Goddard published a paper in the Smithsonian reports in which he gave his initial computations. In that same year he published another paper, "The Method of Reaching Extreme Altitudes." We urged him over and over again to publish more, but he was anxious to keep his work as secret as possible, for he knew others in distant lands were working on the same problem and that it had great significance in military affairs. A paper entitled "Liquid-Propelled Rocket Development" was published for Dr. Goddard in 1936.

During these early years the Smithsonian Institution, under the leadership of Charles G. Abbott, made several financial grants in support of the rocket project. This was a critical period and the financial help was most welcome. The late John C. Merriam, when director of the Carnegie Institution in Washington, took a very keen interest in this project and arranged for a substantial financial contribution from that institution to Clark University for the support of the experiment. With the combined aid of Clark University, the Smithsonian Institution, and the Carnegie Institution of Washington, Dr. Goddard carried on year after year, until he actually demonstrated that he could produce a rocket which could carry heavy recording instruments into the air.

As the work proceeded, Dr. Goddard's personal interest seemed to be largely in the scientific investigation of the upper layers of the atmosphere. He showed me plans worked out in great detail for carrying instruments that would record air temperatures, air pressures, humidity, electrical conditions, radioactivity, and a device which he thought would collect a sample of air at the maximum altitude reached by the rocket. He also planned to send up a camera, by which he might possibly, by continuous exposure of a film, bring back important photographic shots. His plans were to have each instrument returned by a parachute and so tagged that it would be returned to him by the finder.

In 1929 a somewhat famous test was made from a field on the outskirts of Worcester, when one of the experimental rockets, about 11′ long and under control so that it would not go too far, attracted the attention of residents of that region by the noise of its initial explosion. Someone saw an object falling from the sky and reported that an aviator must have fallen from a plane. This report reached the fire and police departments and they, together with newspaper men, were soon on the spot. Dr. Goddard begged them not to give publicity to this incident, but it was such a good news item that the reporters could not resist the temptation to publish.

This experience led to such a scare in the vicinity of Worcester that Dr. Goddard found it necessary to request the government authorities at Camp Devens, about 25 miles north of Worcester, to grant him permission to carry on his field tests with rockets from an abandoned farm near the artillery range of that camp. Permission was secured, and late in 1929 he and his assistants were busily engaged erecting a steel tower 100′ high, from which the trial flights of sample rockets were to be started.

About this time a New York paper published a short article about the rocket experiments, which caught the eye of Col. Charles Lindbergh. This was a most fortunate occurrence. The reporters who could not be restrained had performed a most helpful service to Dr. Goddard, Clark University, and scientific research. Col. Lindbergh came at once to the University campus and went immediately to Dr. Goddard's laboratory. This was on November 23, 1929. The Colonel was at that time particularly interested in any research that would provide accurate information about the upper layers of the atmosphere. He and Dr. Goddard became good friends, and he returned to New York most enthusiastic about the possibilities in the rocket experiments.

Charles Lindbergh was a very close friend of Daniel Guggenheim, and because of his recommendations and conferences with Dr. Goddard, Mr. Guggenheim made a very generous contribution to the University for the support of the work in which Dr. Goddard was engaged. This first grant came to the University early in July of 1930.

The experiments had been in progress for nearly 20 years, but there was much left to be done, and the project needed more financial support than we had ever been able to command. The generous contributions that came from Mr. Guggenheim and from the Guggenheim Foundation continued until early in World War II, when the U. S. Navy invited Dr. Goddard, with his entire equipment, to move into its laboratory at Annapolis.

When a laboratory was established for Dr. Goddard at Roswell, New Mexico, all the equipment at Clark University that would be of value in promoting the experimental work and construction of more rockets was shipped there. It fell to my lot to visit the Roswell laboratory and report to the Trustees on this work which was being carried on by one of our staff. At that time Dr. Goddard was on leave of absence so that he could give his full services to the experimental work. He had erected a one-story laboratory near his home. There he had a rocket under construction about 18′ in length which resembled in many ways the chief object in the exhibit now at the American Museum of Natural History. Several assistants were at work making delicate parts; large sheets of light metal were at hand, mangled parts of rockets that had been high in air were being studied, and a new gyroscope was under construction. We visited the field, several miles out of town, where trial flights were started. There a tower similar to that built at Camp Devens was ready for use and electric power lines brought the necessary spark for actually starting the combustion of the liquid fuels.

One of Dr. Goddard's chief problems while at work in New Mexico was to keep the rocket moving in a straight line. He told me then that he planned to attach a gyroscope to the rocket, and later did so. Little by little the mechanical problems of constructing larger and larger rockets were solved. Various new metals were experimented with in order to reduce weight and to give greater strength. Each trial flight helped to disclose the places that needed to be reinforced. Various fuel combinations were used.

From time to time the University received formal reports of the progress being made and requests for an extension of Dr. Goddard's leave of absence. The problem of maintaining our graduate work in physics with the head of the department away for several years was a tough one. The University sacrificed much for the sake of this project.

Soon after receiving the first grant from Mr. Guggenheim, I organized, for the University, a committee of outstanding scientists who would direct the continuation of the experimental work on the rocket and jet propulsion. On that committee were John C. Merriam, director of the Carnegie Institution of Washington; Charles G. Abbott, secretary of the Smithsonian Institution; Charles A. Marvin, of the U. S. Weather Bureau; Robert A. Millikan, of the California Institute of Technology; Walter A. Adams, of Mt. Wilson Observatory; Col. Charles Lindbergh, Trustee of the Guggenheim Aeronautical Foundation; John A. Fleming, of the Department of Terrestrial Magnetism, Carnegie Institution of Washington; and Henry Breckenridge, of the Guggenheim Foundation.

The meetings of this committee were held in the Board Rooms of the Carnegie Institution of Washington. Each time, Dr. Goddard came on from his New Mexico laboratory, presented a report of progress, and outlined the chief problems awaiting solution. On one occasion he brought a moving picture of a rocket in ascent. This group of men pooled their knowledge on the scientific and technical problems involved in the work and most frankly and generously helped Dr. Goddard in every way possible. The University was deeply appreciative of their services.

The imaginations of those now interested in jet propulsion are leading to predictions that are far beyond anything of which Dr. Goddard spoke. He did say that a rocket might some day be made that could reach the moon, but I never heard him prophesy interplanetary flight, or the transfer of mail and light cargoes in rockets at supersonic speed, or a rocket that might carry human passengers. All this may lie before us in the wonderful challenge which other men will accept.

All who know of this great adventure in science and technology are delighted with the announcement made by Harry F. Guggenheim that this field of research for peacetime service will receive additional support from the Guggenheim Foundation.

The work on the rocket and jet propulsion began in the same laboratory where A. A. Michelson first measured the speed of light and where Louis T. E. Thompson, director of research at the U. S. Naval Ordnance Testing Station at Inyokern, California, did much of his early scientific work on thermodynamics and ballistics. There Dr. Goddard served as an inspiring teacher and remarkably persistent research scientist. He was truly a great man who made many valuable contributions to science and technology.

WALLACE W. ATWOOD, *President emeritus Clark University*