many of them, and Oppie was introducing them to an unfamiliar way of life. We acquired something of his tastes. We went to concerts together and listened to chamber music. Oppie and Arn Nordsieck read Plato in the original Greek. During many evening parties we drank, talked and danced until late, and, when Oppie was supplying the food, the novices suffered from the hot chile that social example required them to eat.

During this time Oppie was a professor at both Berkeley and Cal Tech (where he metamorphized into Robert). The arrangement was made possible because the Berkeley spring semester ended early in April, allowing Robert to teach the spring quarter in Pasadena. Many of his students made the annual trek with him. Some things were easier in those days. We thought nothing of giving up our house or apartment in Berkeley, confident that we could find a garden cottage in Pasadena for 25 dollars a month. We did not own more than could be packed into the back of a car. In Pasadena, in addition to being exposed to new information on physics, we led an active social life. The Tolmans were good friends and we had very warm relations with Charlie Lauritsen and his group. Willy Fowler was a graduate student then and Tommy Lauritsen was still in high school. We spent many evenings at the Mexican restaurants on Olvera Street and many nights partying in Charlie Lauritsen's garden.

One feature of the times that contrasts with present customs was the relatively little personal contact we had with the outer world of physics. The meetings we went to were the West Coast meetings of the American Physical Society. The first conference I can recall was a cosmic-ray symposium in Chicago that Oppie and I drove to from his New Mexico ranch in the early summer of 1939. We had a few visitors, however. Bohr and Dirac and Pauli made short visits to Berkeley or Pasadena, and I met Victor Weisskopf, Hans Bethe, George Placzek, George Gamow and Walter Elsasser at the ranch.

WIDE WORLD PHOTOS

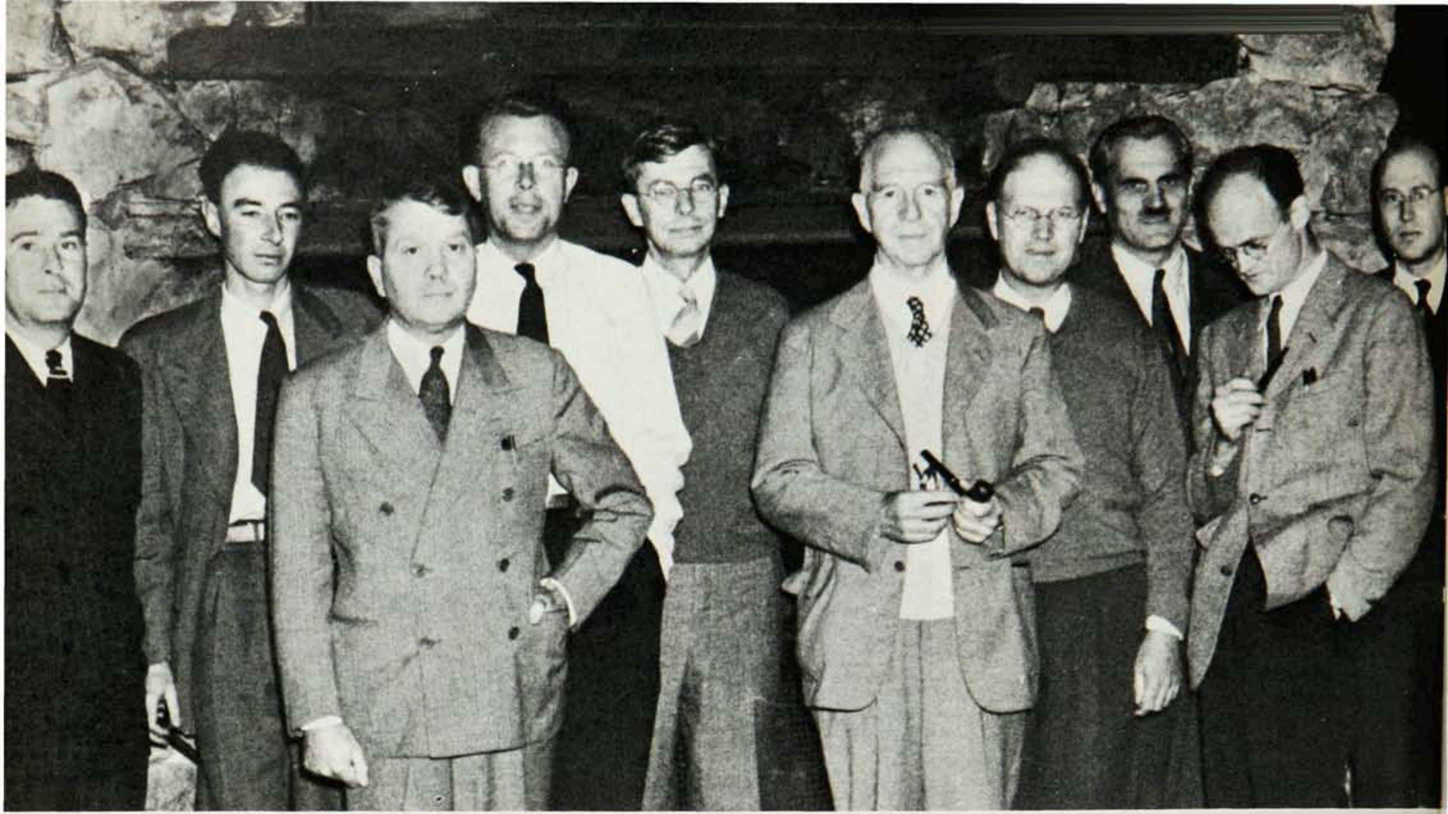
POINTING TO PERFECTION. E. O. Lawrence and Oppenheimer examine diffusion pumps for creating an almost perfect vacuum in an accelerating chamber between poles of the 184-inch cyclotron.

There were many facets of Oppenheimer's character that contributed to his greatness as a teacher: his great capacity as a physicist, his wide intellectual interests, his astonishing quickness of mind, his great gift for expression, his sensitive perception, his social presence which made him the center of every gathering. His students emulated him as best they could. They copied his gestures, his mannerisms, his intonations. He truly influenced their lives. Among his prewar students (besides some I have already mentioned) were Leo Nedelsky, Glenn Camp, Ed Uehling, Fritz Kalckar, George Volkoff, Sid Dancoff, Phil Morrison, Joe Keller, Willis Lamb, Bernard Peters, Bill Rarita, Eldred Nelson, Stan Frankel and Chaim Richman. All of us owe him more than we can say, for his instruction, friendship and affection. For us his death was a great blow and a great loss. □

The Los Alamos Years

by Victor F. Weisskopf

THE YEAR 1939 changed many things. It witnessed the beginning of the most destructive war in history. It has also changed science. Many physicists who never were interested in applications of science devoted their skills to the necessities of war and became applied physicists. They faced new problems, new experiences, different from the accustomed academic environment. But the deepest change in the character of our science came from the discovery of fission. Many of us hoped at that time—and Oppenheimer was one of them—that the number of neutrons released would have been small enough to prevent a chain reaction. But soon enough it was clear that, on the forefront of the most esoteric and basic part of our science, a phenomenon was discovered, full of tremendous destructive and constructive potentialities. It was not yet ready for exploitation; many staggering problems had to be solved, but the way was clearly indicated. Many physicists were drawn into this work, by fate and destiny rather than enthusiasm. A threat hung over us, the frightening possibility of finding this



CREATORS OF THE A-BOMB. On 13 September 1942 the S-1 Committee, which at that time constituted the scientific leadership of the bomb project, met at Bohemian Gove, California and decided to proceed with a production plant for the electromagnetic separation of U^{235}. Left to right: Major T. Crenshaw, Oppenheimer, H. C. Urey, E. O. Lawrence, J. B. Conant, L. J. Briggs, E. V. Murphree, A. H. Compton, R. L. Thornton, Col. K. D. Briggs.

new and incredibly powerful weapon in the hands of the powers of evil, but there is no doubt that we were also attracted by the unique challenge of dealing with nuclear phenomena on a large scale, with taming an essentially cosmic process.

Oppenheimer was chosen leader of the most critical part of the venture: the design of the bomb itself at Los Alamos. It was an inspired choice. Certainly he was the central figure in nuclear physics. No other man commanded so much respect of their colleagues; but he did not have what one calls "administrative experience." There was something else about Oppenheimer; few people were aware of it at the outset. He was to create at Los Alamos a new form of scientific life.

Before I proceed with a description of the Los Alamos period, I want to mention this tragic aspect of human history, when so often great new ventures and new forms of thinking are conceived and carried out only if men are resolved to destroy each other in the name of some cause. At Los Alamos this tragic involvement was painfully obvious.

Los Alamos and fission

The task facing Oppenheimer and his collaborators was stupendous. When the work started at Los Alamos not much more was known than the fundamental ideas of a chain reaction. What happens in a nuclear explosion had to be theoretically predicted in all details for the designs of the bomb since there was no time to wait for experiments; no fissionable material was available yet. The details of the fission process had to be understood. The slowing down of neutrons in matter and the theory of explosions and implosions under completely novel conditions had to be investigated. Nuclear physicists had to become experts in fields of physics and technology unknown to them such as shock waves and hydrodynamics. Oppenheimer directed these studies, theoretical and experimental in the real sense of the words. Here his uncanny speed in grasping the main points of any subject was a decisive factor; he could acquaint himself with the essential details of every part of the work.

He did not direct from the head office. He was intellectually and even physically present at each decisive step. He was present in the laboratory or in the seminar rooms, when a new effect was measured, when a new idea was conceived. It was not that he contributed so many ideas or suggestions; he did so sometimes, but his main influence came from something else. It was his continuous and intense presence, which produced a sense of direct participation in all of us; it created that unique atmosphere of enthusiasm and challenge that pervaded the place thoughout its time. I remember vividly the sessions of the coördinating council, a regular meeting of all group leaders where progress and failures were reviewed and future plans were discussed. The discussions covered everything: physics, technology, organization, administration, secrecy regulations and our relations to the army. It was most impressive to see Oppie handle that mixture of international scientific prima donnas, engineers and army officers and forge them into an enthusiastically productive crowd. The project was not without tensions and clashes between personalities, but he dealt with these problems with a light hand, and he knew how to exploit conflicts in a productive way. I remember the weekly colloquium, where everyone with a white badge—the mark of an academic degree—participated and listened to talks about all essential aspects of the work. Oppenheimer insisted on having these regular colloquia against the opposition of the security-minded people, who wanted each man only to know his part of the work. Robert knew that each one must know the whole thing if he was to be creative.

In the desert

Los Alamos was not the first and only one of those large collaborative enterprises in science. The second world war produced a number of them, not only in the field of nuclear energy, such as Chicago, Stanford and Oak Ridge, but also in other fields. The MIT Radiation Laboratory is one important example. Still I believe that Los Alamos was special and more significant than the others. Many factors contributed to this, all connected with Oppenheimer's personality. The location, which was Oppenheimer's own choice, gave it a special character by its romantic isolation, in the midst of Indian culture. Living in this unusual landscape, separated from the rest of the world, in walking distance of the laboratories—all this created a community type of living, where work and leisure were not separated. But the special flavor came from the kind of people that were there. It was a large community of active scientists, many of them in their most vigorous and productive years. (One can interpret this in many ways; I remember when General Leslie Groves asked Oppie to influence his colleagues in certain ways—he did not want to increase the maternity ward of the hospital—Oppenheimer said, "This seems hardly to be the responsibility of a scientific director.") They came not only from the United States; some of them came to the United States shortly before the war as refugees from Europe; some of them came from England and other allied countries to pool their resources. The most famous examples were Enrico Fermi, Rudolf Peierls, William Penney and, of course, Niels Bohr and his son Aage. The great world of international physics was assembled inside the fence; we felt that that fence kept the rest of the world from us, not us from them. Not only through his participation in the work itself did Oppenheimer form the style of this enterprise, he was helped by the cultural background of this international crowd. Oppenheimer understood that there was a deep common bond among these scientists that was stronger than any national bond, and he had a lucky hand in making use of this bond for the shaping of an unusually creative social unit. Nobody who was there will ever forget the numerous discussions, public and private, on all subjects of interest: physics, philosophy, social problems but foremost the great tragedy of war and what it does to mankind. One of the most important factors that kept us at work was the common awareness of the great danger of the bomb in the hands of an irresponsible dictator. After his defeat, it turned out that this danger was in fact not so great; still the work and the spirit continued until the task was accomplished, until in the desert of Alamogordo for the first time a nuclear fire was kindled by man. All of us, and Oppenheimer more than any one, was deeply shaken by this event.

UPI

POINTING TO THE LETHAL MISHROOM. In 1946 Oppenheimer discusses a photograph of the atomic explosion over Nagasaki, Japan on 9 August 1945. Looking on are Brigadier General Kenneth D. Nichols and Henry D. Smith—the men who wrote the government atomic report.

Obviously, a community like the one at Los Alamos would be deeply concerned with the ominous implications of their work. Long before the great test, the problems of the bomb, the political and moral implications were in the foreground of interest. Oppenheimer himself and Bohr started many discussions about the dangers of atomic weapons and about ways and means of turning this new discovery into a constructive force for peace. There was hope in all of us that this great force of destruction may open the eyes of the world to the futility of war. It was in part his leadership that led to the formation of groups devoted to these problems and to a number of ideas and plans for an international approach to the exploitation of atomic energy, so that this new force would bring nations together instead of tearing them apart.

Futility of war

We know today how successful Los Alamos was in its primary purpose:

the design of a nuclear bomb. We also know that the numerous efforts to end the danger of a future nuclear war were less successful. The predicament in which our country finds itself today is an ominous sign of how little we have learned of the futility of wars.

Physics, science and human society were different after the nuclear explosion in Alamogordo. Let me comment about physics itself. I believe that the new ways of big science, in nuclear physics and particle physics, have been inspired by the Los Alamos venture. I believe that Oppenheimer has given us an example of how large scientific enterprises can be more than the sum of the collaborative effort of their groups. They can be imbued by a creative spirit based upon a common heritage and a common aim. Perhaps the new giant laboratories are beginning to show that great things can be accomplished by inspired collaboration of large groups of scientists, without being aimed at war or destruction. Maybe it is the great idea of science as a concern of all men together, a supranational activity, the idea of science as the spearhead of human coöperation across national and political frontiers, that helps to create that spirit of accomplishment.

Whatever this may mean for the future we do not know. We do not know the final balance of the work at Los Alamos, whether it has changed the world for better or worse. We cannot make such an assessment now or in the near future. Human history is too involved and too contradictory. Things conceived for doing good turn out to be destructive and things made to destroy can sometimes change the world for the better. One thing is certain, however: The achievement of Los Alamos made the world of human relations much more complex than it ever was, and we carry a much heavier load of responsibilities on our shoulders. I doubt that we are ready to carry this load. The ordeal that Oppenheimer had to suffer in 1954 is a sad indication of how little some of the responsible people understood the problems involved. Since we live in a democratic society, every one of us must bear part of the blame for the humiliation that this great man had to suffer publicly. Much has to be done to educate ourselves, our fellow citizens and all humanity, so that we are ready to face our future responsibilities. We are more than ever in need of men with the wisdom and the insight of Robert Oppenheimer. □

The Princeton Period

by Abraham Pais

IN SEPTEMBER 1946 the American Physical Society met in midtown Manhattan. In the minutes of this meeting we read that it "was confined to papers on three topics: cosmic-ray phenomena, theories of elementary particles and the design and operation of accelerators of nuclear particles and electrons. Disparate as these three subjects may appear to be, the trend of physics is rapidly uniting them."[1]

Of that meeting, I have two vivid memories. The first one, being introduced to Robert Oppenheimer by Henrik A. Kramers and discussing with him the problem of radiation reaction on the scattering of an electron in an external field, a subject in which Oppenheimer and Bethe were actively interested at the time;[2] the second one, meeting Isidor I. Rabi for the first time, who at once fired the question: "Do you think the polarization of the vacuum can be measured?" I remember my amazement at a country where experimentalists would know, let alone bother, about vacuum polarization. For this was my first week in the United States. Thus I write as one of those who, because of age, geography or other reasons, did not meet Oppenheimer until after the war. That first week was a preview of things to come.

In January 1947 Oppenheimer gave the Richtmyer lecture at the New York American Physical Society meeting, entitled "Creation and Destruction of Mesons."[3] In this lecture he reported on the first results obtained with the 184-inch Berkeley cyclotron. He then went on to discuss the soft component of the cosmic rays that originates within a few radiation lengths from the top of the atmosphere and suggested that this component derives from the decay of neutral mesons. This pioneering remark on the role of π^0 mesons he made again in a subsequent paper[4] on multiple-meson production.

After the talk he invited me for a drink in a Broadway bar where he told me that he had been offered the directorship of the Institute for Advanced Study in Princeton. He accepted this post in April and thus became the institute's third director and the first to hold this position concurrently with a professorship there.

That spring, I saw Oppenheimer for the first time in full action. Early in 1947 it was suggested from various sides that a number of small panel conferences be held in the various branches of science. Their purpose should be to review recent developments and discuss possible avenues of progress. Under the auspices of the National Academy of Sciences, and with the support of the Rockefeller Foundation, the first such conference in physics took place on 2–4 June 1947, on Shelter Island, New York. For this meeting Oppenheimer wrote the outline of topics for discussion entitled "The Foundations of Quantum Mechanics." As was to happen so often in the following years, Oppenheimer showed himself to be the threefold master: by stressing the important problems, by directing the discussion and by summarizing the findings.

Mesons and cosmic rays

In his outline he discussed the copiousness of meson production in cosmic radiation in terms of meson theories then current and concluded that "no reasonable formulation along this line will satisfactorily account for[5] the smallness of the subsequent interaction of mesons with nuclear matter." In the