PHYSICISTS in

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DURING the past thirty years great changes have taken place in physics not only in California but throughout the country. The membership lists of the American Physical Society for 1920, 1930, 1940, and 1951 provide illuminating data on these changes.

In 1920, for example, the total membership of the APS was 1132. But only 69 members lived on the Pacific Coast—in California, Washington, and Oregon. By way of contrast, in 1951 the APS numbered 10,042 members and of these 1134 live on the Pacific Coast. Thus in 1951 there were two more members on the Pacific Coast than there were in the whole country in 1920. The fraction of the nation's physicists living on this coast also increased from 6.1 percent in 1920 to 11.3 percent in 1951.

The population of the United States increased 42 percent in these 31 years while the population on the West Coast increased 160 percent. The number of physicists per million population increased from 11 per million to 66 per million in the country as a whole, and from 12 per million to 78 per million on the Coast. The concentration of physicists on the Coast has thus increased slightly faster than in the country—an increase in concentration of 6.5 times on the Coast to 6 times in the whole country.

Who were the physicists in California in 1920 and what were they doing? To shed some light on this question we can look at the names of the Fellows * of the American Physical Society residing on the Coast in 1920. There were only 27. Six of them were at the Mount Wilson Observatory—including George Ellery Hale, H. D. Babcock, and P. W. Merrill. There was only one Fellow at the California Institute of Technology—the beloved mathematician Harry Bateman. There were five Fellows at the University of California including E. P. Lewis, Raymond T. Birge, and the famous physical chemist G. N. Lewis. There were four Physical Society Fellows at Stanford, headed by D. L. Webster.

(Incidentally, in 1920 the president of the American Physical Society was J. S. Ames of Johns Hopkins; the vice president, Theodore Lyman of Harvard; the secretary, Dayton Clarence Miller of Case School of Applied Science; the treasurer, then *as now,* George B. Pegram of Columbia; the local secretary for the Pacific Coast, E. P. Lewis of Berkeley. The Council of the Society included such names as A. A. Michelson, E. L. Nichols, Ernest Merritt, A. G. Webster, Henry Crew, R. A. Millikan.)

If we count total members rather than only Fellows we find that in 1920 of the fifty-seven members in California, twenty were at Berkeley, twelve in Pasadena (at Caltech and Mount Wilson), seven at Stanford, one at what was then the Southern Branch of the University of California (now UCLA) and two at the University of Southern California. There appear to be no government laboratories represented though one person was listed at the Naval Observatory at Mare Island. Only one industrial physicist was listed—E. R. Woolcott, of the Western Precipitation Company.

The next ten years—to 1930—saw great changes in this picture. R. A. Millikan had come to Caltech in 1920 and the Berkeley group had begun the growth which was to come to such brilliant fruition in the 1930's. The number of Fellows of the APS on the Pacific Coast had now doubled to 54. The number of members more than doubled—to 170. There were now 13 Fellows and 35 members at the University of California and almost exactly equal numbers at Caltech. There were still only two or three physicists with industry—and still no government laboratories.

In other words during the decade 1920–30 two great centers of physics had been created in California, one at the University of California and the other at the California Institute of Technology. A lively but smaller group was at Stanford and the beginnings of a group at UCLA.

This pattern had not greatly changed by 1941—though the total number of physicists on the Coast had by then nearly doubled again. We now find 80 Fellows and 285 members—with the total national membership at 3750. The great centers of physicists were still Berkeley and Pasadena. The UCLA group had grown substantially. The Stanford group remained small, but distinguished. No government laboratories were yet visible but the beginnings of industrial research had appeared. Both Standard Oil of California and Shell

* In 1920 the two classes of membership was designated as Regular and Associate. The Fellow and Member classes were in effect by 1930. In 1920 44 percent of the total members were "Regular." In 1951 only 11 percent were Fellows.

CALIFORNIA

By ***Lee A. DuBridge***

Development Company were represented among the physicists, as were one or two motion picture companies.

The decade following 1941 has seen the most radical changes of all. We now find on the Pacific Coast 1134 members including 136 Fellows of the American Physical Society. Over 220 members are listed with a Berkeley address, 110 in Pasadena, 120 in Los Angeles, 65 at Stanford University. Many others live in other cities or suburbs adjoining these major centers. Some new locations have now appeared. In place of the three or four physicists listed in San Diego in prewar years there are now over forty. And a place called China Lake (near Inyokern), nonexistent a few years ago, now lists nearly sixty physicists.

The largest groups of physicists by far are still at the educational institutions. Eighty percent of the Fellows are so listed. But there has been an enormous growth of government and industrial laboratories. Large groups of physicists are now to be found especially in the aircraft and oil industries. Hughes Aircraft Company, The North American Aviation Company, The Douglas Aircraft Company, and Consolidated-Vultee have the major groups among the aircraft companies and California Research Corporation (a subsidiary of Standard Oil of California), Shell Development Company, and Union Oil Company among the oil companies. There are also literally scores of smaller companies—especially in the instrument and computer fields—which now employ many physicists. Industrial research has clearly come to California to stay. The days when it was hardly even decent to have a laboratory west of Chicago have gone forever.

In government research two great Navy laboratories dominate the scene: the U. S. Navy Electronics Laboratory in San Diego and the Naval Ordnance Test Station near Inyokern, but many others claim physicists on their staffs as well. Then there is the Rand Corporation of Santa Monica, a private corporation wholly engaged in research for the United States Air Force.

We now inquire as to the nature of the activities of the physicists at these various centers over the years.

It is well known to everyone that West Coast educational institutions have been pioneers in research in

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nuclear physics and in cosmic rays. R. A. Millikan began his pioneering studies in cosmic rays immediately after his arrival at Caltech in 1921. He maintained active interest in these studies until his retirement in 1945. In the meantime, Carl D. Anderson and H. V. Neher have most ably carried on this work up to the present time.

Experimentation in nuclear disintegration began both at Berkeley and at Pasadena in 1932. Lawrence's cyclotron began its brilliant career then, and from that time until just recently the Radiation Laboratory at the University of California has always had an electronuclear machine producing higher energy particles than were being produced anywhere else in the world. At the present moment the record for high-energy particles is held by the Brookhaven Laboratory with a figure of two and one-half billion electron-volt protons. However the Berkeley Radiation Laboratory has a five-billion-volt accelerator under construction.

In the meantime, at Caltech, major emphasis was given by C. C. Lauritsen and his colleagues to precision studies in the range under three and one-half million volts. Just recently, however, under the direction of R. F. Bacher, there was put into operation an electron accelerator yielding electrons of energies of over one-half billion electron volts, the highest electron energies so far produced.

During these years Stanford University has been outstanding in the field of x-rays (D. L. Webster) and nuclear physics (L. Schiff, Felix Bloch) and now has a linear accelerator producing electrons of several hundred million volts with plans for extending the energy to 600-million volts or more. Thus in the newer fields of nuclear physics West Coast institutions have been in the lead for the past thirty years.

The need for the development of theoretical physics was early recognized by R. A. Millikan, who began building a group around such men as P. S. Epstein, R. C. Tolman, and H. Bateman. J. R. Oppenheimer joined this group in 1927 and later, sharing his time between Berkeley and Pasadena, helped greatly to build strong theoretical groups on the Coast—members of which spread to the whole country.

In the field of industrial research the industries for which California is noted are aircraft, oil, and motion pictures. The largest dollar volume of business is in the aircraft field with a whole array of the largest aircraft companies in the country scattered from Seattle, Washington to San Diego, California. Though in the early days (that is, before 1930) airplane building was largely a trial and error proposition, it is nevertheless interesting that by 1928 plans for a large wind tunnel were well along at Caltech and there was close cooperation with the aircraft companies. When the Douglas Aircraft Company was able to add thirty miles an hour (which was quite a lot in those days) to the speed of the early DC-3 as a result of tests made in the Caltech wind tunnel, basic research in aerodynamics came to stay. A dozen important wind tunnels are now scattered throughout the state, several under the auspices of Caltech, and now the important new laboratory of the National Advisory Committee for Aeronautics located at Moffett Field near San Jose.

Possibly it will be thought presumptuous to include research in aerodynamics in a discussion of the activities of physicists. That is now supposed to be a field for engineers. However one of the important characteristics of at least the early work in aerodynamics on the West Coast was that it was directed by men who were physicists. Theodore von Karman, when he came to California Institute of Technology in about 1929, brought to the aeronautics problems the viewpoint of a physicist and his influence on the whole development of the science of aerodynamics has been profound and continuous up to this day.

But not all the physicists employed by aircraft companies are working in the field of aerodynamics. As the enormous program of guided missiles grew up after World War II, airplane companies scoured the country for physicists to do work in electronics, radar, guidance and control systems, and other related areas. The large groups of physicists associated with Douglas, Hughes, North American, Northrup, Rand and other companies are to a large extent in these fields. North American also has a sizeable group working on nuclear reactors.

It is inevitable that the oil industries should undertake research on the Pacific Coast. I think it was probably the Gulf Oil Company which many years ago led the industry in basic research in geophysics and petroleum chemistry. Other companies followed suit and both Shell and Standard Oil of California have built up large research organizations in the San Francisco Bay area during the past 20 years. More recently Union Oil Company has expanded its research laboratory in Southern California and I anticipate that there will be considerable growth in industrial research in the oil industry in the years ahead.

It is rather sad that the motion picture industry has not seen fit to undertake any comprehensive research program. This industry has depended upon the photographic, the chemical and the electrical industries to do its research. As a result Hollywood has been repeatedly caught flat-footed by the appearance of such major new developments as the sound motion picture and more recently television. Every now and then new proposals for motion picture research laboratories are made but so far they have never come to fruition.

As I have said, the two major government enterprises in this area are the Naval Ordnance Test Station at China Lake and the United States Navy Electronics Laboratory in San Diego. Each has an interesting history. During the early part of the war Dr. C. C. Lauritsen, a physicist at Caltech, became concerned because the United States had no rocket development program. After a visit to England he became convinced that rockets had an important future as a military weapon. When he returned to Pasadena he initiated, under the sponsorship of the Office of Scientific Research and Development, a rocket development project which eventually grew to one of the largest war labora-

tories in the country. Rockets were not only developed but also produced under the Caltech program and by the end of the war more than a million artillery rockets had actually been delivered to the Army and Navy. During the war the Inyokern area had been used as a test-firing location and at the suggestion of the Caltech group the Navy took over a sizeable tract of land there in order to establish a permanent rocket development and test station. Its activities now encompass every aspect of rocket and guided-missile work from explosives to electronics. The desert community at China Lake has grown into a city of nearly 10,000 souls working behind a barbed wire fence; and in off-hours successfully growing grass and trees on the desert sands.

In San Diego the United States Navy Electronics Laboratory was founded in 1940 as the United States Navy Radio and Sound Laboratory. Its mission then was to provide radio and sonar assistance to the Pacific fleet. This program continually expanded and today there are over one thousand civilian employees working in physics, mathematics, human engineering, meteorology, marine biology, geophysics, electrical, mechanical and electronic engineering. Its mission is a comprehensive one; namely, "The United States Navy Electronics Laboratory is charged with the design, procurement, testing, installation and maintenance of the fleet electronic equipment and systems." The Laboratory is under the auspices of the Bureau of Ships and the Commanding Officer reports directly to the Chief of the Bureau. The Laboratory, indeed, maintains a small fleet of its own, including a submarine.

A new government laboratory bids fair to be an important asset to the Pacific Coast in coming years—the National Bureau of Standards Laboratory at Corona, California. Now largely devoted to missile development it will eventually be, it is hoped, a real western branch of NBS.

I realize that I have neglected to give adequate mention or emphasis to a host of smaller but extremely valuable research enterprises in other colleges and universities, in other industrial laboratories and in other government laboratories. In California, as throughout the country, both pure and applied physics are moving ahead at a pace which most of us never dreamed was possible a dozen years ago.

It would be a mistake however for me to leave you with the impression that I believe that physics in California or physics in the nation is now in a period of joyous and healthy advance. The scientists of this country, like all other citizens, face grave problems and paradoxical situations which are cause for grave concern. Statesmanship of the highest order will be required to lead the nation into a happier period. I believe that scientific statesmanship is also necessary.

We are all proud of the fact that during World War II, scientists patriotically deserted their scientific activities and directed their efforts to the field of military technology. We witnessed during the years 1940–1945 an enormous and an enormously successful effort to use recently acquired knowledge in many fields of science in order to provide weapons and techniques which would assist our military forces to achieve victory. We hoped in 1945 that we could return to our scientific laboratories; and to a large extent we did so. Fortunately even in 1945 there were those who saw that in spite of the great victories of that year it was still not clear that world peace had been forever secured. Hence they saw it would be necessary to maintain a research and development program in military technology and that some scientists and engineers would need to remain in or be attracted into this program. This was done and the great laboratories like Inyokern and the Naval Electronics Laboratory are the result, for they have had a continuous history since the war years.

Since 1950 however we have faced the question as to whether the technological effort going into defense programs was adequate. Obviously, in 1950 the effort was not adequate and the military budget for research and development has been more than tripled since 1948. There seems to be no immediate prospect that it will not remain at this new level for a substantial period in the future.

This, in turn, has raised the question as to whether the nation is likely to be too short-sighted and abandon to too large an extent its basic programs of long-term research, particularly those of the type going forward in the universities. We face this dilemma; the situation appears sufficiently grave at the present time to warrant more scientists engaging in military technology but it is also sufficiently long-term that it would be dangerous to decrease much further our basic research activities.

There is obviously no single answer to this problem. There is no way of calculating what fraction of our scientific effort should be in one field or the other. Rather each person can make this calculation for himself and each may come out with a different answer depending upon his own estimate of the nature of the world situation, and of his own interests and talents.

I believe that it would be a grave mistake not only for national welfare but for national defense to reduce to any important extent our present programs of basic research in physical science. At the same time I also believe that a limited number of physicists now engaged in these programs probably should, in special circumstances, consider transferring, at least for a year or two, to critical spots in the defense program. Still more importantly I think it is necessary for the Department of Defense to review with exhaustive care its present research and development program to make sure that only the most important and critical projects are being pursued and that full and effective use is now being made of its scientific personnel. Our national situation is too critical and our shortage of scientists too great to allow us the luxury of wasting scientific talent, employing it ineffectively or on ill-considered projects. In the meantime we must expand every effort to increase the number of scientists being trained and do every other thing possible to improve the general health and progress of the scientific community.