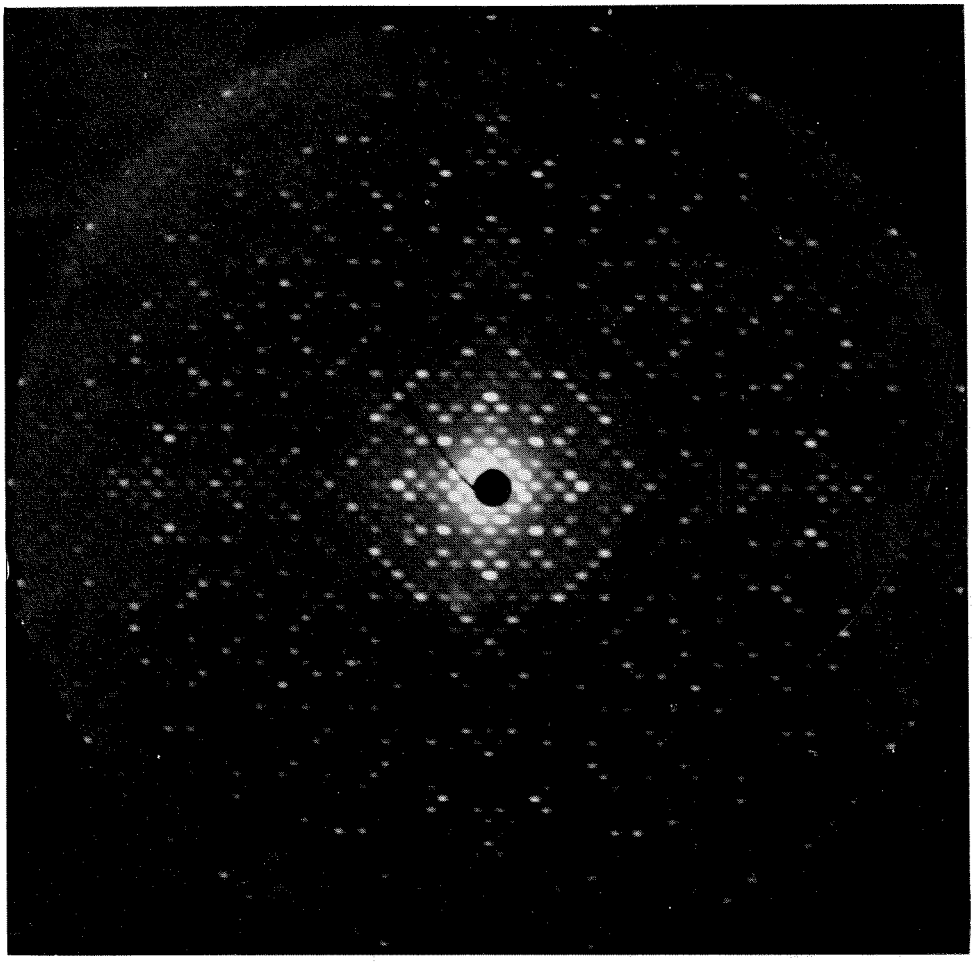

X-ray diffraction pattern of the crystalline enzyme, lysozyme, the structure of which is now being studied by Caltech chemists. This protein occurs in body fluids. When a crystal of lysozyme is placed in an x-ray diffraction camera and irradiated by a beam of x-rays, the crystal acts as a diffraction grating, producing this characteristic diffraction pattern.

An Anniversary

Caltech celebrates the 40th anniversary of the first American papers in x-ray crystallography

CRYSTALLOGRAPHERS from all over the country came to the Caltech campus on December 16 to celebrate the 40th anniversary of the first American papers in x-ray crystallography. Caltech was one of the first two centers in America (along with the General Electric Company) to initiate studies in x-ray crystallography, and the first two papers in this field were published in 1917—by Prof. J. H. Ellis and Dr. C. L. Burdick at Caltech, and by Dr. A. W. Hull of General Electric.

Dr. Burdick was on hand for the 40th anniversary celebration last month, to report on the beginnings of x-ray crystallography, and Dr. Dorothy Hodgkin, who conducts research at Oxford University, England, was the main speaker on current research in the field. Dr. Hodgkin is probably the most distinguished crystallographer in the world; with her students, she is responsible for two of the biggest jobs ever completed in the field of x-ray crystallography—the determination of the structures of penicillin and of vitamin B-12. She is now working on the structure of insulin.

X-ray crystallography is a science concerned with the determination of the positions of atoms in crystals. A tiny crystal is mounted in an x-ray diffraction camera and rotated in a beam of x-rays. The crystal acts as a diffrac-

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tion grating, scattering the rays to a photographic emulsion which surrounds the crystal. After several hours, the film is developed and the spots where the diffracted x-rays struck show up as a pattern of dots. From precise measurements the chemist can then determine the size and shape of the crystal's minute units. The intensity of each of the hundreds of dots is measured and is used in the determination of the positions of the atoms in the crystal.

The technique has been used at Caltech to determine the structure of molecules in crystals of metals, minerals and many organic compounds, especially those related to proteins and other substances of biological interest. The determination of a relatively simple molecule usually takes one or two years to complete.

The study of crystallography dates back as far as the 16th century, but until x-rays were discovered by Roentgen in 1895 the research was conducted mainly by mathematical measurement and visual study. The results obtained from these methods were close to guesswork, but even so, many researchers in the pre-x-ray period came very close to the correct atomic count later proved by x-ray study.

For 17 years after x-rays were discovered the nature of these radiations remained controversial. Finally, in 1912, Professor Max von Laue of Munich University proved that they were like visible light except for their short wave length. His investigations, which changed the whole study of crystallography, got under way after some informal discussions with a student who was preparing his doctoral dissertation on the passage of light waves through crystals. He surmised that the separations between atoms in crystal were of the same magnitude as the probable lengths of the x-rays about which so much controversy existed. And he suggested that crystals would serve as a naturally-made grating for the diffraction of x-rays, in the same way that artificially-ruled gratings made by scratching lines on glass with a diamond will diffract ordinary light. Experimental tests proved this to be true.

Later in the year 1912, Sir William Bragg and his son, Sir Lawrence, began the first x-ray crystallography studies. Since von Laue had used crystals to study x-rays, they figured, it should be possible to reverse the process and use known x-rays to study unknown crystals.

Von Laue received the 1914 Nobel prize for his discovery, and the Braggs' work won them the prize in 1915. The 40th anniversary of their pioneer papers in x-ray crystallography was celebrated in England in 1952 —and Dr. Dorothy Hodgkin was one of the main speakers at these ceremonies, too.

Work on x-ray crystallography started in the United States in about 1916, and the first papers were published the following year. The first of these was written by Dr. A. W. Hull. In 1915 he was doing electronics research at the General Electric Company in Schenectady when he heard a lecture by Sir William Bragg that interrupted his electronics research for several years. Sir William described his new work on the study of crystal structure by means of x-rays. After the talk Hull asked him if he had ever found the structure of iron, and Sir William admitted they had never been able to work it out. Though he was totally unfamiliar with both x-rays *and* crystallography Hull went back to his laboratory and began getting apparatus together to find the crystal structure of iron. In 1917 his paper recorded his success.

The second paper in the field was written by Prof. J. H. Ellis, in the chemistry department of what was then the Throop College of Technology, and Dr. C. L. Burdick. Burdick was a graduate student of Dr. Arthur A. Noyes' at the Massachusetts Institute of Technology. In 1916, at Noyes' suggestion, he spent six months in the x-ray laboratory of Prof. William Bragg at University College in London.

On his return to MIT, Burdick's assignment from Dr. Noyes was to build a Bragg x-ray spectrometer with any improvements which the state of the art would permit. Late in the year, when Noyes left for his annual tour of duty as visiting professor at Caltech, he asked Burdick to come along with him. The uncompleted spectrometer was abandoned in Boston, and work on a new one got under way in Pasadena.

This machine, which was used to determine the structure of the mineral, chalcopyrite, was the subject of the Burdick and Ellis paper. The paper is #3 in the chronological list of papers published from the Gates and Crellin Laboratories at Caltech. Today the list includes 233 papers in x-ray crystallography (out of a total of more than 2,000 papers in all branches of chemistry) and the x-ray crystallography laboratory at Caltech is one of the largest in the field, turning out as much work as any laboratory in the world.

Dorothy Hodgkin, one of the world's leading crystallographers, studies an x-ray diffraction pattern in the Caltech laboratories.