

RESEARCH FACILITIES AND PROGRAMS

History was made at Columbia

Columbia University's original cyclotron, a 10-MeV machine that has stood in the basement of Pupin Hall for 27 years, is being dismantled and sent to the Smithsonian Institution where it will be set up as an historical exhibit. The machine was one of the first particle accelerators constructed in the United States and was used for early experiments on the fission of uranium nuclei as well as other important work.

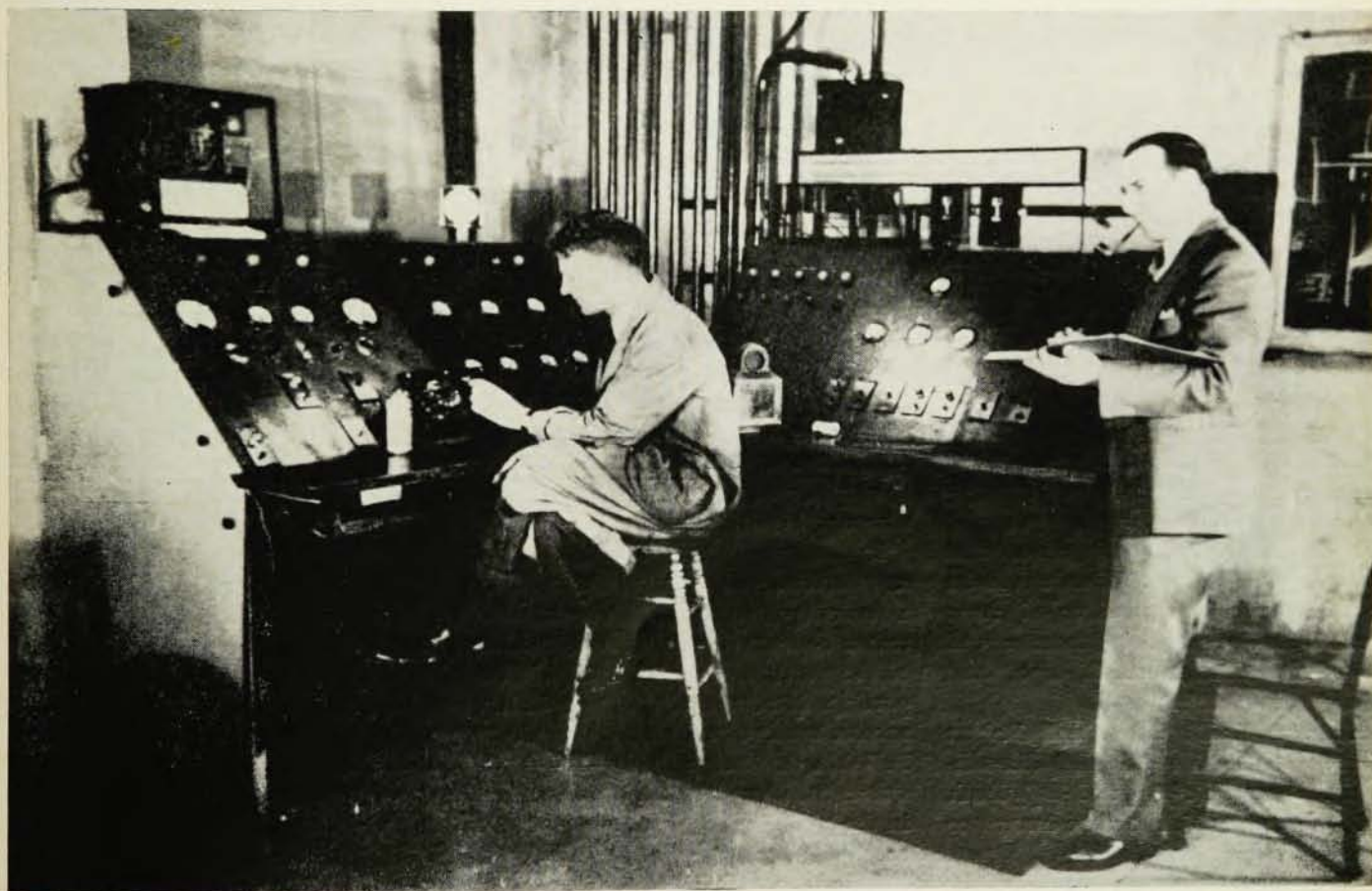
Construction of the cyclotron began in 1935 with a government grant—in kind. The Navy donated a 65-ton electromagnet that it had used in a radio transmitter and no longer needed. The instrument, when finished, had 30-in dees, and the 10-million-volt protons that it delivered were considered highly energetic in those days.

In the winter of 1939 the cyclotron was involved in one of its most remembered pieces of work. In 1938 Otto Hahn and Fritz Strassman had determined from chemical evidence that uranium nuclei could split into daughter nuclei, each of which proceeded to form an atom of a lighter element. The news that this reaction occurred with a large release of energy per fission was conveyed by Lise Meitner to Niels Bohr, who was then on his way to the United States. Bohr came to Columbia with the news, and Hahn and Strassman's publication of their results also spread the information. Among other interested parties, a Columbia group consisting of H. L. Anderson, E. T. Booth, J. R. Dunning, Enrico Fermi, G. N. Glasoe, and F. G. Slack began studies of uranium fission. In a number of trials they subjected uranium oxide to bombard-

ment by neutrons from a radon-beryllium source and from the cyclotron. The experiment was done late in January 1939, and a preliminary result was published on 1 March in *The Physical Review* [55, 511 (1939)].

The experimenters concluded that they had demonstrated uranium fission and went on, following an idea of Niels Bohr, to suggest that the fission occurred in the rare ^{235}U nucleus and not in the common ^{238}U . Dunning and Booth with A. O. Nier and A. V. Grosse confirmed this suggestion early in 1940 in other experiments at the cyclotron. To separate pure ^{235}U they developed the gaseous diffusion process later used at Oak Ridge.

During the war the cyclotron was used by W. W. Havens and James Rainwater for neutron spectroscopy work. They kept the machine running almost 24 hours a day, Havens in the



FIRST OPERATION OF THE CYCLOTRON. G. N. Glasoe (left) and J. R. Dunning at the controls late in 1938.



REUNION AT THE CYCLOTRON. G. N. Glasoe (left) and J. R. Dunning revisit the Columbia cyclotron in December 1965.

daytime and Rainwater at night. The machine kept working as a research and teaching instrument until quite recently. In its old age it may have been the world's oldest working cyclotron.

Shortly after the announcement of the transfer of the cyclotron, the university also announced that its Pupin building has been designated a national landmark because of the important events in the recent history of physics that have happened there.

Harold C. Urey was working in Pupin Laboratory when he discovered heavy hydrogen in 1931. On 24 February 1939, during an APS meeting, Niels Bohr and Enrico Fermi lectured on uranium fission in Pupin 301. A week after the speech Leo Szilard and Walter Zinn performed experiments (on the seventh floor of Pupin) from which they concluded that uranium could be an explosive.

In 1940, with a \$6000 grant from the Army and Navy, Fermi and a number of collaborators constructed the first "atomic pile," an arrangement of graphite bricks that was used to determine the neutron-absorption cross section of the substance and its possibilities as a moderator of chain reactions. The work was later moved to the University of Chicago, and Fermi went with it.

In 1947 Willis Lamb and Robert Retherford discovered the displacement between the $2S_{1/2}$ and $2P_{1/2}$ levels of hydrogen, which is now known as the Lamb shift.

The Pupin building was also the scene of much theoretical work and a

number of theoretical announcements including Yukawa's theory of elementary particles (1950) and nonconservation of parity in weak interactions (1957). In all, five Nobel prizes have been awarded for work done in Pupin. They are: I. I. Rabi for nuclear magnetic moments; Polykarp Kusch for anomalous electron magnetic moments (see page 23, this issue); Willis Lamb for the Lamb shift; Charles Townes for the maser; and T. D. Lee for work on nonconservation of parity.

The building was constructed in 1925. It is named for Professor Michael Ildvorsky Pupin, a physicist whose inventions were important in the development of long-distance telephone service.

CERN storage rings

A pair of intersecting storage rings will stack 28-BeV protons along the French border near Geneva, Switzerland. Construction of the rings, expected to cost 332 million Swiss francs, is scheduled to begin at CERN next summer.

In conventional high-energy physics experiments, energetic particles strike a stationary target and, since momentum is conserved, only a small fraction of the particle energy is available for particle interactions. In the CERN proton synchrotron, particles with 28 BeV kinetic energy in the laboratory system incident on a proton at rest in the laboratory have an energy in the center-of-mass system of 7.4 BeV.

An alternative scheme is to allow two beams of protons to collide. The

CERN device will use a pair of nearly concentric rings intersecting in eight places (at an angle of about 15°). Each 300-meter ring will be filled with protons from the synchrotron, and the two beams will circulate in opposite directions. When the two 28-BeV circulating beams are allowed to collide, the energy available for high-energy interactions will be 56 BeV. This is equivalent to 1700-BeV protons colliding with a stationary target. Proton accelerators with that much energy will not be built for many years. (The biggest existing accelerator is Brookhaven's 33 BeV; a 70-BeV proton synchrotron will be completed soon at Serpukhov, USSR, and the AEC is looking for a site in the US for a 200-BeV proton accelerator.)

The storage ring designers plan to store a 20-A current in each ring (the protons from about 500 pulses of the CERN synchrotron at present intensity). Since the ring will be highly evacuated (10^{-9} to 10^{-10} torr is expected) it is believed that the number of gas collisions will be small enough to store the beam for several days. In a talk at CERN in October 1964 G. Cocconi predicted that the rate of proton-proton collisions will be about 10^4 to 10^5 interactions per second (in a volume of 140 cm^3). He remarked that "experiments on p-p cross section and scattering will be easy . . ." and that the device could also be used to identify and measure characteristics of new particles, such as the quark (see page 44).

Although the proton storage rings will provide a unique tool for studying proton-proton interactions, they cannot be used to produce super-high-energy beams of secondary particles. So the CERN people are the first to admit that they will still need a much larger proton synchrotron than they have now. They hope to start building a 300-BeV accelerator soon if CERN member nations approve the expenditure.

The CERN authorization was made at the 31st session of its council, when 12 member nations (all except Greece) agreed to participate in constructing the rings and extending the CERN site into French territory. Two new experimental halls for 25-BeV work, with auxiliary installations, will