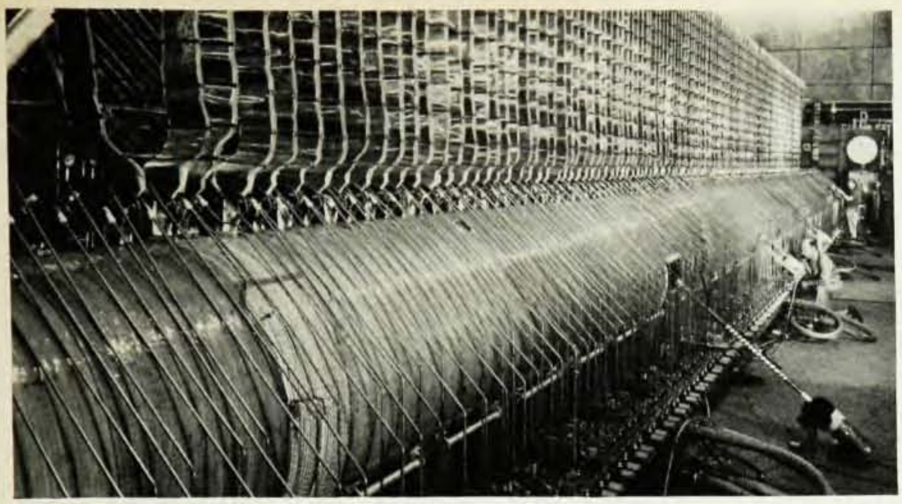

Fig. 3. View of the Astron tank from the west end.

trons of much lower energy. Thus, in the first experimental facility just completed, the electron energy is 4 MeV. The facility is expected to answer the most crucial question about the Astron concept: Is the E layer stable? Under certain conditions, the passage of a beam of high-energy particles through a plasma generates electromagnetic and/or plasma waves, resulting in fast energy exchange between the particle beam and the plasma. It is not known whether this will happen in the Astron; the geometry of the E layer and the electron-density distribution in the E layer are such that theoretical formulation of the stability problem seems to be impossible. The crucial question of the stability of the E layer has been the subject of much controversy among the Project Sherwood theorists during the last five years, but so far there is neither rigorous proof nor disproof of E-layer stability. Hence the question must be answered experimentally.

The first three years of the Astron project were devoted to the development of components for the electron accelerator and to the design of the first Astron model. The electron accelerator, shown in Fig. 2, has now been operating for almost a year. It is a linear machine, operating on the magnetic-induction principle, and it accelerates an electron beam of 150 amperes up to 4 MeV. The pulse length is 0.3 microsecond and the pulse rate is 5 to 50 pulses/sec. Thus more than 2×10^{14} electrons per pulse are accelerated. The relatively large number of electrons per pulse is required by Astron's particular method of trapping electrons. It is not possible to inject and trap charged particles in a magnetic field constant in time. Astron achieves trapping by sending the injected electrons through a large number of resistive rings, shown in Fig. 1 and 1a, before they arrive in the trapping region. As the electrons pass by the resistors, they lose some of their energy by inducing eddy currents in the resistors. This small energy loss of the electrons traps them in a magnetic potential valley. Since the magnetic field is stronger at the ends of the vessel than in the middle region, the electrons are trapped just as a car may be trapped in a valley between two hills if it comes downhill with the brakes applied. The energy loss per electron is proportional to the total number of electrons injected per pulse; therefore the number of electrons per pulse must be great enough to provide sufficient energy loss for trapping to occur.

The high-energy electrons are injected into a tank 90 feet long, with an inside diameter of 2.5 feet (Fig. 3). A long solenoid 4 feet in diameter placed outside the tank generates the vacuum field required to guide the injected electrons in forming a cylindrical E layer two feet in diameter and 40 feet long. Between the injector and the end of the E layer (which are 20 feet apart) the tank interior is filled with resistive rings which slow down the injected electrons.

The central part of the solenoid consists of 128 coils, each one-half foot long, which are energized independently by 64 power supplies. Thus any desired magnetic field shape can be formed. The field shape can be changed during the buildup of the E layer to conform with the field pattern required to maintain the E layer in equilibrium at the desired radius and length. This part of the facility has just been completed, and experiments aimed at trapping the electrons have begun.

The first phase of the experimental program is aimed at trapping a single electron pulse and studying its behavior under a variety of conditions. Following this phase the objective will be to build up the E layer in steps, to study its behavior, and to determine the necessary conditions to circumvent possible instabilities. Finally, the crucial step will be attempted: to build the E layer up to the point of establishing the pattern of closed magnetic-field lines and eventually to generate and confine a plasma. It is estimated that at least a year will be required before the question of E layer stability can be answered.

Meanwhile, the Joint Committee on Atomic Energy, in a report to the Appropriations Committee dated April 21, said: ". . . those approaches (toward controlled fusion) which are explored and prove unproductive should be abandoned. As an example, the AEC testified that ASTRON, an approach which is only now beginning to be tested, will prove its worth or lack thereof during the next fiscal year. If found unproductive, it should be dropped."

If the E layer proves stable, however, then a hot Maxwellian plasma may finally be produced and maintained in steady state. This would be a major achievement—one perhaps opening the door to controlled fusion.

The Farthest Quasar

The most distant object ever observed has been reported by M. Schmidt and T. A. Matthews of the Mount Wilson and Palomar Observatories. The faint (18th-magnitude) object is a quasi-stellar radio source designated as 3C147 in the *Third Cambridge Catalogue of Radio Sources*. The "quasars" are the most energetic objects ever found, and about a dozen of them are now known.

The apparent recessional speed of 3C147 is inferred to be 76 000 miles per second on the basis of its spectral red shift, which is the greatest ever observed. Wavelengths were shifted 54.5 percent, implying that 3C147 is 10 to 20 percent further away than 3C295, a galaxy previously considered the most distant object. The actual distance of 3C147 from the earth depends on the cosmological theory one applies to the calculation.

Dr. Matthews located 3C147 with the twin 90-foot dishes of the Radio Observatory at California Institute of Technology. Its recession rate was then obtained by Dr. Schmidt from spectra he photographed with the 200-inch Hale telescope at Mt. Palomar.

Project West Ford

The Space Science Board of the National Academy of Sciences, in a recent report on the Project West Ford communications experiment, has concluded that the controversial dipole belt placed in orbit last year has not interfered with observations in either optical or radio astronomy. Under the project, which was carried out by the MIT Lincoln Laboratory, more than 400 million copper-wire dipoles, each less than one inch long, were placed in a nearly circular, 2000-mile-high polar orbit early in May 1963. The dipoles were gradually dispersed over a period of several weeks to form an artificial reflecting belt for experiments in directed radio-frequency radiation in the 8000-Mc/sec band. The dipole belt was used during the ensuing months in communications experiments between stations in Massachusetts and California.

The proposed project had been brought to the attention of the Space Science Board by the Lincoln Laboratory in 1959, and several meetings of astronomers, physicists, and other specialists were convened to study the possibility of interference with other scientific activities in near space. On the basis of preliminary findings reported in June 1960, the Board concluded that the first exploratory test belt proposed by the Lincoln Laboratory would probably not have any adverse scientific effects, but it expressed some concern over the possibility that a subsequent operational communications system might interfere with optical and radio astronomical observations. The Board accordingly recommended that any planning for such a system, or for any larger-scale repetitions of the initial experiment, should take into account the protection of the interests of astronomical research and of science in general, and that full information on the scientific and operational aspects of the first experiment be published promptly for the information of the world scientific community.

Also in 1960, the Board created a standing committee of optical and radio astronomers (under the chairmanship of John W. Findlay of the National Radio Astronomy Observatory) to work closely with the project staff at the Lincoln Laboratory, to review developments as plans for the experiment progressed, and to share its information and findings with scientists generally. In a report made public on March 26 and based on review and analysis of the first five months of the West Ford experiment, the committee states:

"We conclude, as was originally forecast, that as of the time of this settlement and with the observing techniques in use today the present West Ford experiment has not been harmful to either optical or radio astronomy.

"The predictions of the effects of the experiment have been reasonably well borne out by the observations. We may therefore rely on essentially the same methods to predict the effects of any experiments similar to the West Ford experiment which may possibly be proposed in the future, suitable allowance being made for the increased vulnerability that may be associated with future advances in observing techniques."

At the time the Committee's survey was completed (in October 1963), the belt was in nearly circular orbit at an altitude of 3640 kilometers, with a predicted lifetime for individual dipoles of the order of three years, and the report cites evidence that some of the material was dispensed in clusters. The clusters were then thought to be following the same orbit as the individual dipoles and would therefore be expected to have the same lifetime. Later measurements have indicated that there is an increasing orbital separation between the individual dipoles and the clusters that would result in differences in their respective lifetimes, but it is emphasized that this development does not affect the conclusions reported by the committee.

In releasing the report of the West Ford Committee, the Space Science Board announced that the duties of that committee have been taken over by the Board's recently established Committee on Potential Contamination and Interference from Space Experiments. Members of the West Ford Committee will continue to work with the new group.

New Cyclotron

The world's most powerful spiral-ridge cyclotron is expected to begin operation on the campus of Texas A & M University some time in 1968. Jointly funded by the Atomic Energy Commission, the Robert A. Welch Foundation, and Texas A & M, the $6 million machine will be a variable-energy, multiple-particle accelerator with a maximum energy of about 120 MeV, twice the energy of the Berkeley 88-inch spiral-ridge cyclotron, and a minimum energy of 10 MeV. The Texas cyclotron will have a 400-ton magnet, measuring 88 inches across the pole face.

The initial research equipment will be designed for heavy-ion nuclear physics, under the direction of John McIntyre; nuclear chemistry, under Dwight Conway; and particle-correlation experiments, under George Igo. Prof. Igo will also head the Cyclotron Institute that will operate the machine. It is expected that nucleon-nucleon and few-nucleon problems will be added to the research program at some later date. John Gammel will be in charge of an associated Theoretical Physics Institute.