Joyce Waddo
Booster

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national accelerator laboratory

MONTHLY REPORT OF ACTIVITIES*

F. T. Cole

November 1, 1968

Abstract: This report covers the activities of the National Accelerator Laboratory for the month of October.

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General

1. Groundbreaking. Ground will be broken for the construction of the National Accelerator Laboratory at a ceremony on Sunday, December 1.

2. Status of Conventional-Facilities Efforts.

   a. Linac Enclosure. The linac enclosure was sent out for bids on October 15. The reaching of this milestone four months ahead of our Design Report schedule was the culmination of a splendid effort by AEC, Laboratory, and, especially, DUSAF staff. The bids are scheduled to be opened on November 13. Ground will be broken December 1 (see above).

   b. Construction Power. Work will begin in November on a temporary line to bring construction power from the southwest corner of the site to the area of the linac enclosure.

c. Rough Roads and Grading. This package is now out for bids. Bids are scheduled to be returned and opened November 19.

d. Booster Enclosure. Review of Design Definition (Title I) is being completed this week. Construction Design (Title II) is scheduled to be completed and reviewed and the enclosure put out for bids by the beginning of January, 1969.

e. Cross Gallery. The Preliminary Design Definition (pre-Title I) is now being reviewed.

3. Laboratory Village (Campus). J. S. Fiedler has been appointed Village Manager. He will supervise operation and maintenance of the Village.

Bids have been received and a contractor selected for the Main-Ring Enclosure Prototype. Work will begin in the first week of November.

Satisfactory bids have also been received for the Main-Ring, Shop, and Beam-Transfer Buildings. It is expected that a contract will be let and construction begun in the next few weeks.

The Beam-Transfer Building was formerly called the "Experimental-Facilities Building." The two sections will share the use of the building; its name has been changed to be in accord with the expected larger use of the building in the near future. A second laboratory building for experimental-facilities work is also planned.

Bids are due to be returned and opened November 7 on the Booster Laboratory and Enclosure Prototype, to be built in the Village.

Figures 1 through 5 of this report show various aspects of the Village and Laboratory activities in it.

4. Research Physics. A Research-Physics Section has been formed to serve as a focus for experimental particle-physics research by Laboratory staff members from other sections. E. L. Goldwasser heads the new section.

5. Laboratory Staff. On November 1, the Laboratory has 270 employees, including 76 scientists and engineers; we are somewhat ahead of our projected personnel buildup.

Main Ring

1. Model Magnets. Two configurations of the 20-ft structural model have been made. The first is the "bolted side-plate" design of W. M. Brobeck, while the second is supported by plates welded to the top and bottom of the core stack and tied to the side straps with welded-on angle pieces. The first configuration is very limber horizontally and in torsion; the second has a large sag. A simplified version of the second design has been developed that should improve the vertical rigidity.

Pulsed tests on the 3-ft wide-gap model give measured fields consistent with those of the dc tests except at low fields, where the pulsed field has somewhat less sextupole component than was present for the dc measurements. This effect is not yet understood.

2. Geodolite. We have received our Geodolite, the precision laser ranging system for the main-ring survey. The instrument transmits an amplitude-modulated cw laser beam to an optical corner-cube target. A 100-power reflector telescope collects the target return, which can either be viewed or sent to a photomultiplier tube. Distance is calculated by a phase comparator operating on the modulating frequency. Absolute distance determination is possible to 100,000 ft. The advertised resolution is 0.003 ft or better. Preliminary tests in the RF Building indicated resolutions considerably better than 0.0001 ft.

3. Plans for the Coming Month. Materials will be procured for a new 20-ft long bending-magnet model to test structural effects. Further tests on the end shape of the 3-ft wide-gap model will be made, and tests on a scheme for compensating the saturation of the magnet at fields above 19 kG will be performed. Magnetic tests of the 3-ft cores with inset side straps will be made.

Booster

1. Magnet Models. Several models are in various stages of construction, for magnetic-field measurements and others for studies of fabrication techniques and vacuum properties. The full-length (10-ft)

vacuum model has now been stacked and coils for this are due early in December. Measurements of the 3-ft model of the earlier design gave results in good agreement with the computed field shapes. The ac power supply is close to completion and will be used to power the 3-ft (24 in. by 16 in.) magnet for establishing the ac field-measurement techniques.

2. Design Progress. A series of notes is being prepared describing the present booster design. Alternative designs for booster magnet-support systems and interconnections are being prepared. To avoid excessive voltages to ground, it has been decided to parallel pairs of coils in the booster magnet. This results in a peak current of about 1200 A; the peak voltage to ground is now about 600 V. The booster ring-module design presently favored incorporates common electrical and water-path connections. The feedthroughs and the various possible magnet-connection arrangements will be tested on the 10-ft vacuum model.

3. Plans for the Coming Month. The week of November 11 has been designated as Second-Harmonic RF Week for the purpose of studying the use of second-harmonic cavities in the booster.

Linac

1. Modelling and Design Program. The 10-MeV linac cavity has

been rolled and welded. Welding of the end flanges and cooling channels will follow.

The fabrication of the first 57 quadrupoles in the linac has been completed. All end caps and cylindrical bodies (for drift tubes 19 through 57) have been roughed out and await final machining. A fabricator has been selected for the electron-beam welding of the drift-tube assembly.

Work continues on the fabrication of the 800-kV high-gradient accelerating column. The interior titanium focusing electrodes have been received.

The fabrication of the modulator and 5-MW 200-MHz power amplifier are on schedule, with delivery expected in January.

3. Plans for the Coming Month. Fabrication of the components for the 10-MeV linac prototype will continue. Fabrication of the triplet quadrupoles in the preaccelerator-to-linac beam transport line will begin. Construction of beam diagnostic equipment to be used with the 100-kV ion source and 10-MeV linac will begin.

Radio-Frequency Systems

1. General. An overall booster rf-system schedule has been produced and individual item schedules have been generated in some detail by the engineers responsible for the items. These schedules will be reviewed and coordinated into a more detailed schedule for the complete booster rf system.

2. Booster Cavity. A number of variations in ferrite-ring size and tuner arrangements were studied, verifying the selection of 8 inches as the o.d. for the ferrite toroids. The prototype cavity will initially be constructed with three pairs of tuning stems with each stem containing fourteen 8-in. o.d. toroids. The same size toroids used in the booster cavity can be used in the main-ring tuners.

Assembly of a temporary 5-V, 2400-A bias power supply from components transferred from Berkeley is under way.

3. Booster RF Amplifiers and Power Supplies. A cascade rf amplifier using a dozen 4CW800 tetrodes driving the X2011M output stage is currently being designed. The tubes for the prototype have been ordered and a filament transformer for the X2011M is under construction in the RF Building.

4. RF-System Controls. Initial plans for our use of a control computer have been completed and the requirements for the computer drawn up and presented to Engineering Services for procurement of a minimal configuration SDS Sigma-2, as part of a three-computer system connecting Linac, Booster, and RF-Section processors together.

5. Plans for the Coming Month. A ferrite specification will go out to prospective suppliers early in November in order to have ferrite available for high-power prototype tests early next year.

Beam Transfer

1. Electrostatic Septum. A recent innovation in the electrostatic septum is the possibility of having the high-voltage electrode outside the "C" that supports the septum foil. This will simplify considerably the mechanical design of the electrode-support system, because it separates the design into two completely independent structures, only one of which, the foil, has critical alignment requirements.

2. Edge-Cooled Septum Magnet. For the 30-mil edge-cooled septum, we are studying aluminum cooling channels that use a thin (less than 1 mil) anodized layer for electrical insulation. This layer has very little impedance to the flow of heat across the interface.

3. Plans for the Coming Month. The fast-kicker development program is just beginning. The week of November 18 has been reserved as Booster-Extraction Week. During this time, we hope to concentrate on fixing the septum and kicker parameters.

Storage-Ring Studies

A one-week study session was held from September 30-October 4 to study the experimental use of the storage rings. About ten experimentalists participated for various lengths of time during this period. As a result of this study, several modifications of the design of the intersection insertions were made. The present major parameters of the storage rings are given in an appendix to the report.

Three types of magnets were studied, all with iron yokes operating at 20 kG, but with (a) room-temperative copper coils, (b) cryogenic (20° K), aluminum coils and (c) superconducting coils at 4° K. Designs (b) and (c) are comparable in cost and both lower in cost than design (a). On the other hand, a certain amount of development work is necessary for (b) and (c). Air-core high-field (40-60 kG) superconducting magnets were also studied. These magnets, in addition to having questionable technical feasibility, do not seem to have any economic advantage, at least in the near future.

To obtain a vacuum of 10^{-9} torr for design (a), we can install a linear ion pump inside the vacuum chamber along the whole length. This linear ion pump will occupy a cross-sectional area in the vacuum chamber of less than 1 in^2. For designs (b) and (c), the cryogenic pumping of the vacuum chamber walls at temperatures below 20° K plus H_2 absorption panels will provide the required vacuum. Preliminary cost estimates for designs (b) or (c) give totals of approximately $70 million.

Radiation Physics

1. PPA Experiment. Absolute thermal-neutron fluxes in a labyrinth opening to a Pb target bombarded by 3-GeV protons have been measured in an experiment carried out by the section at the Princeton-Pennsylvania Accelerator. The Oak Ridge group has calculated these same fluxes and the results are in very good agreement with the experiment.

Experimental Facilities

1. Large Bubble Chamber. A Schedule 44 Construction Project Data Sheet has been submitted to AEC jointly with Brookhaven National Laboratory for Title I and II design and Advanced Procurement funds for a 25-ft cryogenic bubble chamber. The request is for $2, 300,000.

2. Superconducting Program. Preliminary calculations of beam-transport magnets show that significant cost reductions may be attained by keeping the field below 20 kG. The iron yoke provides all or most of the magnetic field, and the superconductor will be used primarily to magnetize the iron. Further analytical studies along these lines are being carried out.

In accordance with this, a joint NAL-ANL program has been started to build and study a model 20-kG ironclad superconducting bending magnet. The purpose of the model is to develop design and construction techniques compatible with beam-transport magnets.

In the first phase, the model will be designed primarily to produce a simple field. The optical characteristics will be taken into account in the design, but materials and construction techniques used will result in operation of the model in minimum time. As such, the model bending magnet should provide information of the superconductor and cryogenic-system characteristics. The attainment of suitable optics will be a later goal of the program.

Appendix. Storage-Ring Parameters

Energy	100 BeV-100 BeV
Radius	1/3 km
Lattice	Separated-function FODO lattice with 6 intersecting matched insertions
Normal cell length	24 m
Field of bending magnet	20 kG
Field gradient of normal cell quadrupole	2.5 kG/cm
Matched insertions	3 type-E insertions 3 type-I insertions
Type-E insertion (all for experiments)	
Intersecting angle	50 mrad
Free drift length	72.5 m
Beam characteristics	min β_y = 4 m non-dispersive
Type-I insertion (2 for injection and beam dump, 1 for future experiments)	
Intersecting angle	50 mrad
Free Drift length	68 m
Beam characteristics	β_x = 49 m β_y = 39 m x_p = 3.6 m
Number of MR pulses injected per ring	20
Beam current per ring	23 A
Luminosity of intersecting point	10^{32} cm^{-2}sec^{-1}
Average vacuum pressure	10^{-9} torr
Pressure in experimental insertions	10^{-11} torr
Half-life of beam	130 hrs

Fig. 1. An aerial view of the village taken October 26, looking south-west. The tent and the two-story house to be made into a conference room can be seen near the Director's Office. To the right, the one-story homes up on wheels are being moved by former residents.

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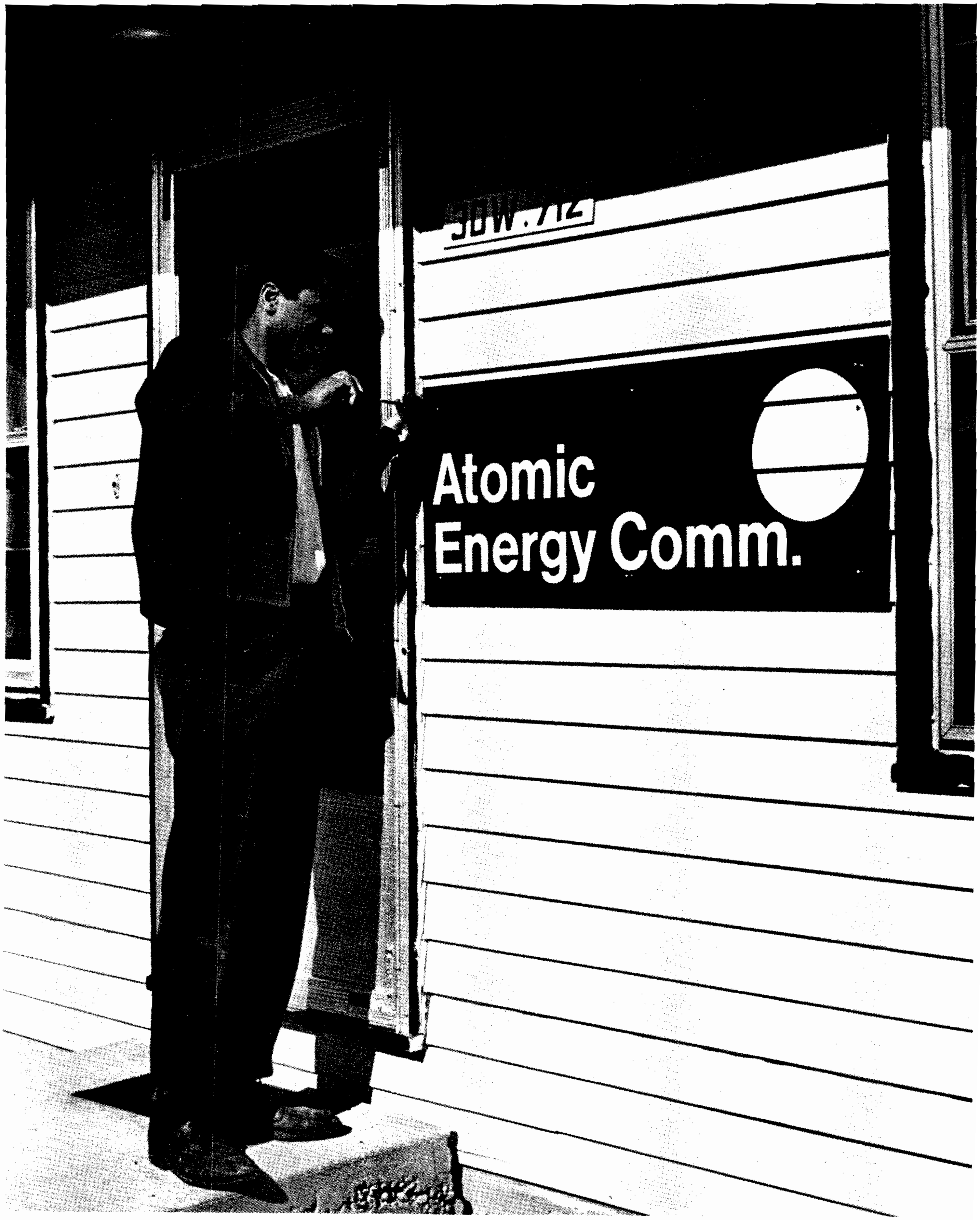

Fig. 2. Welcome, AEC!

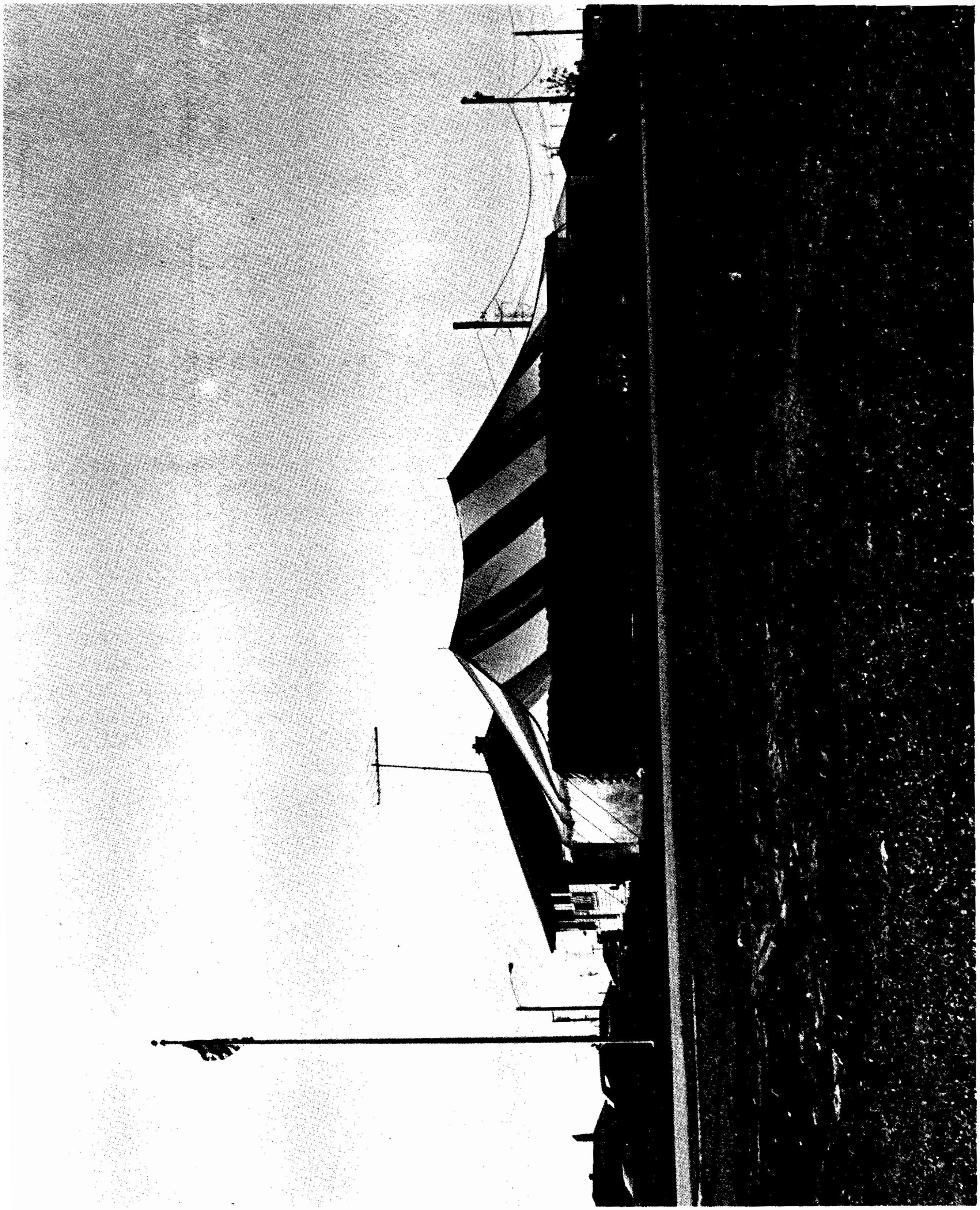

Fig. 3. The meeting tent by the Director's Office.

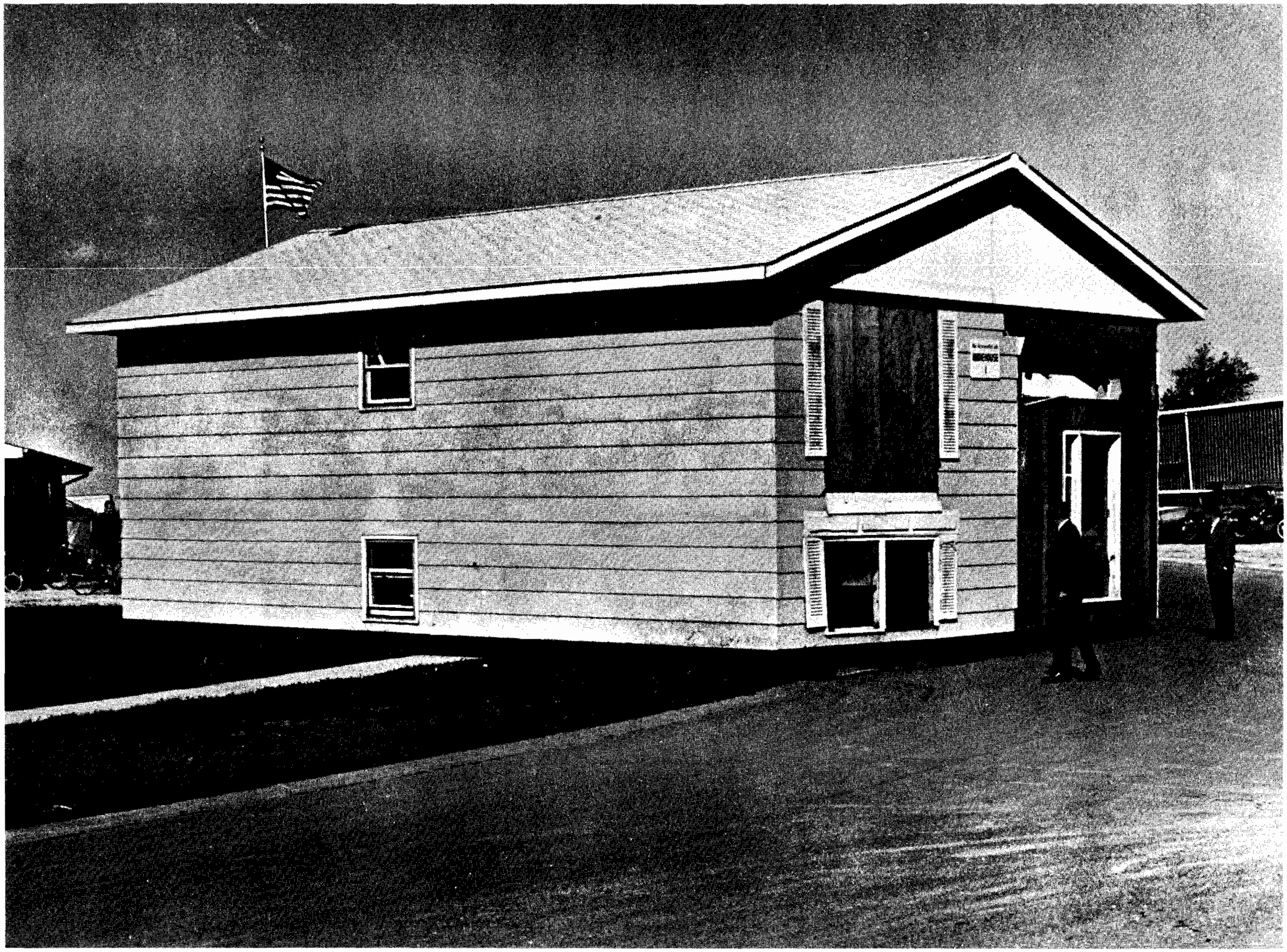

Fig. 4. Two-story house being moved to make a conference room. The move is being supervised by M. S. Livingston and E. D. Courant (who are observing the alternating gradient of the curb) and M. Awschalom (behind the house).

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Fig. 5. Beginning of a bike race during lunch hour on October 18. Barbara Rozic of Main Ring, Carolyn Noble of Planning and Scheduling, Rene Tracy of Technical Reports. (This photograph courtesy of The Chicago Tribune).