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# MONTHLY REPORT OF ACTIVITIES*

F. T. Cole

October 1, 1968

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

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## General

1. Campus. The move of the Laboratory to the Campus, or "The Village," has been carried out and the Oak Brook quarters vacated as of September 30. Figure 1 was taken at the first raising of the flag on September 24. Figure 2 shows the Director's Office; Fig. 3 was taken during the last day of the move from Oak Brook. Figure 4 is a recent photograph of the RF Building, the structure of which is now completed. Work on plumbing, heating, and electrical systems is under way.

Some changes have been made in locations of structures to be built as part of the Campus development. The laboratory building to be constructed for the Experimental Facilities Section will be built north of the RF Building rather than south of it. Other changes have been made in the use planned for existing residences. Our most recent master plan is shown in Fig. 5.

2. Cross Gallery. Inclusion of the Cross Gallery in the work

authorized for fiscal-year 1969 has been officially approved.

3. Laboratory Staff. As of October 1, the Laboratory has 251 employees, including 74 engineers and scientists.

## Theory

1. Magnet Design. Profiles for the booster magnets making use of subsurface voids have been generated using complex-variable transformations. The low-field and high-field profiles have been adjusted to yield the same pole widths and pole-center offsets. Assessment of the profiles so determined is now underway using the TRIM program.

## Main Ring

1. Model Magnet. Preliminary pulsed-field measurements show some effects of eddy currents, but since it has not yet been possible to measure directly the remanent field under pulsed conditions, some uncertainties still exist. It should be noted that the model coils have large insulation thickness, which is expected to produce just such eddy-current effects. The insulation thickness in the actual coil is to be much smaller.

Calculations of the effects of the errors in the placement of the copper in the magnet coils satisfactorily account for the observed shape of the magnetic field at moderate fields both on and off the median plane. It appears that proper tolerances can be met in the fabrication of the coil.

2. Prototype Enclosure. The drawings and specifications for the enclosure went out for bid on September 25.

3. Vacuum System. The 50-ft model chamber with small pumps and straight-section hardware corresponding to present thinking has been finished. Among other uses, it is serving to test various roughing systems.

4. Plans for the Coming Month. A new 20-ft long structural model of the bending magnet will be completed. Magnetic tests on the narrow-gap 3-ft model will start and the 3-ft wide-gap model with inset side straps will be readied for magnetic tests.

## Booster

We are happy to announce that Paul Reardon will become the head of the Booster Section, with Roy Billinge assuming the position of Associate Head.

1. Plans for Initial Booster Operation. Ways are being examined to improve the present schedule, which calls for the first 10 GeV beam in July of 1971. One feature that will be incorporated is to start up initially at at 7.5 Hz with low intensity and with only 8 rf cavities. Later, the Booster will be brought up to full intensity. The possibility of including some second-harmonic cavities is still open, and the week beginning Nov. 11 has been set aside to study this in detail.

2. Building Design. The preliminary Title I of the Booster

complex has been reviewed and we expect to finish the Title I plans by October 5.

A provisional design for the first part of the 10 GeV transport system and beam dump has been used to specify the buildings. In this new arrangement, the beam dump is at a depth of about 20 feet below the floor level of the 10 GeV transport and main-ring enclosures.

3. Model-Magnet Program. The first stage of the magnet-measurement program was aimed at developing measurement techniques. Excellent agreement has now been obtained between results from a differential Hall probe and balanced search coils. Two 3-ft magnets have been stacked and fitted with coils for ac power supply tests and for developing ac field measurements. A delay has occurred in the manufacture of the coils for the dc magnet. Consequently, some dc measurements will be made in one of these 3-ft magnets to compare measured and computed field shapes.

A quarter-length 16 in. by 12 in. magnet is now stacked and will shortly be enclosed in a stainless-steel chamber for vacuum tests. It is shown in Fig. 6. A 1-ft model is also being assembled from half laminations and will be used for comparisons of fabrication techniques.

## RF Systems

1. Power-Amplifier Fabrication. The technical problems of the rf power amplifiers, drivers and modulators have been discussed on

an initial level with prospective suppliers, including RCA, Raytheon, and Continental Electronics. Further discussions will be necessary because of the special amplitude and phase requirements of the accelerator rf system as compared to those of the usual communications transmitter.

2. Booster-Cavity Fabrication. A technical specification for 8-in. ferrite rings has been prepared for submission to ferrite producers. Vincent Kelleghan, mechanical engineer, has joined the rf section this month and is pursuing mechanical design of the power amplifier and booster cavity. Inasmuch as certain mechanical and electrical features of the power amplifier are common to both the main ring and the booster, it is planned to use identical parts in the two systems wherever practical.

3. Storage-Ring RF System. An rf system design was produced for the 333-m proton storage-ring being studied. The principal rf problems are the suppression of beam-cavity interactions and the provision of accurate rf amplitude and frequency control to permit beam stacking with minimum dilution. The proposed system employs a coherent frequency synthesizer, phase-locked to the main ring at the time of transfer, to generate an accurate reference rf signal.

A quarter-wave cavity of 10 $\Omega$ characteristic impedance close-coupled to the power tube provides 20 kV peak accelerating voltage. A feedback system continuously compares the cavity gap field to the reference signal and acts to reduce the difference. Unwanted cavity response to higher rf harmonics is damped by ferrite loading blocks placed at the short-circuited end of the cavity.

## Linac

1. Modelling Program. Progress is being made on the fabrication of the 800-kV high-gradient accelerating column. Plans are being formulated for the construction of an 800-kV high-voltage power supply to allow testing of the column to proceed in the absence of the high-voltage supply ordered from the Haefely Company. An ion-source test stand, complete with electronics, has been assembled and the first acceleration of protons (to 100 KeV) will take place as soon as the ion vacuum pumps have been delivered (delivery is expected in October).

The 10-MeV linac cavity is being rolled. The quadrupole fabrication for the first 57 drift tubes in the cavity is nearing completion at BNL. The parts of the first 18 drift tubes are being fabricated in our shops and contracts for the balance of the work are being negotiated. The purchase order for the fabrication of these quadrupole power supplies has been released.

Experiments using the recently delivered SDS Sigma II computer to measure the 200 MHz rf fields in the 10 drift-tube test cavity are in progress. Further computer peripheral and interface equipment proposals are being solicited in coordination with the other sections with similar requirements.

2. Building Design. The review of the 90% Title II drawings for the linac building was carried out on schedule in collaboration with the AEC and DUSAF. The 100% specifications and drawings were received from DUSAF on September 30 and are now under review.

3. Plans for the Coming Month. Fabrication of the components for the 10 MeV linac prototype will continue. Review of the specifications of the linac permanent buildings will be completed and the construction of the buildings will be put out for bids.

## Experimental Facilities

1. General. During the summer of 1968, the staff of the Experimental Facilities Section has increased from 4 to 11. In this time, there have been two principal activities in the section:

(i) Participation in the 1968 Summer Study Program at Aspen, whose purpose was discussed in a previous monthly report. The Summer Study is further discussed later in this report.

(ii) Continuation of the experimental study of secondary-particle production by high-energy protons using the 30 GeV BNL AGS. The experimental setup has now been fully tested in a low-intensity AGS test beam and the experiment proper will probably start in the spring of 1969, in the AGS external proton beam.

During September and the next few months, the staff of the section is concentrating on the assimilation of the contributions of the participants in the Summer Study. There are two primary initial goals:

(i) A zero-order projection of the distribution of the \$60 M of equipment funds expected to be available in FY 69 through FY 73. The magnitude of the initial high-energy physics program will be determined by these expenditures.

(ii) A revised master plan of the experimental areas. This plan is to be completed by January 1, 1969. Using this master plan as a basis, Title I design of the first (upstream) target station and experimental station will start early in 1969.

2. Review of the Summer Study. A number of informative papers have been written on an enormous variety of beams, detectors, and experiments by the participants. The topics include:

(i) The design of bubble chambers for use at NAL and their application to specific high-energy physics experiments.

(ii) Hybrid spectrometers, consisting of combined bubble-chamber and spark-chamber systems, taking advantage of target-vertex visibility in the bubble chamber and the measurement accuracy achievable in the spark chamber.

(iii) Streamer-chamber spectrometers.

(iv) Proton-proton scattering experiments using the extracted proton beam in specially constructed target stations.

(v) New and less costly schemes for targeting and dumping the external proton beam and for shielding in the target areas.

(vi) New suggestions for master plans of experimental areas, including the question of the internal-target area.

(vii) The design of a wide variety of secondary-particle beams, for example, neutrino and antineutrino beams, pion beams, separated K beams, and of specific experiments that require the availability of these beams.

(viii) Experiments to search for intermediate bosons, quarks, and Dirac monopoles.

(ix) Applications of superconducting techniques to secondary-particle beams.

Internal-Target Area. The tentative decision of June, 1968, not to construct an internal-beam target station and associated experimental facilities was considered by the Summer Study. No argument was developed that established a clear need for an internal target for any specific experiment or class of experiments, and there was essentially unanimous agreement with the decision to drop plans for an internal target in the initial design.

The design does not preclude the possibility for modification of one of the unused long straight sections to provide an internal-target capability, should that be considered desirable at some future time. The tentative decision has therefore become a firm decision not to build an internal-target station in the present construction project. To retain the scope of the experimental facilities at the previous level, the scope of external-beam experimental areas and facilities will be correspondingly increased.

Bubble Chambers. A number of major controversial questions were clarified by the end of the Summer Study. A somewhat oversimplified view of two of the major points is as follows:

(i) A major fraction of the important neutrino-physics program is likely to require a large hydrogen-deuterium bubble chamber. The required volume of liquid is large, because of the weakness of the neutrino interaction with nuclei. The visibility of the target vertex is often highly desirable or even essential, hence the need for a bubble chamber rather than a liquid target followed by spark-chamber systems for a wide variety of requirements.

(ii) A large bubble chamber will almost certainly play a major role in the exploration of strong interactions in 25-75 BeV region. On the other hand, for strong-interaction physics at very high energies such a chamber is a tool of questionable value. Relative errors in momentum and angle measurements of particle tracks are most often required to decrease proportionally as the incident-particle energy increases. The required improved accuracy is ultimately limited by multiple scattering in the chamber liquid and by the errors in measurement of individual bubble locations. Empirically, measurement errors have tended to scale in magnitude with the linear dimensions of a chamber. Furthermore, because greater track length is required to maintain accuracy, the probability for nuclear interaction increases and the fraction of analyzable events decreases.

These difficulties stimulated examination of a number of proposed alternative methods for very high energy strong-interaction studies. Among these are the use of combinations of a small bubble chamber with a counter-spark chamber array and the use of a large streamer chamber in a magnetic field.

Two plans for large chambers at NAL are now being put into operation.

(i) To explore with Argonne National Laboratory, AEC, and other appropriate bodies the possibility of moving the ANL 12-ft hydrogen bubble chamber (now under construction with an estimated completion date in 1969) to NAL for exposure to secondary-particle beams at the beginning of the NAL research program. A decision will need to be made a year or two before turn-on of the 200 GeV accelerator. ANL has expressed its enthusiasm for this project.

(ii) To develop a design and to initiate construction of a very large (100 cubic meter volume) hydrogen-deuterium bubble chamber. This project will be jointly undertaken with the Brookhaven National Laboratory bubble-chamber group; NAL having over-all respondibility for the project, for the beams supplied to the chamber, and for conventional facilities to supports its operation and BNL having responsibility for the design, construction, assembly, and initial operation of the chamber.

In the coming months, as various topics treated during the summer program are considered by members of the Experimental Facilities Section, their deliberations and conclusions will be described in these monthly reports.

Fig. 1. First Flag Raising at the Campus, September 24, 1968. With Dr. Wilson are Dr. Paul W. McDaniel, Director of the Division of Research, USAEC; Enzi De Renzis, Assistant to the Assistant General Manager for Research and Development, USAEC; K. C. Brooks, 200 BeV Accelerator Facility Area Manager, USAEC; and most of the directors and section leaders of the Laboratory.



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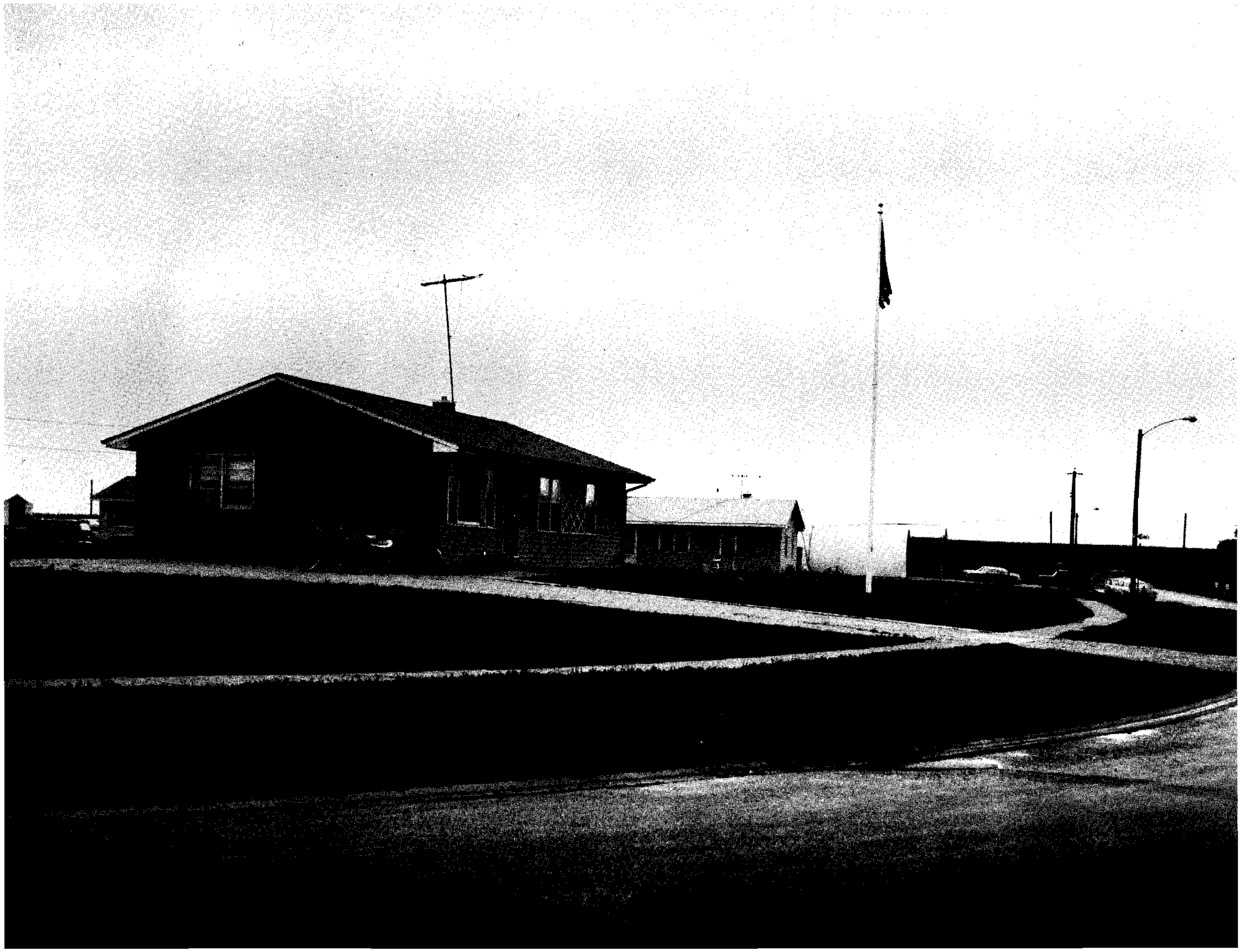

Fig. 2. Director's Office. The photograph looks north. The main-ring laboratory and the main-ring enclosure prototype will be constructed between House 139, across the street, and the inflatable building, whose entrance can be seen behind the flagpole. The shop building will be constructed behind the inflatable building.



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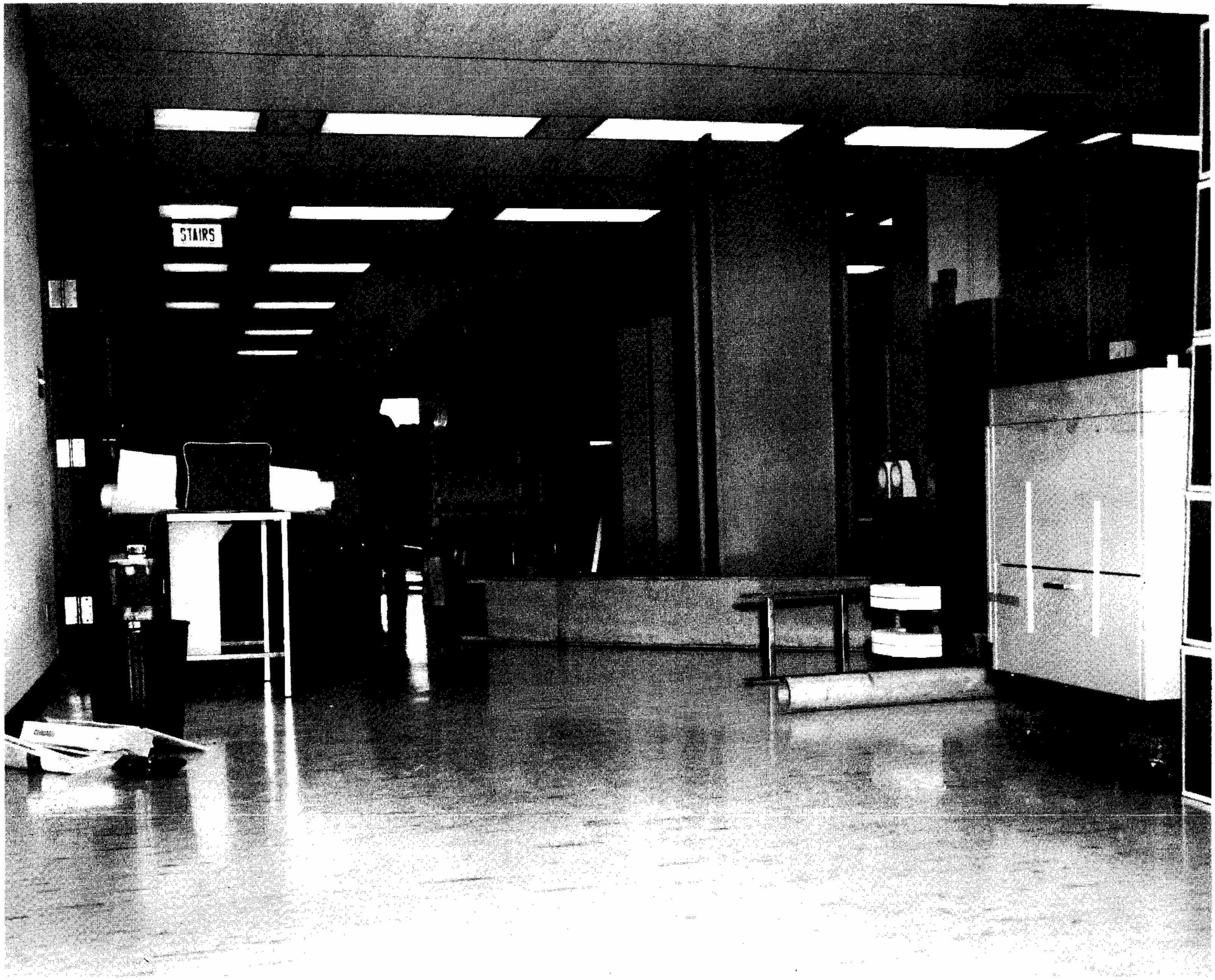


Fig. 3. The Last of Oak Brook. The main-ring enclosure model being dismantled on September 30 to be moved to the Campus.



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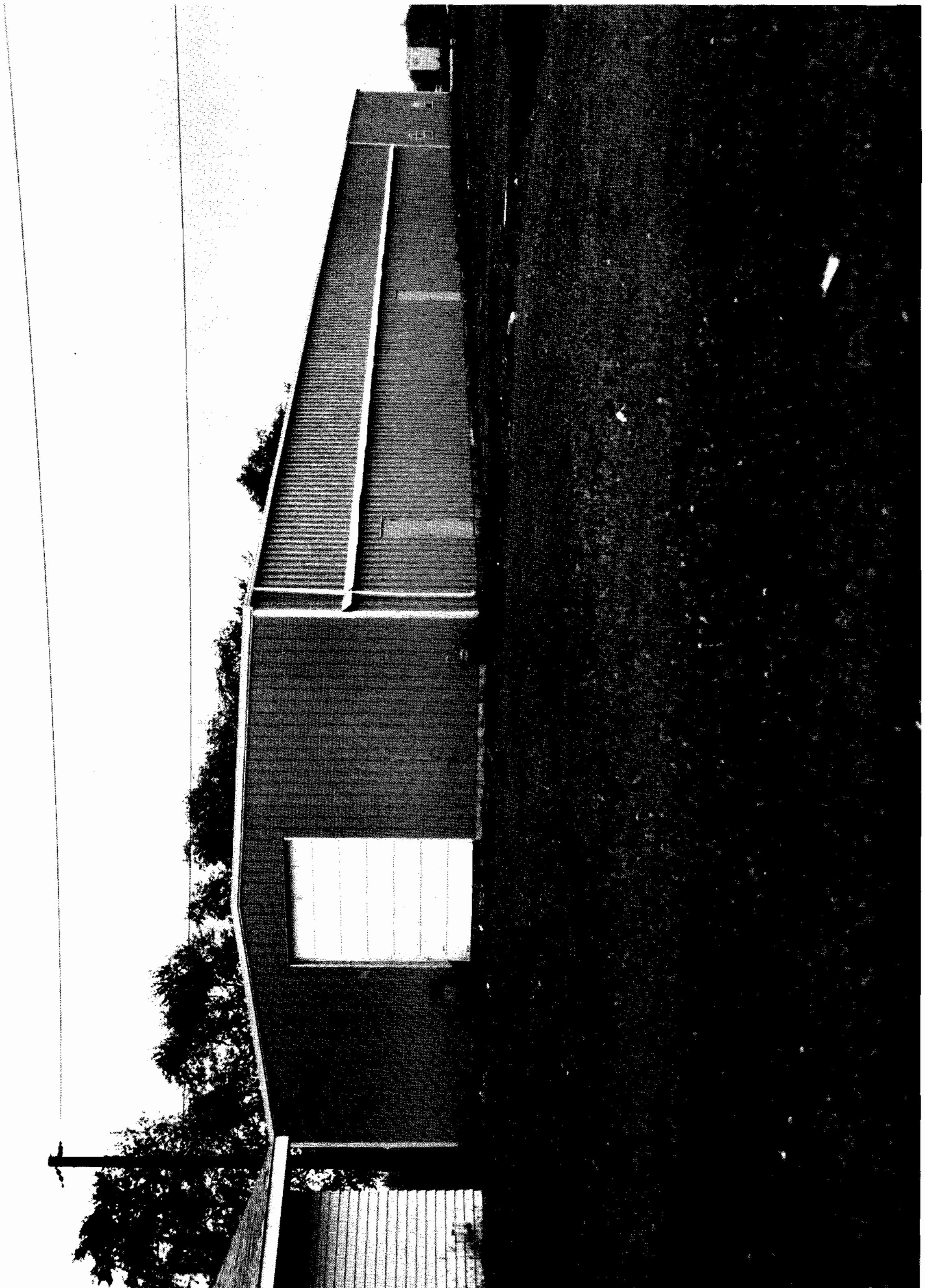

Fig. 4. Completed RF Building.

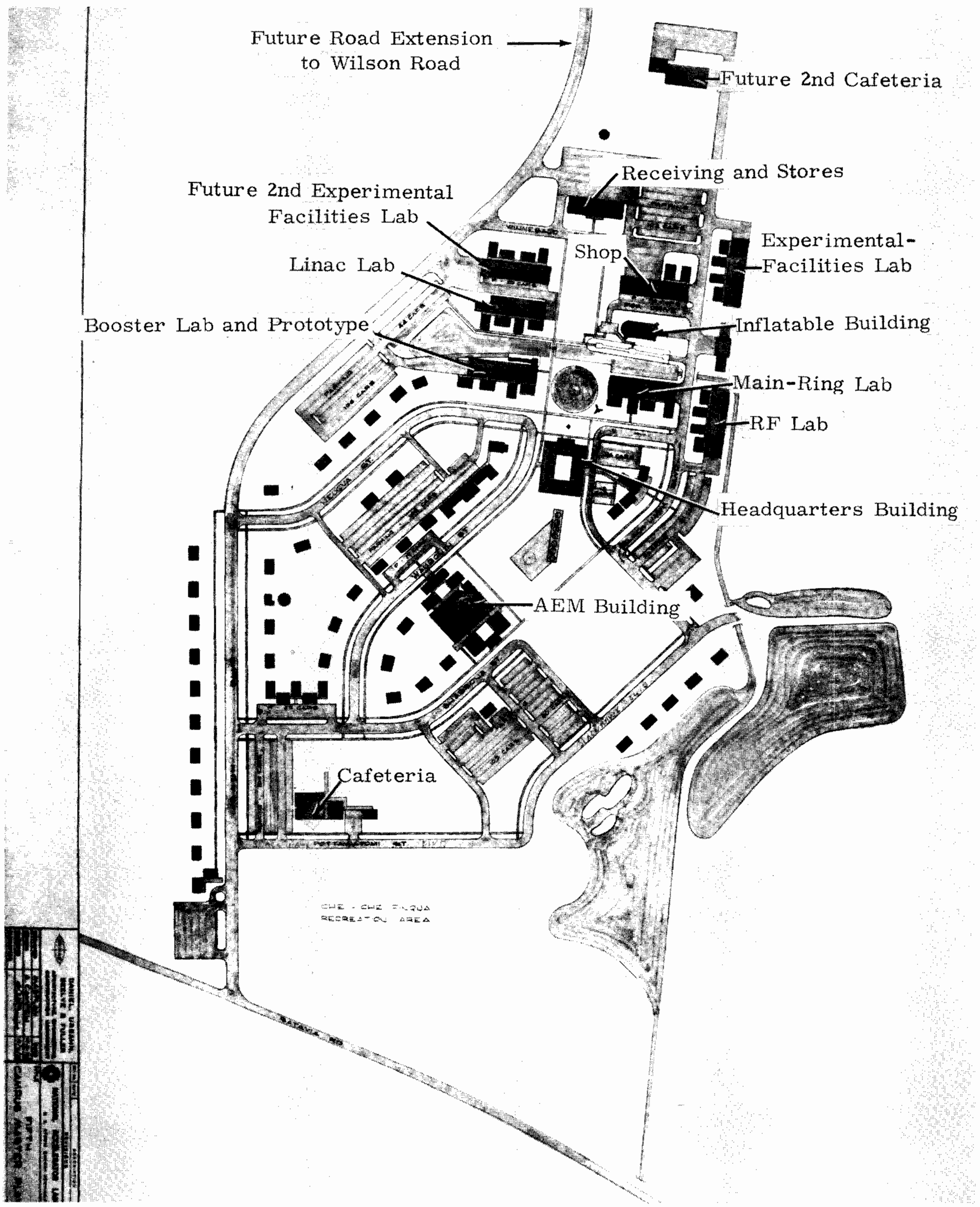


Fig. 5. Current Master Plan of the Campus.

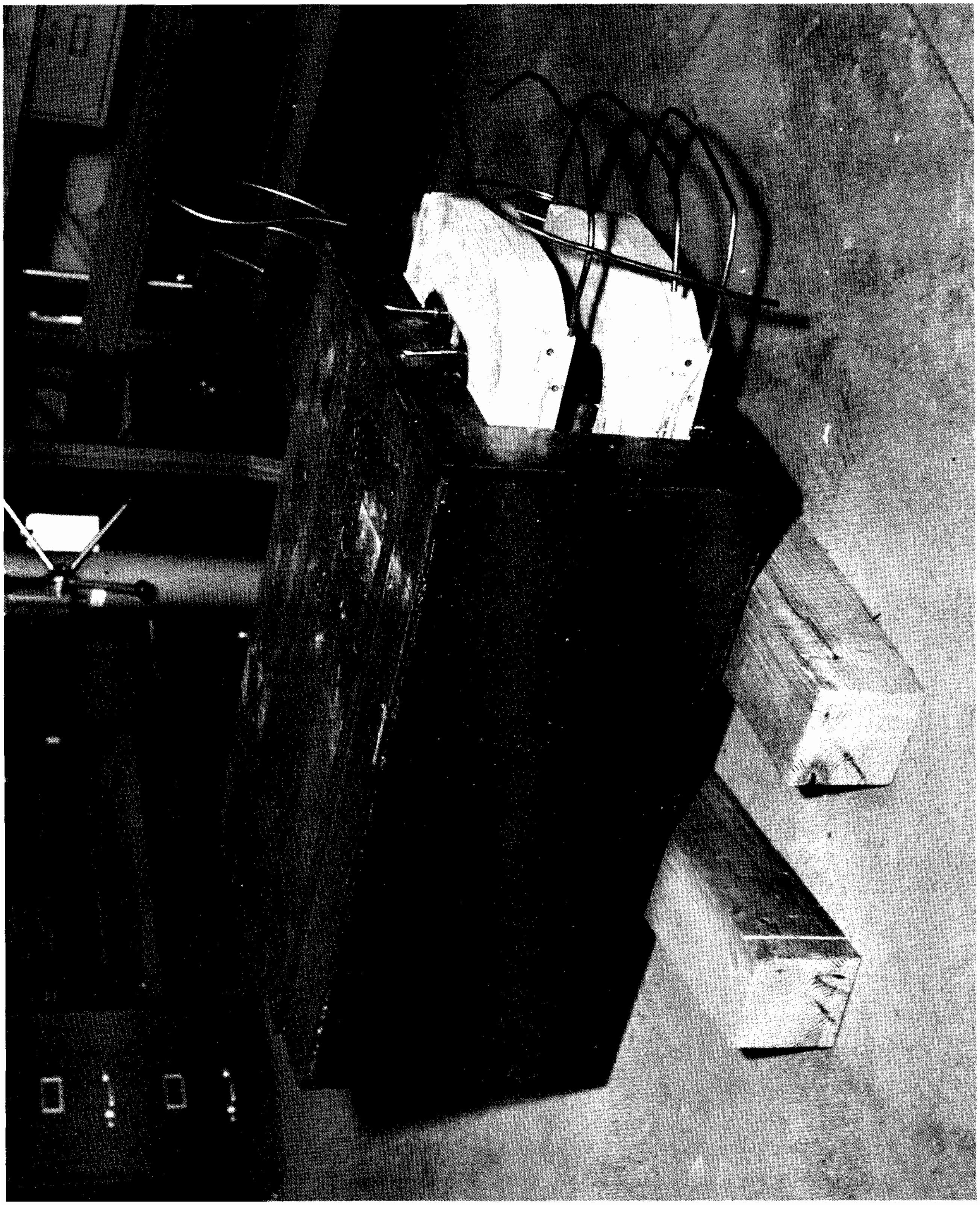

Fig. 6. Booster Model Magnet.