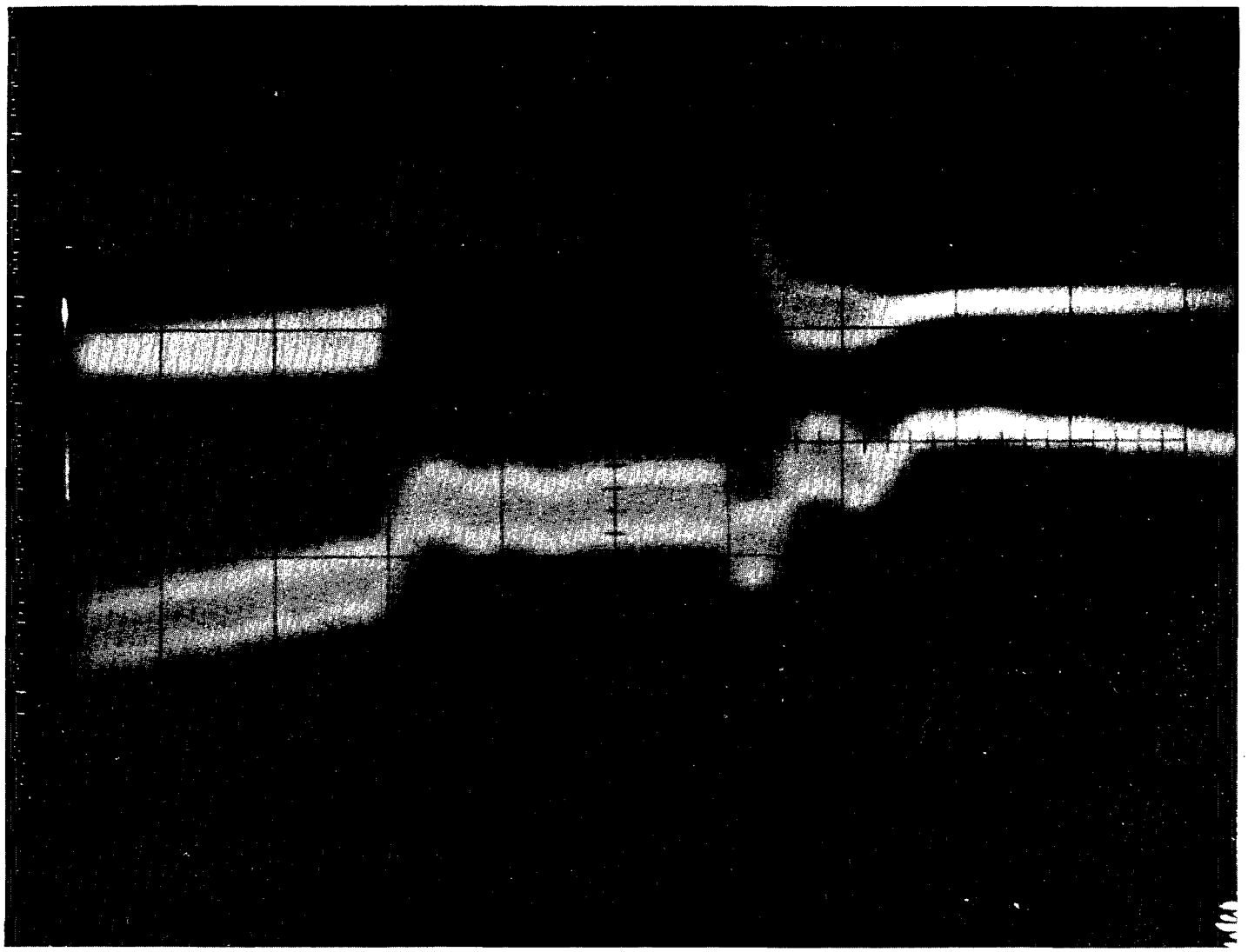
national accelerator laboratory FERMILAB-NAL-027

MONTHLY REPORT OF ACTIVITIES

June 30, 1969



OSCILLOSCOPE TRACE OF 10-MEV PROTON BEAM

Operated by Universities Research Association Inc. Under Contract with the United States Atomic Energy Commission

MONTHLY REPORT OF ACTIVITIES

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June 30, 1969

Abstract: This report covers the activities of the National Accelerator Laboratory for the month of June, 1969.

General

1. Proton Beam at 10 MeV. A proton beam was accelerated to 10 MeV on June 26 in the prototype linear accelerator. The cover is the first photograph of oscilloscope traces of the beam. The lower trace is the beam current of protons with energy greater than 9 MeV, measured at the end of the linac cavity. A more complete description of the operation is given under "Linac" below.

2. Construction Progress. A contract for Phase I of the Cross Gallery has been awarded to the Schless Construction Company of Batavia. The Phase I contract, for $616,098, includes excavation and construction up to ground level and will provide access to the Booster Enclosure. The Schless Company is also constructing the Linac Enclosure.

Work on the existing construction contracts is close to schedule in all cases. Figure 1 is an aerial photograph* of the Linac Building. The concrete work is virtually complete and structural-steel erection beginning. The Linac Building contract is now 44% completed.

The Booster Enclosure is shown in Fig. 2. A portion of the underground ring structure is now in place. This contract is 15% completed.

*The aerial photographs in this report were taken by Donald Mendenhall of the Linac Section.

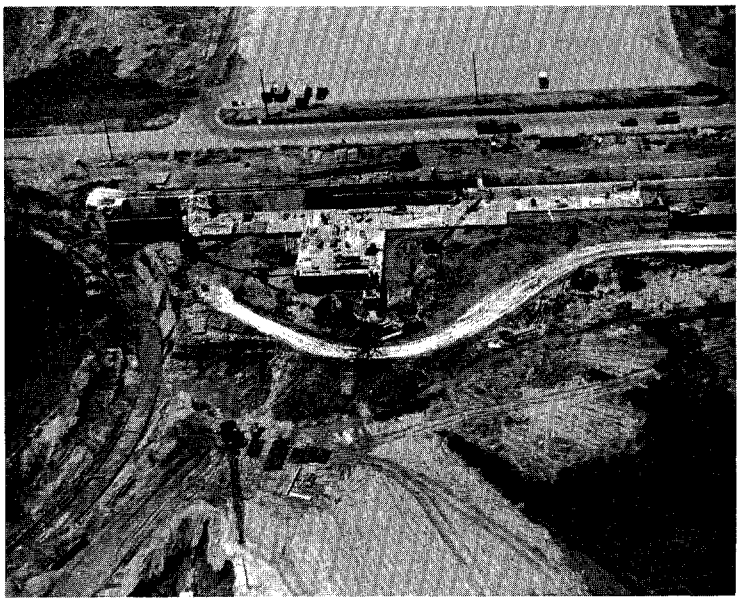


Fig. 1. The linac building from the air. The booster enclosure is to the left, the site of the cross gallery in the foreground.

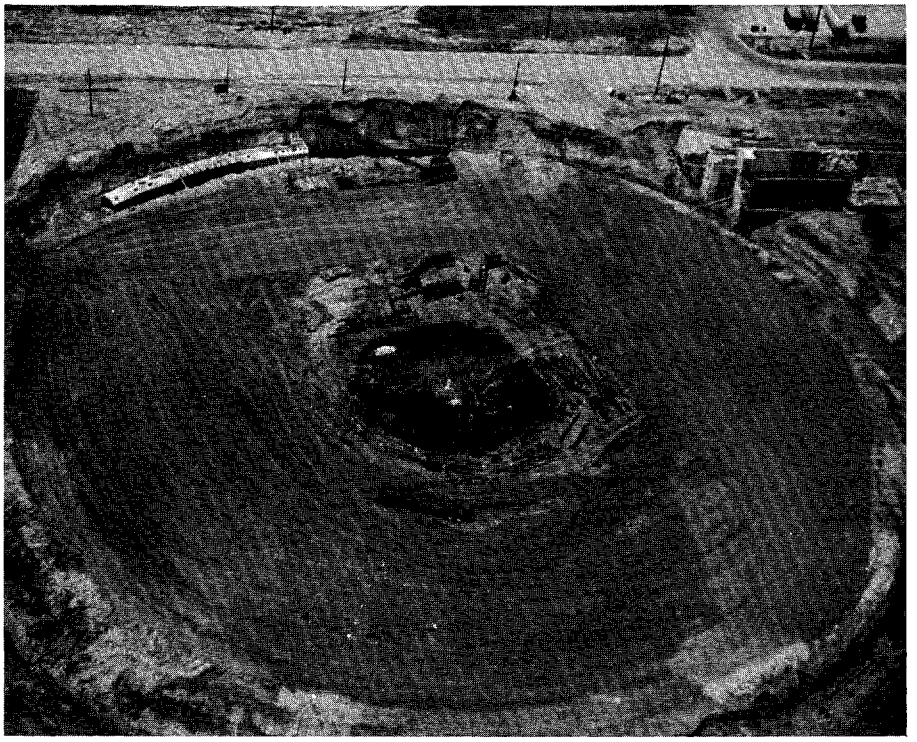


Fig. 2. The booster enclosure.

The temporary drainage ditch around a large part of the main ring is now complete. The aerial photograph of Fig. 3 shows the position of the main ring on the site as outlined by the temporary ditch.

Figure 4 shows the present state of the Laboratory Village, with six large temporary laboratory buildings and the machine shop now in use.

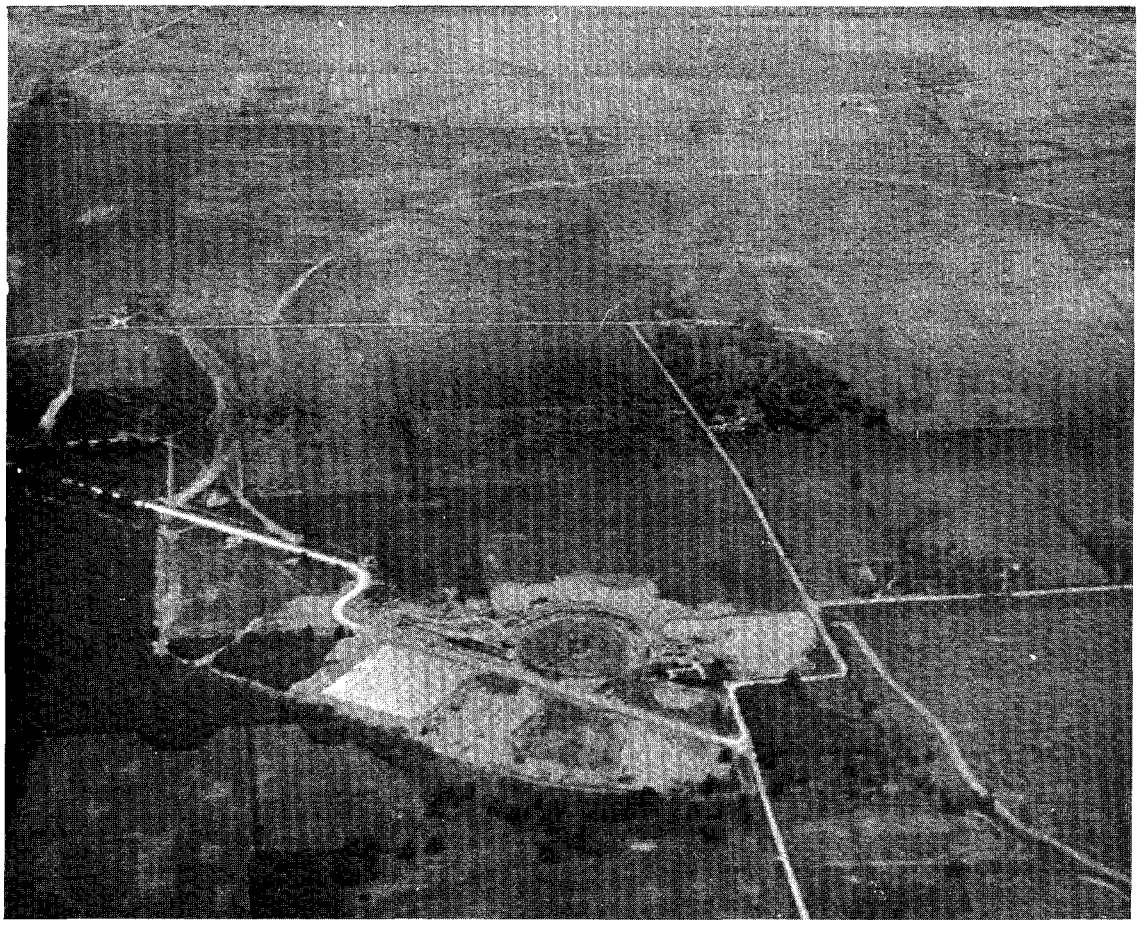


Fig. 3. The main ring, looking southeast. The linac and booster buildings are in the foreground. Eola Road is beyond the ring, Butterfield Road (the southern boundary of the site) in the upper right.

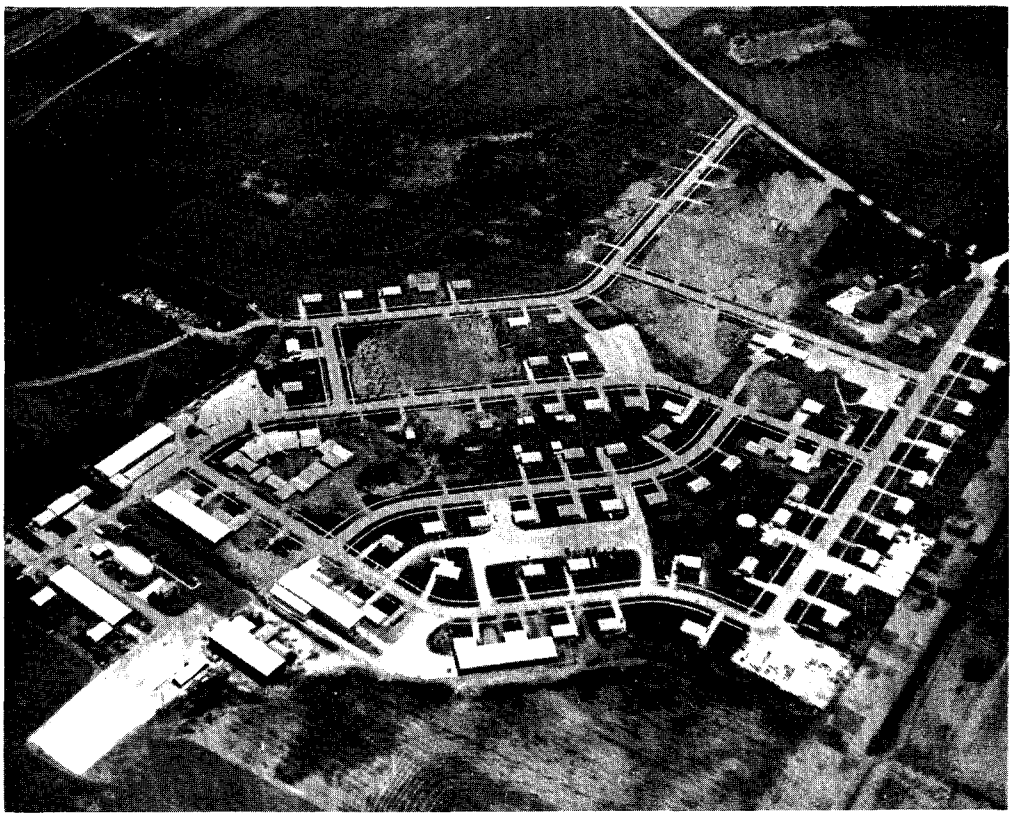


Fig. 4. The Laboratory Village.

3. Laboratory Staff. As of June 30, the Laboratory has 410 employees, including 92 engineers and scientists.

Linac

1. Prototype Operation. Acceleration of protons to 10 MeV was achieved on June 26, the scheduled date.

The cover photograph shows beam current on two detectors. The upper trace is the current on a foil at the end of the prototype linac cavity. The thickness of the foil is chosen to stop protons of energy 9 MeV or less. This foil will detect 750-keV protons from the preaccelerator that drift through the linac out of synchronism with the rf accelerating voltage.

The lower trace is the beam current on a Faraday cup behind the 9-MeV foil and therefore shows accelerated beam. The trace is somewhat smeared by rf pickup. In both it and the upper trace, the sweep speed is 20 microseconds per centimeter, so that the beam pulse is approximately 50 microseconds long. The presence of accelerated beam has also been indicated qualitatively by neutron monitors at the high-energy end of the linac.

The last days and weeks of the effort to reach this milestone form a saga that is, fortunately or unfortunately, beyond the scope of this report. There were many problems with severe arcing in the preaccelerator, largely across the limiting resistor between the high-voltage power supply and the high-voltage electrode. The unusually high humidity of the last month was undoubtedly a contributing factor to the arcing. In the last few days, the high-voltage supply was moved to increase the distance between the two electrodes, the limiting and measuring resistors completely rebuilt and installed, and a borrowed 5-ton air-conditioning unit installed to lower the humidity. It was then observed that arcing was occurring in the sulfur-hexafluoride gas inside the pressure vessel insulating the accelerating column. It was found that the last gap in the column was nearly shorted. This gap was shorted completely and the sulfur-hexafluoride, which had deteriorated, replaced. After five hours of voltage conditioning, it was then possible to achieve 705 kV on the remaining gaps of the column. This voltage was above the threshold for capture and acceleration in the linac.

The beam trace shown is the first record of 10-MeV protons at the Laboratory. It corresponds to approximately 5 microamperes of accelerated proton beam. Larger currents were later observed. After a short period

of operation, we decided that the preaccelerator performance was too ragged to give useful quantitative data, and we therefore shut down to avoid possible further damage to the accelerating column from sparking. Operation will begin again in the second week of July.

2. Cavity Field Measurements and RF System. Figure 5 shows the drift tubes installed in the cavity and Fig. 6 shows the cavity after closing up. The accelerating electric field was measured after installation of the drift tubes, by means of a frequency-perturbation technique and using the Sigma II computer in the analysis. The measurements show remarkable agreement between the experimental and computed fields. Figure 7 is a plot of accelerating field as a function of distance along the linac.

The cavity was then evacuated and excited to full rf power. The usual problems of outgassing and low-level multipactoring were observed, but after only two hours of conditioning the field level in the cavity had exceeded the design value. The rf system runs steadily at levels up to at least 40% larger than the design electric-field gradient.

The reflected rf power is quite small, showing that the match of the power amplifier to the cavity is very good. Figure 8a shows the envelope of the rf power in the cavity and the reflected power. Figure 8b shows the effect of closing a feedback loop to control the cavity field. The feedback loop uses an amplitude signal from the cavity to regulate the power-amplifier plate modulator. This loop improves the buildup of the rf in the cavity.

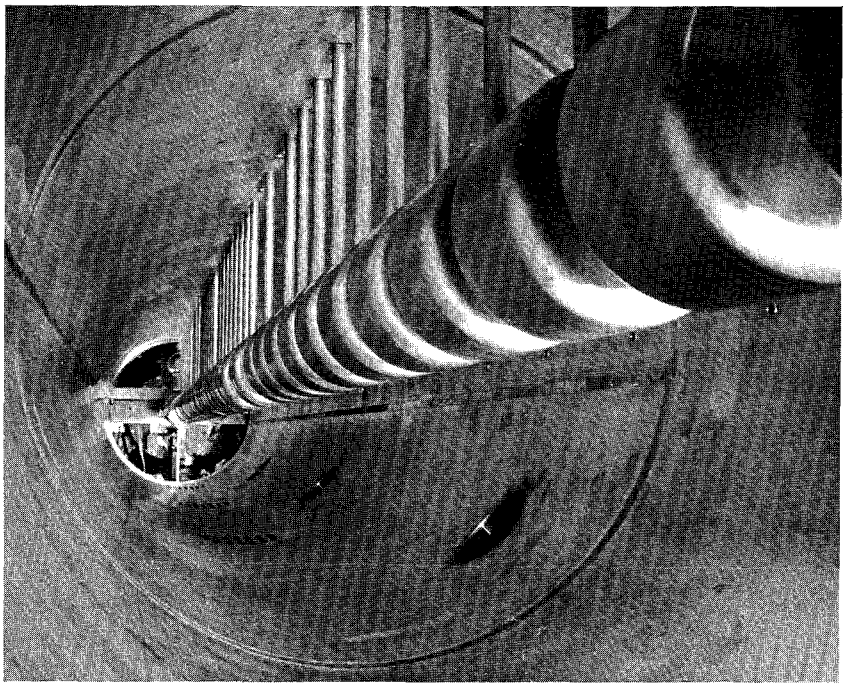


Fig. 5. Interior of the prototype linac cavity, with drift tubes in place. The other holes are for tuners and vacuum ports.

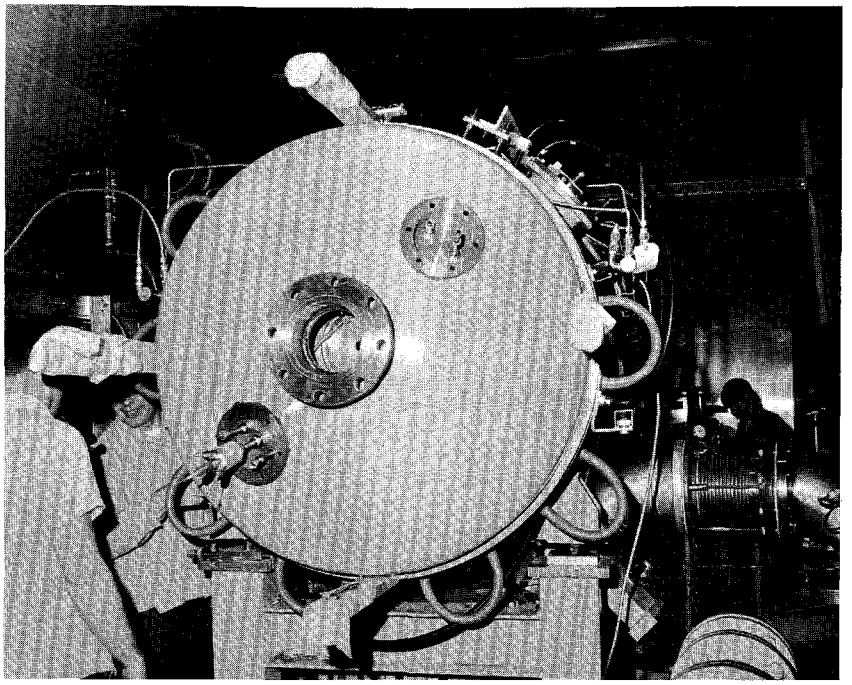


Fig. 6. The high-energy end of the cavity after closing. Andy Mravca and John O'Meara at the left, Jim Hickey at the right.

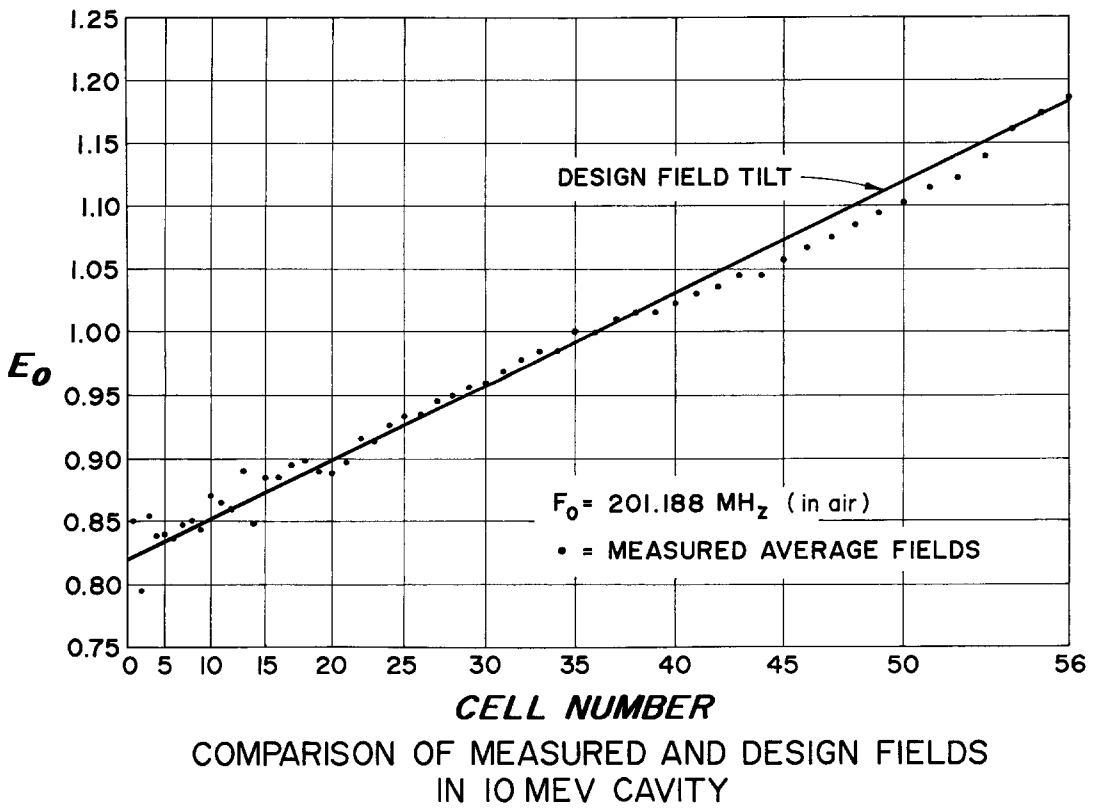
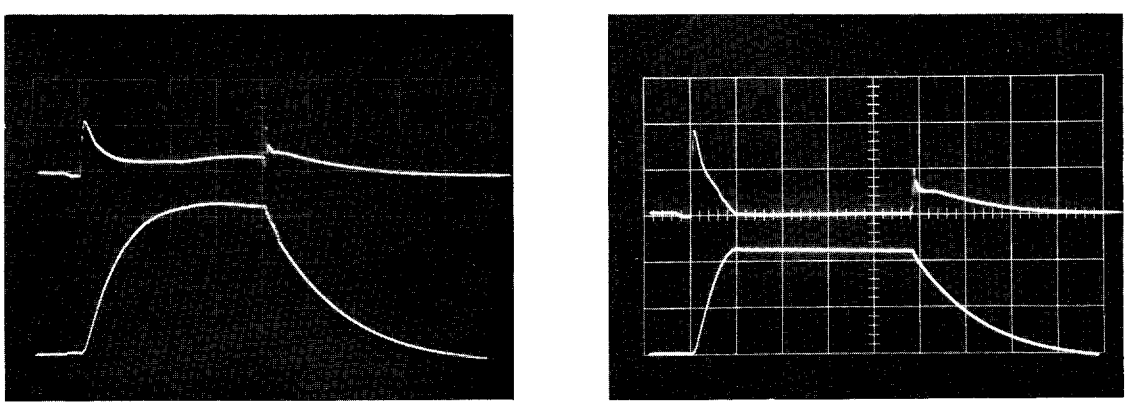


Fig. 7. Measured electric fields in the prototype cavity.



(a) (b)

Fig. 8. Reflected power (upper trace) and field level (lower trace) in the cavity. Case (a) is with the feedback loop open, case (b) with the loop closed.

Booster

Magnet Design. The main impact of the change in the final energy from 10 to 8 GeV is on the chokes of the magnet power supply, which are reduced in size. New designs for prototypes have been completed and negotiated with the suppliers.

The carbide die for F laminations is now complete and an initial run of laminations is being measured. The D-lamination die will be complete in mid-July.

Work is also in progress on producing the shaped end packs of laminations. The program for computer-controlled milling is almost ready and the first machined end pack should be completed in July. An alternative method (electro-mechanical milling) is being investigated in the Argonne National Laboratory shops.

Some trouble has been experienced on the first 10-ft magnet impregnated with a heat-cure epoxy system, both with cracking and with maintaining adequate tolerances. Figure 9 is a photograph of this magnet during stacking.

Main Accelerator

Model Magnets. A 20-ft half-core has been stacked and welded for a structural model of the "angle magnet" discussed in last month's report. It is shown on the stacking fixture in Fig. 10. Coils for the 3-ft B2 model have been received from both vendors. One set is shown in Fig. 11 on our new granite surface plate, 22 ft long by 3 ft wide. This plate will be used to check the accuracy of coils and fixtures.

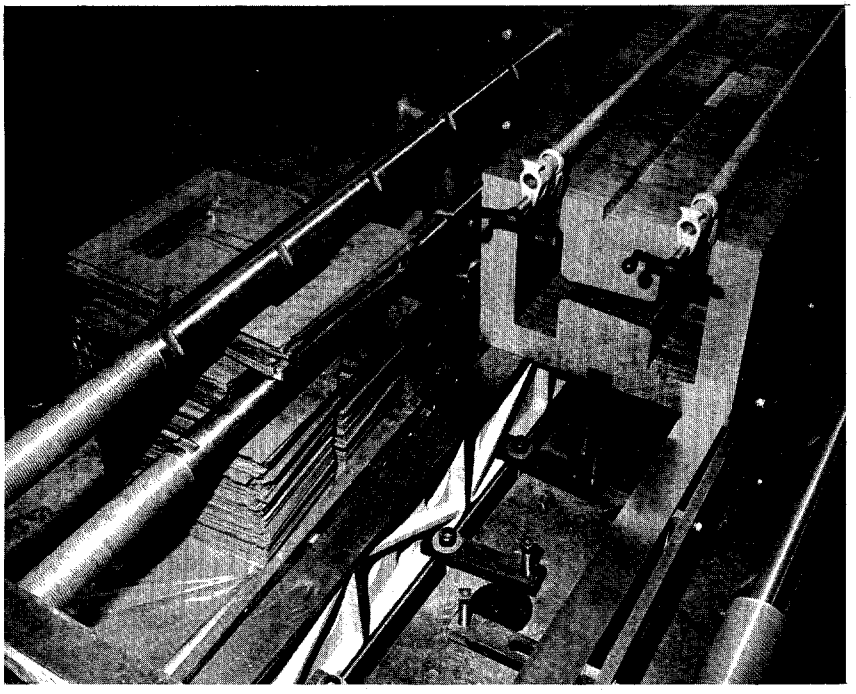


Fig. 9. Booster prototype magnet during stacking.

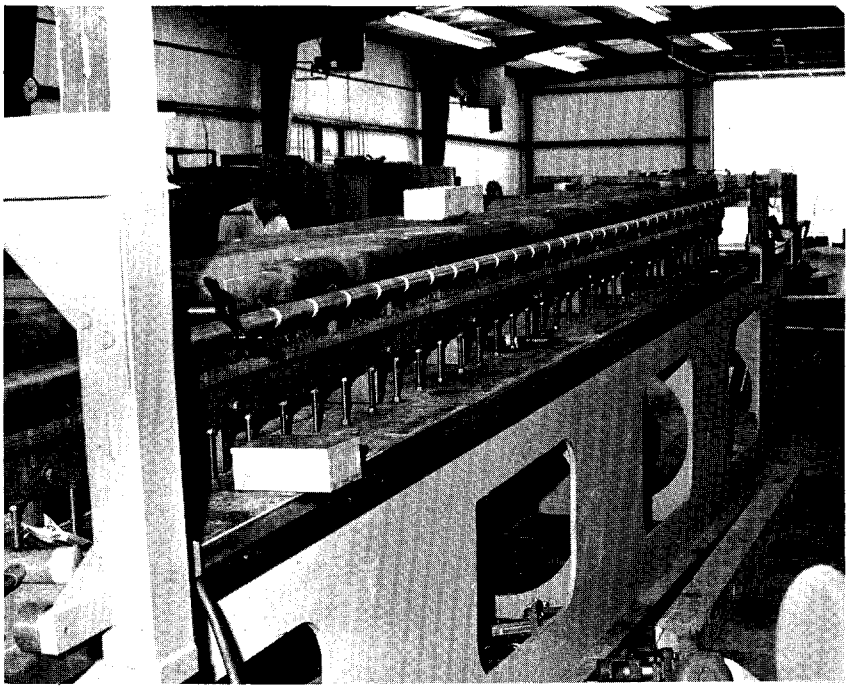


Fig. 10. Main-accelerator prototype magnet on the stacking fixture.

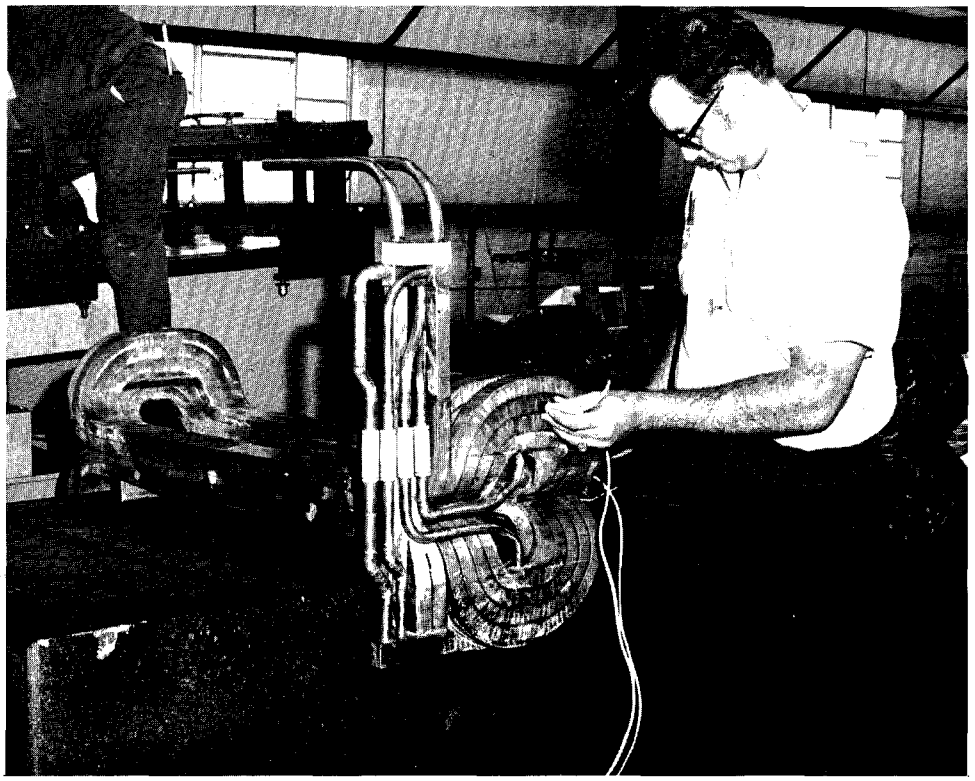


Fig. 11. John Satti tests a 3-ft B2 model coil on the granite surface plate.

Radio Frequency

1. Power Amplifiers. Fabrication of a prototype power amplifier will be completed in July. Proposals are due back July 21 from prospective vendors for the 100 kW power amplifiers for both booster and main ring.

2. Ferrite Delivery. The entire order of 180 ferrite toroids has been received from one manufacturer in Japan. All have passed mechanical inspection and are now being tested electrically. A few toroids have been received from some of the other three manufacturers and the remainder of the order from another Japanese company is en route.

Accelerator Theory

1. Neutrino-Beam Focusing. A new study has been made of the use of quadrupoles, rather than a pulsed horn, for focusing pions and kaons in the neutrino-beam system. A quadrupole system may be more economical, but the momentum band it can focus is narrower than in the case of a horn. Results of the study so far indicate that a system using triplets with field gradients somewhat higher than normal is feasible. Further efforts are being made to broaden the momentum band.

2. Magnet Calculations. Discrepancies between measured and computed booster magnetic fields have prompted us to look again at the internal consistency of the LINDA program. The discrepancies were traced to the smoothing process used in specifying pole-profile points and remedies are being made. These tests also confirm our profile tolerance estimates, that a ± 0.0005-in. profile error causes a ± 1% gradient error.

Physics Research

An experiment has been started in collaboration with the University of California at Los Angeles and the California Institute of Technology. The experiment will study K-π scattering using photographs from a deuterium-filled bubble chamber in a separated 2 GeV/c K^+ beam. Scanning has begun here using the scanning table pictured in last month's report, which is on loan to us from the Lawrence Radiation Laboratory.