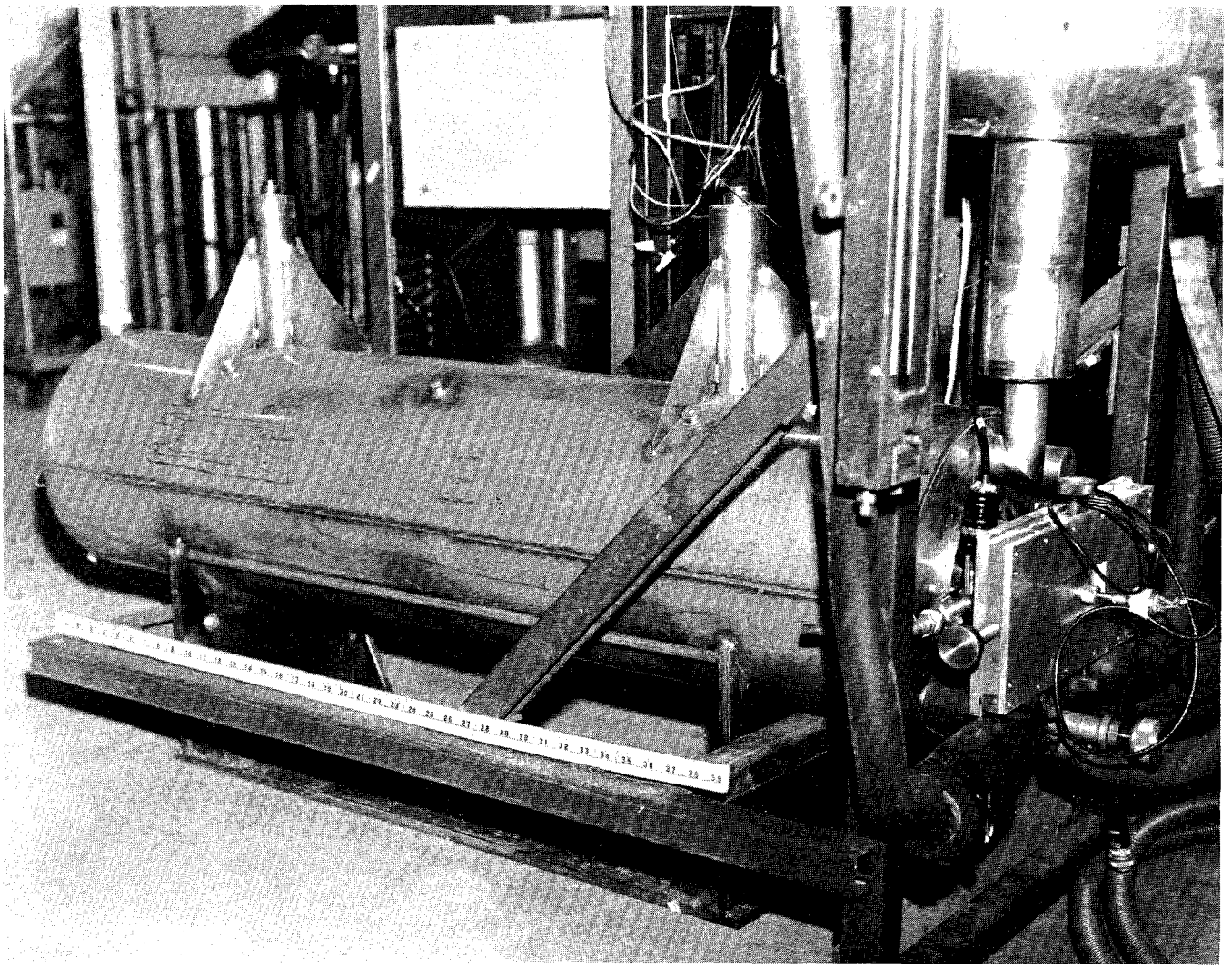
national accelerator laboratory FERMILAB-NAL-035

MONTHLY REPORT OF ACTIVITIES

December 31, 1969



SUPERCONDUCTING MODEL MAGNET

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

NAL-35
0090.01

MONTHLY REPORT OF ACTIVITIES

F. T. Cole

December 31, 1969

Abstract: This report summarizes the activities of the National Accelerator Laboratory in December, 1969.

General

1. Appointments. It is with regret that we announce that Donald K. Poillon is leaving the Laboratory for a position in private industry. Paul J. Reardon has been named to replace him as Director of Business Administration. Roy Billinge has been named Head of the Booster Section to replace Paul Reardon.

In another change, Thomas L. Collins has been named Associate Director for Planning Advice. He has in the past been the Laboratory's liaison with DUSAF on architect-engineering work. In his new post, he will advise the Director on planning and technical matters.

2. Program Committee. A Program Committee made up of members from the Laboratory staff and from outside has been appointed. It will advise the Director on the high-energy physics research program of the 200-BeV accelerator. The outside members include Owen Chamberlain, University of California; Thomas H. Fields, Argonne National Laboratory; Val L. Fitch, Princeton University; Murray Gell-Mann, California Institute of Technology; T. D. Lee, Columbia University; W. K. H. Panofsky, Stanford University; Robert G. Sachs, University of Chicago; Nicholas P. Samios, Brookhaven National Laboratory, and William J. Willis, Yale University.

The first meeting of the Program Committee will be this winter. It is expected that after this first meeting, there will be a call for experimental proposals to be submitted by early summer. The Committee will then meet to evaluate these proposals and to advise the Director. Definite plans for some of the initial experiments must be formulated by autumn of 1970 in order that apparatus can be ready by the time the accelerator is operating.

3. Construction Progress.

a. Linac Building. The building was completed at the end of December and occupation by the Laboratory begun. The preaccelerator pit and linac tunnel were completed and occupied on December 15, well ahead of schedule. Figure 1 shows the preaccelerator pit with the high-voltage power supply, now erected.

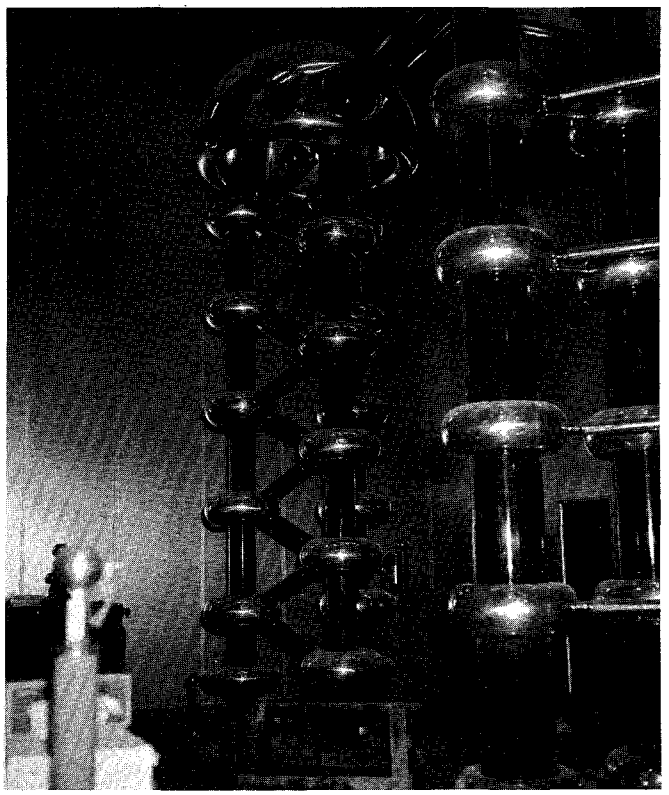


Fig. 1. The high-voltage rectifier stacks erected in the preaccelerator pit.

Figure 2 shows what will be the temporary control room in the Cross Gallery stub. Figure 3 shows the linac tunnel.

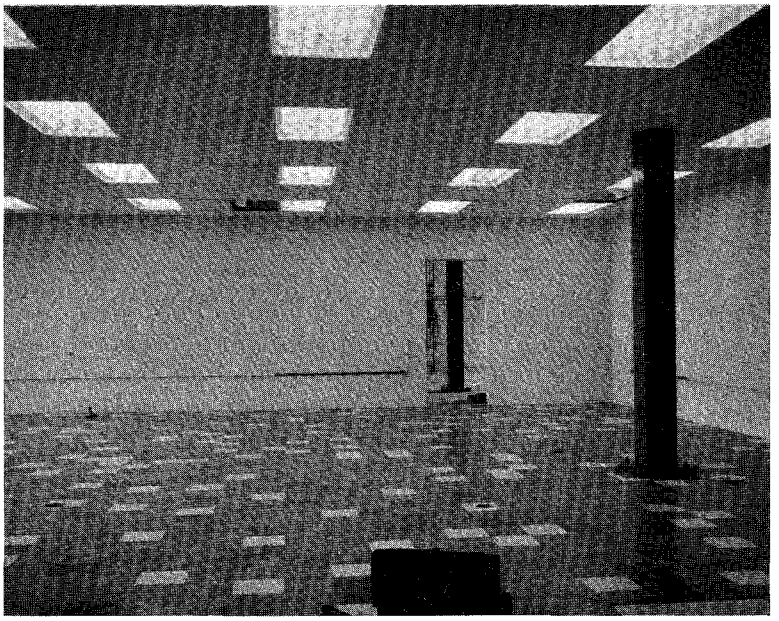


Fig. 2. Temporary control room just prior to occupancy.

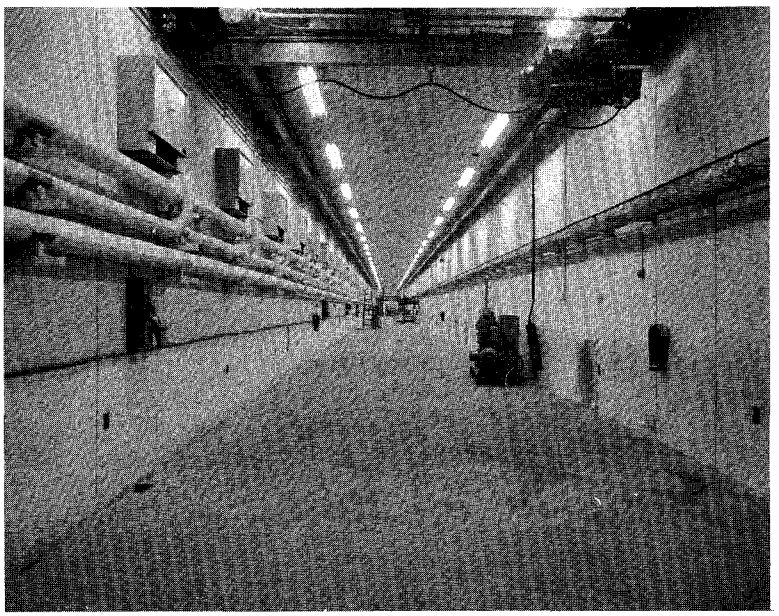


Fig. 3. Looking down the Linac Tunnel from the high-energy end. The prototype tank is barely visible at the far end.

b. Booster Enclosure. Forming and concrete work is well under way for the equipment galleries above the tunnel. This work can be seen in Fig. 4. The building is now 61% complete.

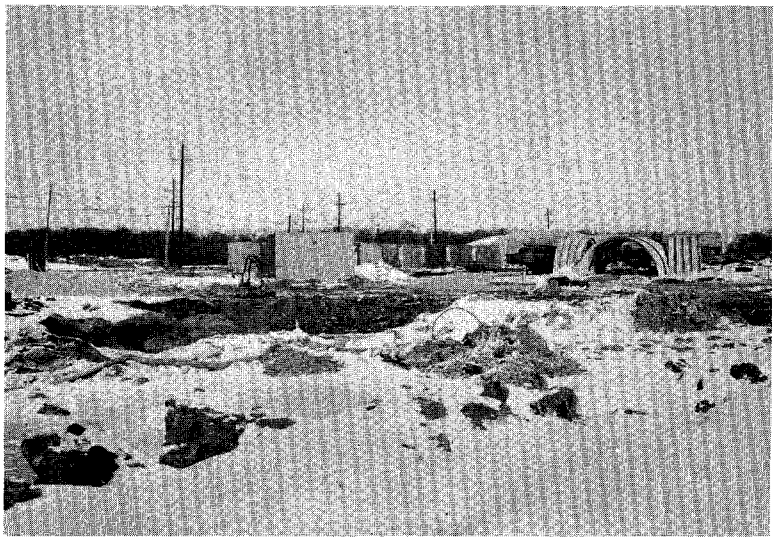


Fig. 4. Work on the West Gallery of the Booster Enclosure. The photo is taken looking across the booster ring toward the linac.

c. Industrial Buildings. The steel frame of the first industrial building is now in place, as shown in Fig. 5. The contract is 18% complete. We

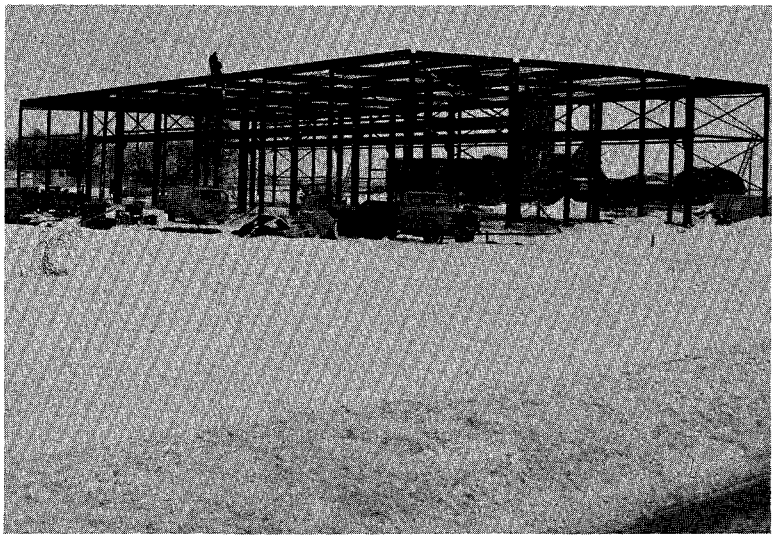


Fig. 5. Framing of the first industrial building, taken from the Ring Road.

are making use of incentives to get the first building completed ahead of schedule, in order that it can be used by the Main-Ring Section for magnet assembly and staging.

All other construction contracts are moving ahead close to their schedules. These include the Cross Gallery (46% complete), the Ring Road (75% complete), the Master Substation (7% complete), and the Central Utility Plant (3% complete). The Main Accelerator Phase I is 20% complete. The work is shown in Fig. 6.

Fig. 6. Looking north from the Transfer Hall along the Main Ring.

A number of responsive bids were received for the remainder of the main-ring enclosure. Most of the bids were clustered around the DUSAF estimate, but the Corbetta Construction Company bid $7.27 million, approximately $800,000 less than the next lowest bidder. Notice to proceed will be issued immediately on the below-ground tunnel, the rf house above straight-section F, and the service buildings around the ring.

4. Professor of the Month. Under this new program, a theoretical physicist is invited to give a series of talks at the Laboratory developing some subject that is relevant to Laboratory programs. The series began in December with Professor J. J. Sakurai. The next Professor of the Month will be C. N. Yang on February 2, 3, and 4. Later Professors will include S. Fubini and G. Veneziano in February and March, S. Adler (April), S. Treiman (May), and T. D. Lee (May-June). All visitors who wish to participate in these sessions are welcome.

5. Laboratory Staff. As of December 30, the Laboratory has 585 employees, including 129 engineers and scientists.

Linac

1. 10-MeV Prototype. A proton current of 160 milliamperes was accelerated to 10 MeV on Dec. 11, just before the prototype was shut down to be moved. This beam had an emittance of 12 cm-milliradian (80% of beam) and a momentum spread of 9×10^{-3} (85% of beam). If the results for a 100-milliampere beam are extrapolated theoretically to 200 MeV, the emittance is about 90% and the momentum spread 55% of those of the nominal design values of the 75-milliampere beam of the Design Report.

The results of this intensive study will be discussed with workers from

other laboratories at an informal meeting Jan. 5. Further measurements to be made when the prototype is back in operation in March, 1970 will also be discussed.

2. Permanent Building. Assembly and erection of the high-voltage set in the permanent building began in the middle of December and was completed mechanically by the end of the month. The prototype 10-MeV tank has been moved over from the Village and is being installed. The remainder of the permanent building will be occupied early in January.

Booster

1. Prototype. The prototype magnet period was successfully run continuously for 100 hours. During this run, the entire system was monitored and controlled by the booster computer. The combination of a turbomolecular pump for roughing on each pair of modules and a 400 liter/second ion pump on each module gives pressures of 3.7×10^{-7} torr at the pump and 7×10^{-7} torr at the farthest distance from the pump. These pressures correspond to the design goal of an average pressure of 5×10^{-7} torr around the ring. Orders are now being placed for the major components of the vacuum system.

2. Magnet Production. The dies have been resharpened and punching is again proceeding. Both F and D dies are now producing staisfactory laminations. The D-magnet end shape is completed and the first end pack delivered to the fabricator. The F-magnet end shape has given considerable trouble and is not yet completed.

Main Accelerator

1. Magnet Fabrication. Contracts have been let for approximately half the main-ring steel, for the vacuum chambers, and for B1 and B2 outer coils. A B2 inner coil has been successfully fabricated at the West Chicago facility. It is shown in Fig. 7. The dimensions of the complete coil are within tolerances.

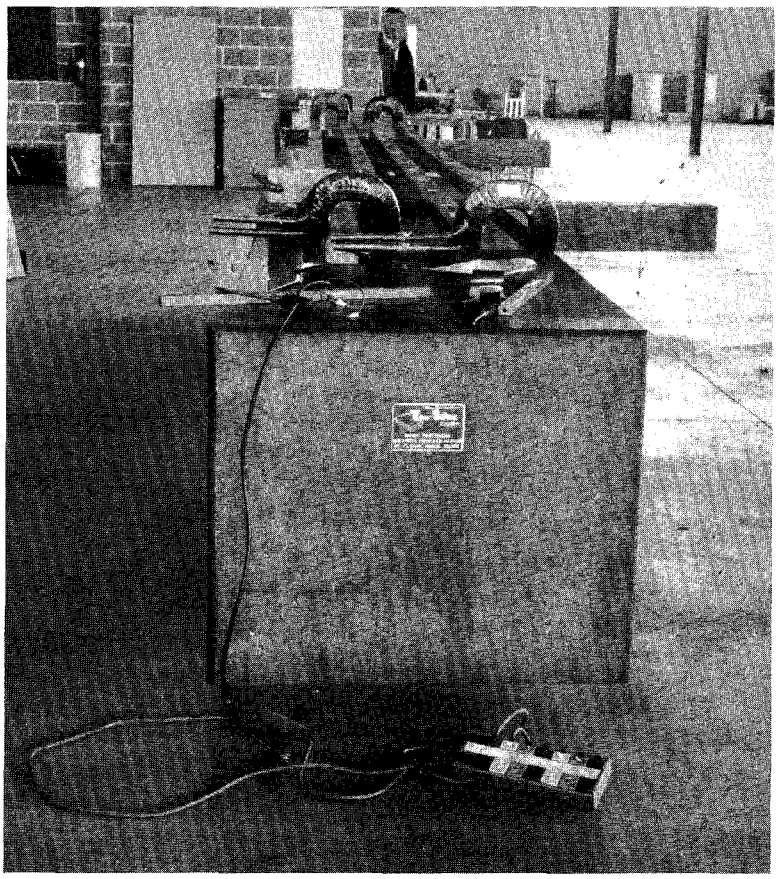


Fig. 7. Completed inner coils at the West Chicago factory.

2. Pole Shape. A modification of the bending-magnet pole shape has been adopted. In this modification, tapered sides are used to improve field quality at high fields. Computations predict that the field shape with this modification will be acceptable without further correction up to 21 kilogauss, corresponding to 467 BeV.

3. Magnet Alignment. Tests have been made on a laser system to measure quadrupole positions. A system has been developed to eliminate errors caused by ground vibrations. Transverse displacements of 0.001 inch in 100 feet can be measured.

Accelerator Theory

1. Alternative Method of Operating the Main Accelerator above 400 BeV. With the pole-shape modification mentioned above, the upper limit in proton energy now appears to be set by the shrinking of the good-field region of the focusing quadrupoles. The separated-function design makes is possible to operate the main ring at lower quadrupole gradients and consequent lower ν values. For example, an operating point of $\nu_x = \nu_z = 16.25$ can be obtained with 18% less quadrupole gradient than the nominal operating point $\nu_x = \nu_z = 20.25$. The increases in the amplitude function β and the momentum-dispersion function x_p are only 25% at 16.25.

2. Magnet Shuffling Procedure. Measurements of coercive force on magnet steel samples show variations of 0.5%, large enough to give a risk of large orbit deviations at injection. Schemes for shuffling complete magnets are being investigated. Preliminary results indicate that the injection orbit distortions can be reduced to acceptable levels by maintaining a 60 to 70 magnet stockpile between production and installation and by choosing pairs from the stockpile for installation in the ring. This is only one example of many possible schemes of shuffling.

3. Transition Energy in the Booster. Bunch-shape oscillations are induced by longitudinal space charge during the passage through transition energy. These oscillations, which can lead to beam losses at high intensity, can be

eliminated by shifting the transition energy at the time of crossing. This scheme has been used at the CERN PS with great success. A system has been developed for the booster making use of six 30-cm long quadrupoles with peak gradients of approximately 20 kG/m.

Beam Transfer

1. Kicker Magnet. Tests of a 1-foot model of the Booster fast kicker magnet were performed with the 10-MeV linac beam. Figure 8 shows the beam profile with and without kicking. The experimental results on impulse and rise

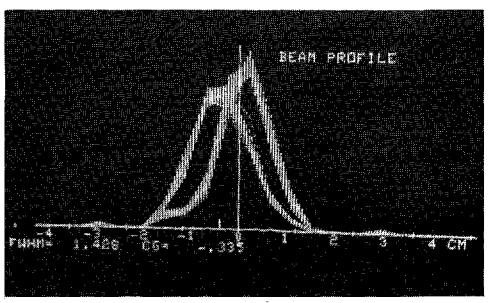


Fig. 8. Beam profiles at 10 MeV. The density distribution is shown with the kicker off and then deflected to the left by the kicker.

time are in agreement with expectations. These tests will be continued when the linac is back in operation.

2. Septum Magnet. Model tests had shown difficulties with jitter errors in magnet currents. A new power supply utilizing silicon-controlled rectifiers has been installed and has eliminated the problem. This model is shown in Fig. 9.

Experimental Facilities

1. Superconducting Magnet Program. The Mark II model dipole magnet, which has a picture-frame iron yoke and a superconducting coil, was

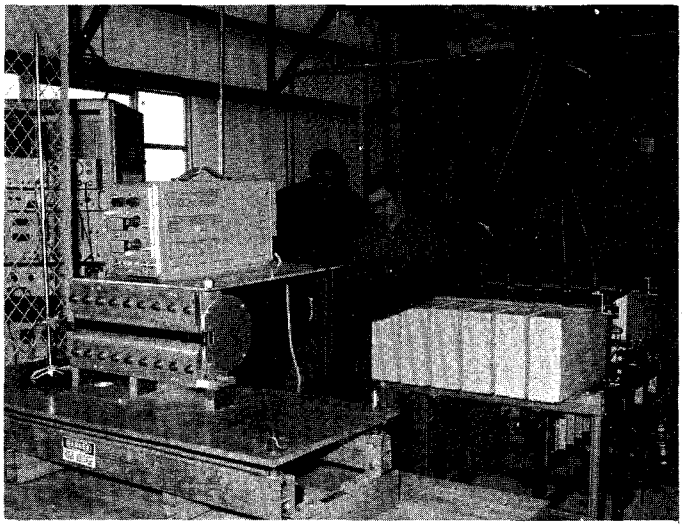


Fig. 9. Larry Jackson and Walter Jaskierny testing the pulsed septum magnet model.

successfully operated on December 19. It is shown on the cover. A peak field of 21 kG was reached. The magnet was charged from zero field to 20 kG in about five minutes. During the initial tests, the coil was quenched eleven times with no subsequent degradation of performance. Preliminary design work on Mark III, a ten foot version of Mark II, has begun.

During December, a contract was negotiated with a supplier to design and build a ten foot long dipole magnet, where the magnetic field of 35 kG is produced by cos θ windings. Delivery is scheduled for July 1, 1970. Negotiation has started to solicit proposals from industry to design and fabricate a 7-foot long, 10-kG/in. quadrupole and cryostat.

A contract was signed in December for a 20 liter/hr helium liquifier-refrigerator. Delivery is scheduled for May 1, 1970.

2. Spectrometer Studies. An extensive computer program has been written and is being used to analyze the resolution of various large-aperture spectrometers. The program consists of two parts: the first traces particles

through a given spectrometer taking into account multiple scattering in digitizing planes and the intervening gas and resolution of the planes. The resultant tracks are then fitted with error analysis to obtain the momentum and angular resolution of that spectrometer. Their variation with magnet length, number of digitizing planes, particle momentum, and the location of planes following the magnet has been studied. Contrary to some previous indications, a long length of track detector following the magnet does not give a large improvement in resolution for a reasonable choice of other parameters. This seems to be due to multiple scattering effects. For 100 GeV/c particles, an appropriate spectrometer magnet, if made of iron, would be about eight meters long and contain twenty digitizing planes. It would have a momentum resolution $\Delta p/p$ of 1% and a $p\Delta\theta$ of 25 MeV.

Focusing spectrometers have been studied with an adaptation of the TRANSPORT program. In particular the effect of scattering in detectors placed along the spectrometer has been studied. This effect is minimized by defocusing in the plane of momentum analysis. A typical spectrometer with a reasonable set of detectors can yield a momentum resolution $\Delta p/p$ of less than 0.1% at 180 GeV/c. This also takes into account scattering in a hydrogen target.

These results and others were presented at the Spectrometers Workshop held at NAL on December 12. Some 120 visiting users attended this workshop and discussed our spectromerer needs. Afternoon sessions studied hybrid systems in addition to the focusing and large aperture spectrometers. Technical presentations were made of fast cycling bubble chambers, streamer chambers, and a number of specific hybrid spectrometers.