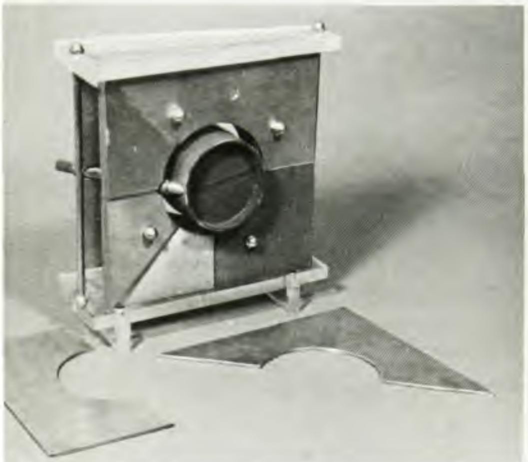
torus. The project is a collaboration between the Francis Bitter National Magnet Laboratory and the MIT interdepartmental plasma-physics group; the project is led by Bruno Coppi and D. Bruce Montgomery.

Alcator will use the existing motor-generator sets at the Magnet Laboratory to produce a very high confining magnetic field—130 kG. The Tokomak T-3 at the Kurchatov Institute in Moscow has 25 kG and the proposed Tokomak T-10 would have a 50-kG field.

One of the key ideas of Alcator is to take advantage of anomalous plasma resistivity, to reach a high temperature



PART OF COIL ASSEMBLY for MIT Tokomak. Model shows two turns separated by 15 deg; each is made of two conducting plates of copper sandwiched between two reinforcing plates of high-strength stainless steel and one insulator. Inside the bore is the plasma chamber, which has a thick-walled copper shell to help stabilize the plasma column. At left is 2-cm viewing port. Conductor plates can each be made of two 180-deg half-plates (shown) to facilitate assembly about plasma chamber.

in a time shorter than the confinement time. Coppi explained that plasma resistivity is determined not only by electron-proton collisions, but to a great extent by interaction between particle and collective effects. By having a sufficiently large current density flowing inside the plasma, one excites plasma collective modes; so a greatly enhanced plasma heating occurs. The same high magnetic field that permits the attainment of an enhanced resistivity and the proper choice of geometrical parameters are expected to allow very good plasma containment.

The major plasma diameter will be 108 cm and the minor plasma diameter 26 cm. The coil will be cooled with liquid nitrogen and pulsed for 1 sec from the existing 32-MW power supply at the Bitter Laboratory. Total cost of the experiment is expected to be \$750 000, of which \$525 000 comes from the AEC. Construction is expected to take 18 months.

We asked Coppi to compare Alcator with the proposed T-10. He feels that MIT has a much better chance to be able to heat its plasma. The Kurchatov device would increase its energy content by choosing a better aspect ratio and larger dimensions (3-meter major diameter and 1-meter minor diameter) and somewhat higher field than T-3. So T-10 will probably have a substantially longer confinement time than Alcator. The MIT device, Coppi says, can achieve high specific energy content by optimizing the magnetic field and the aspect ratio at the same time.

What are the limitations on Alcator? Coppi says that trapped-particle modes might give difficulty, and since temperatures will be higher, radiation losses are uncertain. But in any case the experiments should be interesting because they open a new plasma regime for study. —GBL

No Sign Found in Search For Neutral Tachyons

While theorists debate whether tachyons are forbidden or compulsory (PHYSICS TODAY, December 1969, page 47), the search continues for these faster-than-light particles. Last year Torsten Alväger, Michael N. Kreisler and Michael B. Davis[1] failed to find evidence for charged tachyons. Now Charles Baltay, Gerald Feinberg and Noel K. Yeh of Columbia, and Ralph Linsker of the Goddard Space Flight Center, have set an upper limit on the production of neutral tachyons.[2]

The Columbia–Goddard group looked for tachyons among the neutral particles produced by K^- and $\bar{p}$ beams stopped in the 30-inch Columbia-BNL hydrogen bubble chamber. The reactions studied were

$$\bar{p} + p \rightarrow \pi^+ + \pi^- + X^0$$

and

$$K^- + p \rightarrow \Lambda^0 + X^0, \quad \Lambda^0 \rightarrow \pi^- + p$$

Once all the charged-particle tracks are measured, kinematics allows one to calculate the energy E and the momentum p of the missing neutral(s). Thus each event is tagged by a value of its missing mass squared, $MM^2 = E^2 - p^2$. For tardyons (that is, ordinary particles) MM^2 must be positive. However, if X^0 is a tachyon with imaginary mass, MM^2 must be negative. In the more likely case that X^0 is a pair of neutral tachyons, the value of the missing mass squared can be either positive or negative and the phase space for obtaining a value of MM^2 within the range of the experiment is large for all possible values of the tachyon mass. Thus by studying the distributions in missing mass squared, the experimenters hoped to see the signature of neutral tachyons if they exist. One advantage of this method is that it does not depend on any assumptions about the interaction of tachyons with other matter, after the tachyons are produced.

The film used in the experiment consisted of 20 000 pictures with an average of 8 stopped K^- events per picture and 10 000 pictures with an average of about 1 1/2 stopped $\bar{p}$ events per picture. The resulting missing-mass plots gave evidence only for production of gammas and known tardyons such as neutral pions. The researchers estimated the upper limit for tachyon production to be at least a thousand times smaller than a typical strong-interaction process. —BGL

References

1. T. Alväger, M. N. Kreisler, Phys. Rev. **171**, 1357 (1968); M. B. Davis, M. N. Kreisler, T. Alväger, Phys. Rev. **183**, 1132 (1969).
2. C. Baltay, G. Feinberg, N. Yeh, R. Linsker, Phys. Rev. **D1**, 759 (1970).

Low-Field Room Built at High-Field Magnet Lab

A magnetically shielded walk-in room whose residual field is about 100 nanogauss is now operating at MIT's Francis Bitter National Magnet Laboratory. The room's designer, David Cohen, has recently reported[1] using a point-contact "SQUID" (superconducting quantum interference device) inside the room to record the magnetic field of the human heart without noise averaging. Cohen also plans to use the room for ac and dc measurements of the magnetic field from the human brain; roughly the brain's field is 1 nanogauss and the heart's peak field is 1 microgauss.

The room is also suitable for testing cryogenic magnetometers, measurements of geophysical samples and other physics experiments requiring less than 1 microgauss. It is a national facility, available to all experimenters, just as the high-field magnets at the laboratory. Construction was supported by the Office of Naval Research and the Damon Runyon Fund.

The room is roughly spherical, but is actually a rhombicuboctahedron (26 sides) whose outside diameter is 3.8 meters and inside diameter is 2.8 meters. Shielding is achieved with five layers; three of them are made of a high-permeability alloy made of nickel, molybdenum and iron. The inner two layers are screwed onto aluminum shells; the aluminum provides mechanical rigidity and eddy-current shielding. The floor and its supports are mechanically isolated from the room itself.

To increase the permeability of the shield, Cohen uses "shaking," a process in which an alternating magnetic field is applied to the alloy, keeping domains in continuous motion and decreasing their "friction." By this technique the shielding factor (ratio of the amplitude of the external **B**-vector to the amplitude of the **B**-vector at the center of the shielded volume) can be increased by a factor of six or more. With shaking the shielding factor is 900 at frequencies below 0.1 Hz, rises rapidly with frequency and passes through 10 Hz at 10^5, apparently still rising, Cohen said. He has not yet finished measurements at higher frequencies because of the difficulties involved with such high shielding factors. He says that under many ambient conditions the ac level in the room is now less than 10 nanogauss (rms).

The dc level at the room center has been made arbitrarily small (limited by dc sensitivity of magnetometers) by passing current through coils in the room walls. Gradients are gradually being decreased by degaussing and are now less than 10^{-5} gauss/meter. The most sensitive experiments are done during evenings and weekends when the high-field magnets of the laboratory are not running.

In the magnetocardiogram measurements Cohen, Edgar Edelsack (Office of Naval Research) and James Zimmermann (National Bureau of Standards, Boulder) used a single point-contact SQUID in a configuration of high mechanical stability, which was recently developed by Zimmerman. The magnetocardiograms had a noise level of several nanogauss (rms). The experimenters note that their magnetocardiograms approach good medical electrocardiograms in clearness.

SHIELDED ROOM now operating at MIT has residual magnetic field of 100 nanogauss. It uses three layers of high-permeability alloy and two layers of aluminum. When photo was taken, three sets of double doors had not yet been installed.

One project under way, supported by the American Cancer Society, is to find out if magnetic detection of the natural brain alpha-currents can show the presence of brain tumors. Another project, supported by NSF, will investigate whether or not the steady currents of the human heart can be detected through the steady magnetic fields that they produce. Injured hearts are said to produce heavy steady currents, but these can not presently be detected by skin electrodes because of local potentials. —GBL

Reference

1. D. Cohen, E. A. Edelsack, J. E. Zimmerman, Appl. Phys. Lett. **16**, 278 (1970).

Quests and Questions Concerning Quarks

Some seven months after the announcement of evidence for quarks by Charles B. A. McCusker and his colleagues at the University of Sydney,[1] more evidence has come forth from a second experiment.[2] William T. Chu and Young S. Kim of Ohio State University, W. J. Beam of Rose Polytechnic Institute and Nowhan Kwak of the University of Kansas claim to have observed one track that could be interpreted as a quark after examination of cosmic-ray tracks in 10 000 pictures exposed in the Argonne 40-inch heavy-liquid bubble chamber.

In such pictures, the bubble density depends on the time when the track is formed; so it is necessary to compare bubble density on contemporary tracks. The age of a track was determined by the size of the bubbles. Chu and his colleagues found two contemporary tracks where the bubble density on one track was about half that on the other. The ionization on this possible quark track was consistent with that expected of a charge-2/3 particle if its mass is less than 6.5 GeV.

Meanwhile, the observation of quark tracks by the Sydney group has not gone unchallenged. In particular, Robert K. Adair of Yale and Henry Kasha of Brookhaven,[3] and David C. Rahm and Robert I. Louttit of Brookhaven[4] feel that the low-density ionization of five tracks seen in cloud chambers by the Sydney group can be explained by the presence of low-energy electrons and muons and does not necessarily imply the existence of fractionally charged particles.

At the same time, Hans Frauenfelder, Ulrich E. Kruse and R. D. Sard of the University of Illinois[5] assert that both the velocity spectrum of shower particles and the fluctuation in droplet formation along the tracks must be experimentally determined before one can make a definitive statement about the existence of quarks. Adair, Kasha, Rahm and Louttit make similar assertions.

These critics say that the Sydney group may have underestimated their statistical error by using the total number of ions developed. Because one ion pair produced by a primary ionizing collision may in turn produce other ion pairs, the number of primary ionizing collisions, the statistically independent events, is less than the total number of ions. However, McCusker