MIDWESTERN UNIVERSITIES RESEARCH ASSOCIATION

Quarterly Report of the Laboratory Director

For the Period

July 1, 1959 to September 30, 1959

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REPORT OF THE LABORATORY DIRECTOR

The third quarter of 1959 has been occupied with putting the finishing touches on components of the Two-Way Model, adjusting the magnetic field to the required magnitude at all points, and life testing completed components. The present status of the model components is as follows:

1. Magnet

After six months of work using two shifts a day, the magnet is now complete. The field with the original windings has been measured, correction coils have been calculated, designed, constructed, tested, modified and installed. Δ K coils (see last quarterly report) have gone through the same procedure; correction turns have been added to take into account the finite permeability of the iron, and turns have been added to adjust the horizontal component of the field in the median plane to zero within the required tolerance. It is obvious that the number of separate measurements of the field has been enormous, but perhaps the principal reason for the long time required by the correction procedure has been the fact that every time a significant change has been made in the windings it has been necessary to recycle the magnets (turn them off and on several times) and then wait about fifteen minutes for the field to reach a final steady state.

The top halves of the magnets are now being removed to allow insertion of the vacuum tank and other components. Tests have shown that top halves can be removed and replaced without altering the field, and a check procedure has been developed.

2. Vacuum Tank

The vacuum tank is complete, except for some seal trouble on two of the twelve probes. Tests on the separate quadrants indicate that it will be possible to maintain a vacuum of better than 10^{-7} mm of mercury in the tank.

3. Equipment for Acceleration

The equipment for betatron acceleration has been constructed and tested and is awaiting installation.

The equipment for radio-frequency acceleration has been running on test for some time. The tubes which were used at first in one of the power amplifiers proved to have a short life, but the equipment has been modified to take a different tube and now the life appears to be satisfactory. The equipment is ready to be installed.

4. Injector

One injector-inflector assembly has been completed and tested, and a second one is nearing completion. It is expected that both will be ready for installation by the time they are needed. In any event, one is now ready so that at least one-way operation is assured.

A number of MURA staff members are working on plans for studying the colliding electron beams in the model. We almost certainly will be able to detect electron-electron collisions, but the precision required at this energy in order to make a significant test on the limits of validity of quantum electrodynamics is probably beyond present experimental techniques. One member of our staff is making longer range plans to use the model for photonuclear studies.

Several physicists from MURA Universities have also expressed interest in this possibility.

A number of MURA people took an active part in the International Conference on Accelerators held at CERN in September. Drs. Cole, Haxby, Mills and Symon were invited from the MURA Laboratory, and Drs. Jones, Laslett, Sessler and Terwilliger, who have been active collaborators on the MURA program, were invited from MURA Universities. There was considerable interest in FFAG machines at the conference. Both CERN and the Lebedev Physical Institute of the U. S. S. R. are working on Two-Way Electron Models.

Although the Two-Way Model has had top priority in the Laboratory, it has been possible to make significant progress in the component work looking toward final design of a large accelerator. Two half scale models of magnets for a radial sector accelerator are being wound by Allis-Chalmers and delivery is expected soon. Steel for a half scale spiral magnet is on hand but actual construction cannot begin until the design is complete. Some preliminary experiments on machining for this model have been completed.

Vacuum tank problems seem to be well in hand except for the insulating seal. Although teflon has proved to be better than was expected, it cannot be considered completely satisfactory, both because it cannot be baked at high temperature and because of its deterioration when exposed to radiation.

A small RF Cavity for testing ferrites has been completed and a number of samples have been tested. At first it was hoped that the cost of ferrite might be reduced by a factor of between five and ten, but this hope is dimming. The cheaper varieties have to date not been satisfactory and although they are good

enough to be encouraging, progress has been very slow.

The Summer Study Group was profitable to us in that it helped us choose the path which further development should follow and made the needs and desires of the high energy physicists much clearer to us than they had been before. Detailed reports of the work done by the study group are nearing completion and should be out soon.

The Summer Study showed that there is great interest among high energy physicists in a 10-15 Bev Proton Accelerator which will produce a time-average accelerated current of about 30 microamperes, more than 100 times the intensity of present day accelerators. There is also interest in increasing intensity by another factor of 100, to the milliampere range, in the more distant future. One of the more interesting possibilities which was discussed was the high repetition rate AGS (MURA-467) which could be developed to reach time-average currents of 30 microamperes. However, it was generally agreed that the beam stacking possible in a Fixed Field Accelerator would give rise to flexibility in beam duty cycle which is very desirable.

We are now engaged in design studies of a Spiral Sector FFAG Accelerator which will permit beam stacking and which will, with presently known injection techniques, accelerate a time-average current of approximately 50 microamperes. As we envision it, this accelerator will be capable of further development in several ways:

1. Injection techniques will undoubtedly improve in the future. With such improvement and with an increased acceleration rate, which is technically feasible at increased cost, the machine will be capable of

accelerating currents of milliamperes before fundamental limitations are reached.

2. If it becomes desirable to make use of colliding beams to reach very high reaction energies, this accelerator can be used to inject into a storage ring system, a method of producing colliding beams which has certain advantages over the Two-Way Accelerator of our 1958 proposal. The cost of the storage ring system is probably the same order of magnitude as the additional cost of the Two-Way machine over that of the Spiral Sector FFAG.
3. If further study shows that the small aperture Alternating Gradient Synchrotron with multi-Bev injection proposed by Sands (MURA-465) is a better method than colliding beams of reaching energies over 100 Bev, the high intensity FFAG will be an excellent injector because of the large current which can be stacked and injected.

Likely parameters of the accelerator we have in mind are listed below.

These numbers are reasonably accurate, but it may be that further work will improve some of them. The energy, 12 Bev, is chosen for illustrative purposes only and is not intended to represent a final choice.

1. Energy - 12 Bev - above all known particle production thresholds.
2. Injection Energy - 200 Mev - linear accelerator.
3. Largest Beam Radius - 70 meters - approximately 230 feet.
4. Peak Field - 12 kilogauss.
5. Circumference Factor - 2.

6. Magnet Weight - 15,000 tons.
7. Copper Weight - 2,000 tons.
8. Time - average current - about 30 microamperes.
9. Ultimate Possible Current - about 2 milliamperes.

Progress toward a decision on the type of accelerator which should be recommended to the AEC has been somewhat slower than we had hoped, partly because the model work has taken longer than expected, but ideas are beginning to crystallize and a definite plan should be formulated during the next few months. However, both additional theoretical work and experiments with models must be completed before we are ready to choose a design.

During the final quarter of 1959, especially as staff members who have been working on the Two-Way Model become available for other work, the emphasis in the Laboratory will be shifted to design and cost estimates on a large accelerator.

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