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UNIVERSITY OF CALIFORNIA — BERKELEY

RADIATION LABORATORY

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RESEARCH SERVICE BRANCH
Atomic Energy Commission
Berkeley Area
Berkeley, California

MINUTES OF MEETING OF MTA ACCELERATOR COMMITTEE
HELD JUNE 21, 1951

Present: UCRL: Alvarez, Brobeck, Chunn, Dimmick, Farly, Kilpatrick, Lofgren, Martin, Norton, Panofsky, Reynolds, Wallace

CR&D: Chaffe, Fossati, Hildebrand, Kent, Kallman, Waithman

AEC: Ball, Fidler, Fleckenstein, Lilly, Weil

Hildebrand said that there have been tentative indications that the Commission may want us to go ahead as rapidly as possible with the construction of a Thomas-type cyclotron at Livermore. In order to test the feasibility of the cyclotron approach to the attainment of high beam currents it is necessary to build a machine of full beam voltage--namely, about 300 Mev. The machine recommended by UCRL and CR&D to be built at Livermore would be a stripped-down model with no target. To construct such a machine would introduce a manpower problem which would have to be solved by the assignment of priorities to Marks I, II, and III. We would start out continuing with Mark I as having number one priority and prove it out as rapidly as possible but we would put our number two priority on Mark III. The number three priority would then be the Weldon Spring job. In order not to spread our forces too thin we would largely drop the pursuit of research and engineering directed toward optimizing Mark II and stick strictly to the 12-megacycle design as far as engineering is concerned. As far as we have capacity available without interfering with the other two jobs we would continue with some exploratory work on 20-megacycle operation of Mark II.

Things are going rather nicely with Mark I at the moment. The cavity pressure is down this morning to 3.6×10^{-5} millimeters. Work still remains to be done to get the pressure down where we need it but we feel we have a very nice start. Work on the Chapman valves is underway to get them to seat better. There is a difference of a factor of two between pressure readings with and without the liquid nitrogen traps, so there must be some leakage in the vessel. The liner fabrication rate has picked up markedly.

Research-wise, there is not much work to be done on Mark I. Considerable research will have to be done on Mark III before very much engineering would be required so the engineering studies on A-12 would not be much altered for several weeks at the earliest. We have been requested orally to write another feasibility report covering the Mark III proposal--that is, the Livermore experimental model--and also to explore

as nearly as one can at this date the ultimate comparison between the linear accelerator and cyclotron approaches, assuming they will both work. Although the Radiation Laboratory will carry the burden of writing the Mark III feasibility report, CR&D will have to be called upon to assure proper comparison between Mark III and A-12 to assure that the same unit costs, etc. are used in the Mark III study as were used in the recent report on A-12, which was prepared by CR&D.

Lawrence and Powell discussed the Mark III proposal with the Commission last week.

Martin said that last week they built three liner panels out of three scheduled. This week they have four scheduled in the polishing shop. If they can continue to build four large panels per week, counting one end panel as half a liner panel, then the liner fabrication will be complete on August 15. If the production rate can be increased to five per week they will finish by August 1. Martin added that the leak hunting procedure on the panels at Livermore prior to installation is being discussed currently with CR&D field forces. A study will be made by CR&D and the Radiation Laboratory regarding leak hunting methods. Farly asked if measurements were being made of rf conductivity of the finished panels. Martin said that conductivity is now based upon measurements at 100 megacycles. A 20-megacycle test will be applied in the future. Panofsky said that the transmission line losses showed a satisfactory agreement with theoretical calculations. Hildebrand said the schedule for completion of the baffles in Mark I matches the construction schedule for the liner panels. If the liner schedule improves materially we will have to increase the work on the baffles.

Panofsky said that the "magic formula" treatment for cleaning the ball in the B-1 cavity gave poor results as judged by visual inspection. The ball will be repolished this afternoon.

Hildebrand said we have approval and a substantial amount of funds to proceed with engineering and research on A-12 so that if any work is stopped on A-12 it will be for lack of people rather than lack of funds.

Martin said that one of the reasons for proposing Mark III is that, although it does involve some problems, two of the major A-12 problems (namely, holding high voltages in the tank and excessive X-ray loading) are problems which are of minor consequence in Mark III. The estimate of X-ray loading on a Mark III machine is only a few kilowatts and the voltages which are required are approximately 500 KV or less, which is small compared to the voltages required in A-12. Dee voltages of this magnitude may, however, prove difficult to attain because in the presence of the magnetic field one gets a type of collimated sparking which causes sputtering of the copper surface.

Martin said this phenomenon will have to be explored further although tests on XC indicate that the introduction of graphite, tungsten, or molybdenum greatly reduces the damage from this type of sparking. These tests cannot be carried further on the present XC because there is not enough stored energy in the present XC resonator to produce the sparking damage expected in a full-scale Mark III. One of the immediate experimental programs is to design a resonator with about 10 times the stored energy of the XC resonator to investigate this sparking problem. This will possibly require a new power supply and more oscillators. It is desired to obtain dee voltages as high as 750 kilovolts with this new system at a frequency in the neighborhood of 10 megacycles. Alvarez suggested since the magnetic field required is only about 2000 gauss that use be made of Baker's cavity and that a magnet be built to supply the necessary magnetic field. The consensus was that this suggestion merited considerable study.

Martin said they will also continue the work on the electron model of the cyclotron to investigate beam removal and the variation of beam current with radius. There are still some unexplained phenomena with regard to threshold dee voltage and bumps in the magnet field. There are presently some bumps required in the magnet field which are not explained by theory but which probably result from a deformation of the median plane.

Martin said it is also planned to modify the 20-inch injector cyclotron (previously used as the injector for the quarter-scale bevatron model) to test 3-phase dee operation and to investigate ion source development and methods of capturing the beam in stable orbits in a 3-phase electrical field and to give the electrical engineers some experience with 3-phase oscillators at a higher power level than has been studied thus far. There are about 11 kilowatts of DC power per phase required for the amplifier for the 20-inch cyclotron. We will thus have a 33-kilowatt, 3-phase rf system. Equipment for this should be assembled about the first of July.

Martin said magnet model tests will also be made to determine the maximum energy for which Mark III may be designed. The limit for iron-core magnets is probably between 250 and 300 Mev. They will also conduct tests on the resonator part of the system; there is a possibility of putting the dee stems through holes in the valleys or the magnet. Holes in this location should not seriously disrupt the magnet field. It may be necessary to abandon this suggestion in the interest of time. The magnet being considered for this experimental Mark III has no return yoke. Sewell discovered in some of his model measurements that the amount of copper and ampere turns required without the return yoke is small enough so that the saving in steel more than compensates for the increased magnet power required. This appears especially desirable for this first machine since it will be

originally designed without a target and we will need the maximum degree of freedom.

Farly inquired as to the magnitude of the stray field from such a magnet and its effect upon electronic instruments. Martin said this problem has not yet received detailed study. Panofsky said that almost any piece of electronic equipment will have to be provided with a magnetic shield. Martin said consideration is being given to shielding with iron ore concrete so that the radiation shield can also serve to a degree as a return path for the magnet.

Martin said the diffusion pumps will be welded onto the cyclotron tank and the tank will be welded onto the magnet pole. Welded joints will be used wherever possible in lieu of gasketed joints in order to eliminate organic gasket materials which are subject to radiation damage.

Martin said that estimates of the power requirements indicate that this experimental cyclotron can produce a 15-milliamp beam by using 6 tubes rated at one megawatt CW. He said a choice between pulsed and CW operation also remains to be decided. Farly suggested pulsing only the arc instead of all of the rf equipment. Lofgren said that pulsing may be desirable for other reasons--for instance, in baking out the tank it might be desirable to be able to terminate the discharges which occur. He recommended that pulsing equipment be considered unless its cost proves unreasonably high.

Thornton said it looks as though 300 Mev is the maximum energy attainable with magnet fields obtained by the use of iron. To go higher one would have to resort to the use of coils to make the hills higher and the valleys deeper. The limit imposed on the energy is a combination of a theoretical limitation and practicalities of magnet design. He said the effects of perturbations of the magnetic field on threshold dee voltages has not been explored but will have to be studied. Farly asked if the manner in which the beam peels off is dependent upon the energy gain per turn or is it simply a function of geometry of the magnetic field. Thornton said it is not possible at the present time to give a clear answer to that question but he does not think it would be strongly dependent upon energy gain per turn. He added they have not yet investigated the peeling off of the beam as a function of dee voltage.

Martin said that Brown has estimated that if the 15-milliamp deuteron beam from this experimental Mark III were run into heavy water a neutron flux of about 10^{15} would result.

Martin said that the data for estimating the cost of Mark III at Livermore is in pretty good shape. He said within the next few days CR&D will be supplied with drawings and data to allow CR&D to apply

its cost yardsticks and thereby enable CR&D and UCRL to prepare individual cost estimates of the Mark III installation. Martin said that it should not be difficult for CR&D to estimate the cost of the production Mark III installation since the bulk of the cost is made up of cooling and power equipment.

Martin said, in answer to a question by Farly, that differential plate voltage control will be required for each oscillator. Martin said it is important to prevent phase shift in the voltage between the upper and lower dees. He said if prevention of this phase shift proves to be a serious problem it may be necessary to tie the upper and lower dees together, although it is hoped these connecting straps can be omitted so we can take advantage of the greater flexibility of the machine that would result. He said that 1600 killowatts will be required for the magnet excitation.

Brobeck said that the effect of dimensional variations upon frequency for A-12 have been written up as an engineering note.