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MINUTES OF MTA MEETING, TUESDAY, APRIL 25, 1950

Present: UCRL: Baker, Brobeck, Cooksey, Farly, Gordon, Lofgren, Longacre, Martin, McMillan, Norton, Panofsky, Reynolds, Richardson, Sewell

CRDC: Hildebrand, Kent

AEC: Ball, Fidler

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Panofsky discussed the problem of the holes in the liner and their associated radiation loss. He said that there will have to be sleeves on the holes in order to minimize the radiation loss. It doesn't make much difference what size the holes are because the attenuation of the sleeves is so great. In a round pipe the power attenuation is 3.2 times 10^{-4} per diameter and with the magnetic field perpendicular to the long dimension of a rectangular pipe the attenuation 1.7 times 10^{-3} per unit of the small dimension. [For the purpose of calculating attenuation for a round pipe the length is measured in units of the diameter; for the rectangular pipe the length is measured in terms of the smallest cross-sectional dimension.] This situation will be examined in order to establish a proper balance between power loss by radiation and attenuation of pumping speed.

Brobeck stated that we need to calculate carefully the effect of this power loss on heating the tank which might give rise to out-gassing and complicate the pumping problem.

Panofsky and Henrich have been making some calculations on what happens to the injected beam which is lost before reaching the target. They traced the phase oscillations on the basis that there were 180 electrical degrees during which particles begin to be accelerated and 180 degrees during which they are pushed back toward the injector. Of the 180 degrees that come in the right phase in the accelerator, 90 degrees of them are accelerated all of the way. The other 180 degrees will run into retarding fields and will end up on the entrance sleeve ahead of the first gap. That will amount to about 30 kw at that point. This is about $\frac{1}{2}$ of the total power of the injector. The beam current of the injector will be 50 ma average and 200 ma peak. Of the 200 ma peak leaving the injector, 100 ma will meet a retarding field and be lost. Of the remaining 100 ma, 50 ma will be lost along the length of the accelerator and the remaining 50 will be satisfactorily accelerated. Primary interest lies in the 50 ma that will get lost along the way because that beam could pick up quite a bit of power before it gets lost.

Present calculations estimate that, of the 100 ma's of the beam that is initially accelerated, the following percentages will strike the first five drift tubes: 11, 13, 7, 6, and 3 respectively. [Note: At the meeting these values were reported as 5, 18, 9, 5, 2, and 1 percent respectively.

These losses should add up to 45 percent. Since all of these values were read off a series of graphs the remaining 5 percent is accounted for by the remaining drift tubes and errors in reading the graphs.

As far as the shielding problem is concerned the important thing is not the power loss but the neutron yield. This is obtained by multiplying the above loss percentages by the excitation function of the d,n reactions concerned. The shielding calculations made by Moyer were made on the basis of having $\frac{1}{2}$ of tolerance dose on the outside of the shielding for an 8-hour shift. On the present standards this permits 10 - Mev cm^{-2} sec^{-1} for neutrons. On this basis six feet of concrete look reasonable. The attenuation length to reduce the radiation intensity by a factor of e is about 4 inches. Shielding foundations are now being provided for 7 feet of shielding.

Another question on the shielding requirement involves the question as to whether or not one wants to have the target on the inside of the primary accelerator shield and Norton suggested that if an internal test target were used one could use a water target and eliminate the cooling problem. [The shielding planned is adequate for a target located inside the shield. Cooling a target required for measurement of the full beam current at 30 Mev is not expected to be difficult and space for such a target is available inside the shield. W. M. B.]

Brobeck inquired regarding the angle of incidence at which the stray beam will hit the various drift tubes. Panofsky stated that this beam would come in at a fairly large angle because the ratio of aperture to length of the drift tubes is very large.

Sewell asked if there were a possibility of the ions that are being lost hitting the liner so steeply as to penetrate it and activate the copper. This could present a serious source of radioactivity. Panofsky said that his present calculations would not show this. He has not calculated any actual trajectories across the gaps. All that is now known is how much of the beam will be lost at each drift tube and little is known about how it is lost. He suggested that one should plan to handle the drift tubes as one would pile targets.

Brobeck asked whether there were any way the drift tubes could be designed so the phase acceptance angle would be better at the high energy end than at the injector end so that more of the particles will all fall out of phase at low energy. Panofsky replied that one could design the drift tubes in the far end for a lower average energy gain so that the acceptance angle would be larger in the far end. One will not be concerned with this problem if rf extraction from the ion source proves possible.

Brobeck stated that we should determine soon the required location of the graphite liner in the drift tubes.

Gordon reported that last week the tests from the 800 megacycle model were about completed on the last 4 drift tubes--that is, on drift tubes 4 through

7, inclusive, with actual radii, lip radii, and bores simulated in a region in which it was possible to bracket the curve obtained for the tank taper we have selected. That is, the straight line plot of D/λ versus the length of the tank was made from values of D/λ from .71 to .64. It was then possible with these drift tubes to get a ratio of drift tube diameter to drift tube length and at positions of these drift tubes a cross plot was made of D/λ versus d/λ for each drift tube number. Then, knowing for each drift tube the value of D/λ the value of d/λ was determined which satisfies the resonant conditions of that position. This has been done for the last 4 drift tubes and work is proceeding on the first drift tubes. For the shorter drift tube the measurements are more difficult because of the smaller dimensions. The smallest drift tube turned out to be No. 5. They are almost constant diameter but No. 5 is somewhat smaller than the others.

The actual values of drift tube diameters are somewhat embarrassing. It had been expected that the drift tube diameter would lie in the neighborhood of 8 feet; that is, around 96 inches. They seem now to be around 7 feet 4 inches, so they are now working on the design of focusing magnets again. The only magnet that has been re-calculated on this basis is the one for No. 7 drift tube. For this one the new values to provide the same magnetic field show that it will be necessary to go to a current density of 3000 amps/in^2. This will increase the power from 300 to 375 kw. The weight of the magnet is down to 23 tons from the previous figure of 30 tons, the weight reduction coming out of copper. When the current density is increased 50% the power loss goes up about 25%. The power requirement seems to be worse and it is not felt that it can be improved by changing the tank taper because they have already found the smallest drift tube to lie within the 60-foot tank with the present taper. One might make the taper more gentle at first and then more rapid later.

The principal difference between the present and the former tests was the presence of the central hole through the drift tubes in the present tests. Theoretically this should have given a larger outside diameter for the same frequency, whereas the diameter actually came out smaller. This indicated an error in the tests or the effect of some other change in the model. The accuracy obtained and required in these tests was discussed and Panofsky stated that in the 60-foot tank a change in the drift tube diameter from 7 to 8 feet would probably not greatly affect the operation. He said he could calculate this effect from the existing data.

Previous linacs had always been designed with drift tubes of the ideal diameter to give the desired frequency but where magnets are used the optimum diameter would probably be larger than the ideal value and some lack of uniformity of voltage gradient could be tolerated.

Panofsky said the distribution of the voltage in the first section of the accelerator will not be sensitive to these errors. For the rest of the tank the unit cell approximation is good but then you can consider the first section as a unit cell. The effect of the mistakes that you are making now is not going to get any larger as time goes on.

Sewell asked what the effects of the stray magnetic field would be if the magnets were just solenoids with no iron for a return path. The power requirement for such magnets should go down but there would be an increase in stray magnetic field.

Panofsky said they are already afraid of the effects of magnetic fields on discharges. If the magnetic field leaks into a region of high electric field the situation will certainly be worse. Therefore we should try to keep the magnetic shielding at a maximum. Norton suggested that one advantage of reducing the frequency a little bit would be that it would reduce the requirement for focusing, to which Panofsky replied that if you started lowering the frequency too much then the first drift tubes are going to start to become huge. Brobeck said that we will proceed on 8-foot diameter for the present until some difficulty appears that requires a change. The recent fire in Building 8 will probably not affect the schedule of this work. There is quite a bit of re-drawing to do, although not much of it is on the MTA project. At the suggestion of people from Cal Research we will hold our meetings in the future beginning at 3 o'clock and will try and hold them down to 45 minutes to an hour in length.

Russell H. Ball

CC: W. B. Reynolds, UCRL
John Q. Cope, CRDC
H. A. Fidler, BAO
J. Norton, UCRL
R. K. Wakerling, UCRL
W. M. Brobeck, UCRL
A. Tammaro, COO
K. S. Pitzer, WOO
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