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RADIATION LABORATORY — UNIVERSITY OF CALIFORNIA — BERKELEY
ENGINEERING NOTES

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Possible Improvements in Cavity Geometry at High Energy End of Mark II

NAME L. W. Alvarez

DATE February 9, 1951

When the MTA was in its early discussion days, several modifications of the basic drift tube geometry were explored, but all were found to be less efficient than the geometry used in the 40-foot linear accelerator.

Longacre's extensive data on shunt impedance per unit length and transit time factor, both as functions of β, have shown a rapidly decreasing acceleration efficiency as β is increased. The so-called figure of merit of a "unit cell" of the accelerator is defined as $Z'T^2$, where Z' is the shunt impedance per unit length relative to that of a simple cavity with no drift tubes, and T is the fraction of the gap voltage which appears as particle energy. At high values of β (0.5), the figure of merit has dropped to about 20 percent.

It appears likely that by changing the basic geometry of the machine at some value of β in the neighborhood of 0.4, that the overall figure of merit of the accelerator can be raised substantially. Figure 1 shows the geometry of the accelerator at near the critical value of β.

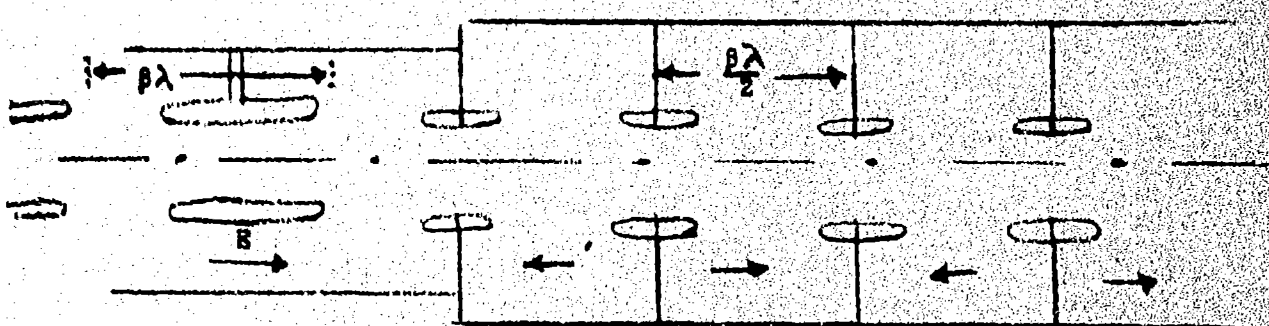

Figure 1

The new geometry consists of a series of Klystron type cavities back to back, with neighboring cavities excited out of phase. This has some similarity to the mode used in electron accelerators, which is shown in Figure 2.

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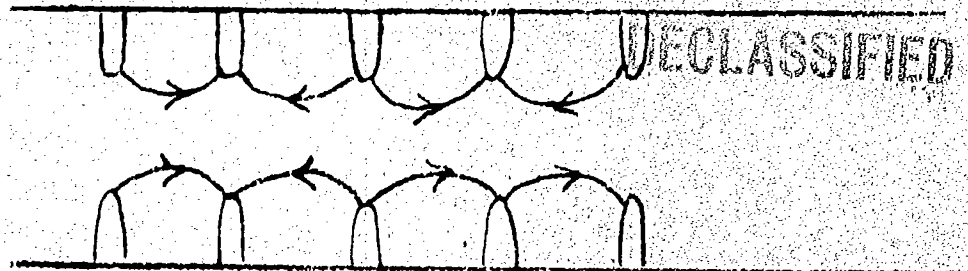

Figure 2

In this geometry, the holes are large enough to allow good coupling between adjacent sub-cavities. In Figure 1, it would probably be necessary to cut holes through the diaphragms, near the cavity wall, so that the cavity fields could "find out what was going on in their neighboring cavities". There is little doubt, from experience with electron accelerators, that the proper mode pattern could be established in a stable manner in a long cavity designed to these specifications.

We now investigate the gain to be had by such a change in geometry. The main difference between the two types of geometry is in the repeat length, $\beta\lambda$ or $\beta\lambda/2$. At a repeat length of $\beta\lambda/2$, the "effective β" of a cell is $\beta/2$. In other words, the shunt impedance can be found by looking up the shunt impedance of a "standard cell" with half the value of β. Since we know that Z goes down as β goes up, this gives an immediate gain. Also, the transit time factor is considerably increased, for the following reason: The drift tube field is roughly equal to the average field divided by g/ℓ. So if we design to a certain maximum field, for x-ray reasons, we design to a minimum value of g/ℓ. (If we could make g/ℓ smaller, the transit time factor would increase, but the electron loading would also go up.) But with a repeat length of $\beta\lambda/2$ instead of $\beta\lambda$, the transit time across a gap of given g/ℓ has been cut by a factor of 2, since both g and ℓ are smaller by a factor of 2. The new geometry therefore gives higher values of T, as well as higher values of Z.

The one thing left out of this argument is the effect of end walls of the unit cells. In "standard geometry", the end walls can be left out, but in the new geometry, they must be retained to carry the charging currents, which are in the same direction on either side of the wall. The simplest calculation shows that at a β of 1/2, probable increase in the figure of merit is greater than 50 percent, when the end walls are accounted for.

It would appear that a serious investigation should be made of this possible change in cavity design. The data are all available from the work of Longacre's group.

One additional advantage of the new geometry is that the absolute voltage across any gap is one-half of that across a "standard geometry" gap. This may be of great importance in eliminating x-ray induced activities.

LWA/pw