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UCRL-1183
Technology - Materials
Testing Accelerator

UNIVERSITY OF CALIFORNIA
RADIATION LABORATORY

Contract No. W-7405-eng-48

CALIFORNIA RESEARCH & DEVELOPMENT COMPANY
Contract No. AT(11-1)-74

MINUTES OF MTA PROGRESS MEETING
HELD MARCH 13, 1951

Russell H. Ball

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RESEARCH SERVICE BRANCH
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MINUTES OF MTA PROGRESS MEETING
HELD MARCH 13, 1951

Present: UCRL: Alvarez, Baker, Brobeck, Byerly, Cork, Farly, Gow, Hanson, Kilpatrick, Latimer, Lawrence, Lofgren, Longacre, McMillan, Norberg, Norton, Panofsky, Reynolds, Robertson, Serber, Street, Thornton, Twitchell, Van Atta, Wallace

CR&D: Cope, Davis, Hansen, Hildebrand, Kent Maker, Powell

AEC: Ball, Campbell, Fidler, Fleckenstein, Platt

G.E.: Webster

Westinghouse: Andrews, Hulse, Kresser

N.A.A.: Taylor, Howard

Baker discussed the new pre-exciter oscillator which was mentioned last week. Recent tests with the RCA 2332 tubes have shown them to be free of parasitic troubles, easy to drive and to have a high power gain. Also the tube is shielded from the output so that little energy can feed back through the tube. This advantage combined with the high power gain means that only a small transmission line is required to feed the driving signal from the resonant load.

Once past the startup period it is planned to use this tube in the same manner as in the past, namely to feed power to the cavity through the anode circuit and drive the tube with a signal picked up from within the cavity.

When plate power is applied at the beginning of the start-up period most of the voltage drop will be a DC voltage drop across the tube and this will result in a transient high power dissipation in the tube. To minimize the duration of this effect it is desirable to amplify the driving signal from the cavity during the build-up period, whereas after this period direct drive is most advantageous because it eliminates the slight phase distortion introduced by the amplifier. Recent studies have been directed toward development of an oscillator for use on Mark II which would use these two modes of operation in succession by being provided with a switch to short out the amplifier signal and permit direct driving after the build-up period.

The amplifier used has a gain of about 20,000 and will supply a constant output signal over a range of input signal strengths of 1000/1, with a phase distortion of only about 10%. It is necessary to have the input

circuit to the 2332 tube remain in tune over the entire buildup period. This is accomplished by applying to the plate of the tube a voltage opposite in phase to the grid voltage and of a magnitude which will neutralize the current flowing through the internal capacity of the tube. This neutralizing voltage is derived from the cavity itself so no difficulty occurs from parasitics. This neutralizing signal is fed from the cavity to the tube through a variable capacitor. When converting from pre-exciter operation to normal operation a switch is closed to cut out the variable coupling condenser and provide direct drive from the cavity to the grid.

The Mark I pre-exciter will be driven by an amplifier and will use a small transmission line (in addition to the two normally required) to provide a neutralization current for the grid.

Baker also discussed recent work on the resnatron. A model has been constructed to test the optics of the system. No experimental results were obtained with the first model because of insulator trouble and a second model has therefore been constructed. The pulses supplied to the resnatron have been restricted to 10 microseconds to minimize the heating problem. The heating problem is severe because with the tube running at rated current the ratio of peak current to the DC value is 6 to 1, so that if the tube were tested on DC there would be 6 times as much current flowing through the tube as would ever be encountered in an operating case. DC voltage was applied to all of the other electrodes; then electrons were gated through from the normal grid. The results were very promising. It was found that back bombardment of the accelerating grid was not serious. When running at 12 amperes plate current and 2 amperes per centimeter emission from the filament the screen current is only 250 milliamps. He said that secondary electrons must still be produced but that the space charge in front of the collector is probably driving the secondary electrons back. They have also been experimenting with a Phillips-type cathode in the resnatron. The original intention was to build a resnatron capable of operating in the accelerator vacuum system so that the anode of the tube could be hooked directly to the main resnatron without the use of any insulators. The Phillips-type cathode does operate satisfactorily in the type of vacuum which will be produced in the accelerator. The life of the Phillips-type cathode should be in excess of 1,000 hours. When the pulse length was increased from 10 microseconds to one millisecond the screen current increased linearly with time during the pulse length from its previous value of 250 milliamps to a final value of about one ampere. This behavior is at present unexplained. During some of the pulses this rise in screen current leads to sparking.

Alvarez said that two enlightening developments have occurred during the past week or two regarding the X-ray problem. One is the result obtained at MIT with a 10 cm (3000 mc) cavity which was used to investigate the frequency dependence of the X-ray yield. MIT had reported developing

2,000,000 volts across a very small gap and made no mention of X-ray production. Subsequent investigation showed the X-ray production to be rather large. Evidence is now available that the X-ray production at 10 cm (3000 mc) is the same as that produced at 200 mc. Further information comes from experience with Van de Graaff columns where the X-ray production increases as the 6th or 7th power of the voltage, which is the same voltage dependence as obtained with 200 mc rf fields. If the Van de Graaff column is evacuated with mercury diffusion rather than oil diffusion pumps the X-ray yield is reduced by several orders of magnitude. Recently the High Voltage Engineering Corporation at Cambridge has operated a Van de Graaf at a voltage of 5.7 million volts. This voltage was obtained in a machine which normally would have been expected to hold only about 4 Mev. Robinson, who did the work, stated that the Van de Graaff could probably have been pushed to hold higher voltages than the 5.7 million volts but that this was not attempted because the machine was scheduled for prompt delivery to Oak Ridge.

Alvarez said the Laboratory has now ordered two 6-inch mercury diffusion pumps which will be attached to a 200-megacycle X-ray test cavity. Robinson, of High Voltage Engineering, is also to supply us with several small 100 liter/sec. mercury diffusion pumps. These will be used on the X-ray test cavity. This will allow experimentation to be started on the reduction of X-ray loading obtainable by using mercury pumps. If these results look promising, serious consideration will have to be given to using mercury diffusion pumps on the Mark I cavity. Alvarez said 3 new cavities are being set up to test X-ray production. The electron accelerator is being converted by Jack Frank, a second (B-4) cavity is being set up in the Bevatron building, and the third is Lofgren's mercury-evacuated X-ray cavity (B-5).

Alvarez said that a definitive result has been obtained on the effect of evaporating gold in the B-1 test cavity. It has resulted in no improvement. Gold, copper, and stainless steel coatings have now been tested and the same X-ray yield is obtained from each. Presumably the high emission in each case is due to contamination of the surface with diffusion pump oil.

Longacre has been doing model work measuring theresonant frequency of model cells of various dimensions. He is obtaining a four-dimensional plot of frequency as a function of G/L, β, and the drift tube diameter. Alvarez added that they have been measuring the transit time correction in the gaps. The transit time factor for a gap is the ratio of actual energy gain to that which would have been gained had a D.C. field been used. Measurements of the transit effects are being compared with theory. An interesting effect has been noted. A better transit time factor is obtained for certain critical values of G/L. The transit time factor is measured by pulling a BB (conducting sphere) along the axis of the drift tube and observing the effect on the cavity resonant frequency. From this the electric field is calculated, thereby permitting a calculation of the transit time factor.

Longacre is now spending most of his time determining the taper of the

Mark II cavity so that California Research Corporation can begin preliminary design of the tank. These calculations have been started at the high energy end of the tank and are being worked toward the low energy end, which is the most difficult end to calculate. A complete table of drift tube dimensions is now being prepared. Model experiments will be required to determine the effect of the gap splitters which are to be installed.

Studies are also proceeding to measure the Q of a cavity full-scale. A device is being built at Livermore which is essentially a copper room with copper sheet lining which will have a very large Q. Practice runs on determinations will be made with this.

Another group is working on the problem of aligning the resonant cavities of lengths which are large in terms of the wavelength. Within one week construction will be completed on a 10 cm (3000 mc) cavity 18 wavelengths long. We should know shortly how difficult it will be to align a cavity of this length although the present consensus of opinion is that it should not be difficult. These tests will be made using drift tubes which will be adjustable in length to accomplish the tuning.

One additional problem is to test rf joints to determine the magnitude of currents which can be conducted across them. So far it has been possible to conduct 4,000 amperes across a circular joint approximately one foot in diameter. This current density was maintained for only four minutes due to an oscillator failure. This amounts to about 120 amperes per inch.

Woodyard and Waddell are working on a problem of interest in Mark II; i.e., to find out what happens when sparking occurs in the tank. They are going to determine the time constants for the transfer of energy from the cavity fields to the beam. The dynamics of such a process is presently an unsolved problem. The group velocity of traveling down the machine is essentially 0 so the phase velocity is infinite and the interactions between one end of the machine and the other are not well understood.

Woodyard and Waddell are building an analogue computer which will consist of resonant crystals hooked together in an appropriate manner. Panofsky has been working on focusing magnet design--that is, to determine the required $\int H^2 dl$ required along the machine and where it should be put and what compromises are allowable.

We now have the differential analyzer obtained from the University of Illinois. This is being used to investigate beam dynamics mostly in the low energy end of the machine, where there are space charge and transit time problems and where one needs to be concerned with off-axis fields. They are studying the effects of larger apertures. It now looks as though larger apertures can be utilized in the low energy end. Panofsky has also been working on the divergency of the Mark II beam. The divergence is about 0.6°. Martinelli has been figuring out how to disperse the hot core of

the beam without using a precessing magnet. It is hoped to accomplish this with static fields. Panofsky said that if CW operation is achieved in Mark II then precessing the beam is the only remaining cause of thermal fluctuations in the target and is therefore to be avoided if possible.

Jack Frank is designing a TR box. This is a device which would be used to eliminate rotation of the large coupling loops which must be used during pre-excitation. At the present time this coupling loop is rotated out of position so as to intercept less flux. They are looking into the possibility of using a low-voltage, low-power discharge to reflect impedance back into the line which would effectively open it. In the past Frank built such a device for use on the present linear accelerator so there is good reason to believe it can be used successfully on Mark I. Baker said it is hoped that by the time Mark II operates it will be possible to utilize the combined pre-exciter and driving oscillator which he presented earlier.

Hildebrand said that DPI has reported that the steel sprayed with an aluminum coating is satisfactory from the standpoint of out-gassing. The corrosion tests which were made at Richmond were also favorable. CR&D therefore recommends that if enough aluminum can be obtained in time the interior of the Mark I tank should be spray-coated with aluminum. A procurement problem may cause some delay if an attempt is made to coat the entire tank with aluminum. He asked if it would be satisfactory to spray as much as possible with aluminum and select those portions to include the areas around openings in the liner and then complete the coating job with zinc. Panofsky objected to zine on the basis of its high vapor pressure and behavior under sparking. He said that in early phases of operation discharges may occur at any location between the liner and the tank and this would result in vaporization and random distribution of the zinc. Hildebrand said that, should they run out of aluminum, another alternative would be to pump the tank down and test it for vacuum tightness with part of the tank surface bare and then finish the aluminum spraying later. It was the consensus that although this may involve some recleaning of the bare surface it would be satisfactory.

Hildebrand added that last Friday a meeting was held to outline the scope of the vacuum pump development program. The meeting included Dr. Kenneth Simpson from Santa Barbara, along with UCRL and CR&D representatives. The objectives are to get away from the trouble which is apparently contributing to oil contamination and secondly to develop a system involving simpler or larger vacuum pumps. A substantial cost saving may be possible by doing this as well as gaining a simplified vacuum system. The simplest and perhaps the most rapid approach is to explore the possibility of using mercury diffusion pumps using the same general type of pump as we now have except of larger dimensions if possible. This is nothing fundamentally new since High Voltage Engineering Company has production models of relatively small size mercury diffusion pumps. Letters have been sent to DPI and High Voltage Engineering to see how they might contribute to this part of the program. A second approach, which presumably would accomplish both objectives would be to develop a linear pump which presumably can be made as long as required. In

such a pump the fluid is boiled outside of the pump and the vapor is distributed by a manifolding system to the individual pumps. This appears to offer advantages both in simplicity and cost. By developing from this stage onward with mercury instead of oil the additional advantage of this material might also be obtained. The testing on this vacuum program will be conducted at Livermore. Hildebrand said several other avenues of approach were discussed. These are less sure but seem to warrant investigation to establish their feasibility. One, which might possibly become the most attractive, is an ion pump. This would eliminate the introduction of any extraneous material into the vacuum system. It might be possible to obtain the ionization with an rf loop and suck the ionized gas molecules out by means of an electrostatic field. Waithman will study the theoretical aspects of the problem. Theoretically the power required for such a system is less than that for diffusion pumps. Lawrence said that it should become easy in large volumes to obtain very high efficiency with such a pump. Baker said that one might require a device to increase the path length of the ionizing electrons as in a PIG source since at our operating pressures the mean free path may be several hundred feet. Lawrence said one could utilize a high current density of electrons to construct a curtain such that every gas molecule passing through it would be ionized. Lofgren said that discharges in the tank may make such a pumping scheme more feasible. The tank itself may prove to be a pump and drive the ionized molecules into the tank wall. Hildebrand said they would also study the possibility of using getters although this looks very improbable for a mchine this large.

Hansen outlined the construction program at Livermore. The siding is being installed on the west end of the accelerator building. The decks on the south side are being poured. The 17-foot floor level is being poured. The roof paper and Firtex are going on the roof now. Rigging is now being put in place for erection of the large crane. The fitting and welding of the oscillator housing is well along. The door in the west end of the tank has been cut and the frame installed. Preparations are now underway for sand-blasting the interior of the vessel and as soon as aluminum becomes available spraying can begin. All of the Kinney and diffusion pumps and their manifolds are nearly complete and testing of this part of the system will begin in about one week. The cooling tower is now under construction and will be completed in 2 or 3 weeks. 270 of the 660 shielding blocks required have now been poured. Assembly has begun on the motor generator set for power supply No. 1. The motor has been installed and the generator rotor is in place. Installation of the stator is now beginning. The furnace for welding tubes on the large liner sections has been worked over so that it now gives uniform heating and a good flame distribution over the entire sheet. Work is proceeding well on the fabrication of the aluminum framing and fabrication of the cooling tubes. Also, design has been finished and fabrication begun for the rigging tools to be used for installation of the liner sections.

Brobeck announced that this meeting is the last in the present series of overall progress meetings. In the future each of the major groups involved in the MTA work will hold individual meetings as required.