Minutes of

CERN-PS Staff Meeting

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Present : A.Achermann, J.B.Adams, J.Augsburger, C.F.Bakker, M.Barbier, F.Bloch, G.Brianti, A.Citron, O.Dahl, A.Decae, P.Denis, J.Y.Freeman, R.Gabillard, J.Geibel, C.Germain, F.Grütter, H.G.Hereward, M.G.N.Hine, H.Horisberger, K.Johnsen, F.Krienen, P.Lapostolle, T.Lingjarde, P.Opitz, G.Petrucci, B. de Raad, C.A.Ramm, L.Resegotti, G.Rosset, A.Sarazin, Ch.Schmelzer, W.Schnell, J.P.Stroot, B.Vosicki, E.Zaccheroni, C.J.Zilverschoon.

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Linac Progress Report

Hereward gave an account of the purchasing activity of the linac group.

As we want to start work on the accelerating tube soon, a 500 kV DC set has been ordered from Heafely. A similar set offered by Philips was substantially more expensive. Delivery is promised for September, so that we may be able to accelerate some ions to 500 kV by the end of this year. Space is a problem, as the set would take up a third of the experimental hall.

French Thompson Houston have offered to develop a 2 MW amplifier valve and a circuit for it. This would fit our 3 tank design very well. By the end of this year they hope to have sufficient results for us to take a decision on their valve. Another big valve is being developed in Harwell, which we may be able to fall back upon. We will also continue tests of the Siemens and Telefunken valves for safety, and because we will need them as a driver anyway, the F.T.H. ones having a low gain.

The position with respect to Harwell and Metropolitan Vickers became somewhat alarming since Harwell cut down their 600 MeV linac project to a 50 MeV one. But it seems that the Harwell staff on the project will not be reduced too much, and a contract with M.V. for construction of the three tanks will still save us a considerable amount of design work, and of time. Negotiations on the contract terms are nearly complete.

The question of whether a single tank (made of copper-clad steel) would not be better has been raised by Bradner. It would increase the amount of design work for us, on the other hand we could then employ oscillators instead of amplifiers, as is done in Berkeley, and take advantage of their experience. Our feeling at present is that we should stick to the three tank design.

Johnsen reported about the focusing problems.
Harwell use grid focusing for their first tank, quadrupole A.G. focusing for the other ones. We have considered focusing by axial magnetic field or by quadrupole lenses for the first tank.

The axial magnetic field is produced by pulsed solenoids, placed inside the drift tubes. For the first ones a field of about 30 kG is needed during the acceleration time of 10 μsec. Several coil models were made. They consist of copper strip wound in spirals and embedded in araldite. A condensor bank of 150 μF charged to 2.5 kV was discharged through them. The required field was readily obtained. The drift tube itself acts as a shield. This is desired anyway in order to reduce the forces between coils in neighbouring drift tubes. Without a shield these would be up to 200 kg. It was found that the effect of such a shield on the field inside the coil is small. Now we are trying to make smaller and smaller coils in order to save space and stored energy. It seems at present that focusing of tank I can be done by this method using a stored energy of 9 kJ.

For quadrupole focusing the required field gradient depends on the number of drift tubes in succession containing lenses of the same sign. +−+− leads to 16 kG/cm, ++−−++ to 8, +++−−− to 5. These figures assume a space factor of 0.5. In the last case the μ becomes so high that stability may not be adequate for particles off the stable phase. So the second configuration seems the best. Air cored model coils were produced and a gradient of 10 kG/cm was obtained by discharging 50 µF from 2,5 kV. With such coils the focusing of tank I is estimated to requireda stored energy of 700 J. Iron cored solenoids are also considered in order to get better defined fields.

Summarizing, Johnsen stated that both focusing methods seem feasible. The solenoids are least sensitive to misalignments, quadrupoles need less stored energy. Least space is required by air cored quadrupoles, best field shapes obtained by iron cored quadrupoles. The forces constitute no problem.

Ferroxdure permanent magnet focusing is not possible unless one has a type of accelerating structure, such as the new one proposed by Brookhaven that has a low initial rate of acceleration.

Lapostolle spoke on inflection problems. No experiments have been done yet on this line. There are several aspects

The beam from the linac has to be deflected into the synchrotron. The deflecting fields inside the vacuum chamber have to be switched off after one revolution, i.e. after 6 µsec. Within less than 1 µsec they have to fall to less than 1 o/o of the initial value. This can be achieved only by employing electrostatic deflection. We need 2 pulsed electrostatic deflectors with voltages of 30 kV plus a small correcting deflector, all arranged in straight sections. This switching problem is a difficult one. Moreover there will be an electrostatic deflector, not pulsed, outside the vacuum chamber.

As the beam of the linac has a certain energy spread, and as different equilibrium orbits in the synchrotron correspond to those different energies, we have to introduce a chromatic correction if we want to bring each particle to its proper equilibrium orbit. This can be done by 2 successive magnetic deflection of opposite sign. We expect a width of the linac energy spectrum of 100 kV.

Two magnetic fields of 2 kG over 1 m and with a distance of 8 m give the required correction. This device would also correct for a slightly wrong mean energy of the linac beam. The field strength has to be held constant within 0.03 o/o of its value.

There is also a focusing problem. If we consider for instance horizontal oscillations of the particles leaving the linac with respect to the linac axis we can plot an area in a phase plane of horizontal movement, bounded by a line of constant particle density, which contains a certain fraction of all particles. In the absence of non-linearities the boundary of such an area will be bounded by an ellipse. Likewise for all particles of different horizontal (radial) position and velocity accepted by the machine there exists such an ellipse. The same holds true for the vertical movement. The area of these ellipses is an invariant of the motion as long as the energy is constant. The problem now consists in changing the shape and position of the linac ellipses to make them similar to those of the synchrotron ellipses. Then the maximum number of particles will be accepted in the machine. This transformation can be realized by a set of magnetic quadrupole lenses. Two pairs will be used. Each lens has a field gradient between 0.2 and 1 kG/cm and a length of 15 to 50 cm. The distance to the second lens will be 50 cm and the distance between the pairs 7 m. This whole arrangement will be placed 6 m behind the end of the linac and 4 m in front of the first magnet for chromatic correction.

Finally the problem of aberrations has to be studied. These will be due to non-linearities in lenses and in the fringing fields of the deflecting magnets and the synchrotron magnet. It will be attempted to reduce those non-linearities to a minimum. On the lenses experiments will be done in the laboratories of professor Grivet in Paris, with the end of this year as a target date for the production of lenses with sufficiently small non-linearities.

Citron reported about the valve tests. For producing the RF for the linac various types of valves have been considered. Siemens, Telefunken and Philips have offered TV valves, while a radar valve of FTH was considered at a certain moment. Meanwhile FTH have offered to produce a more suitable valve, which they will test themselves, and the Philips valve does not seem to be available very soon. The Siemens and Telefunken valvesare very similar. Siemens has offered to make us cavity circuits, in which we can test their valve (and possibly the Telefunken one) on RF. They will be delivered in 4 months. We are going to order a drive chain soon.

In the meantime we have obtained one Siemens valve RS 1011 L. Siemens reckoned that we would get 350 kW out of it. This was based on the following operating conditions Class B amplifier, plate DC 25 kV, grid bias -400 V. 24 RF peak voltage will take the anode from 1 kV to 49 kV. 1150 grid RF takes the grid up to 750 V. In this position they reckon to get 60 A anode current. This gives the power as 1/4. 24 000.60 W or 360 kW. It was tried to check breakdown strength and emission under pulse condition. For this purpose a pulse line was built giving rectangular pulses of 70 μsec duration and up to 45 kV height.

Breakdown tests on the cold valve were done. The first tests gave external breakdown as low as 28 kV. After cleaning the insulation and after humidity control had come into operation in the hall we reached 36 kV. The breakdown was now internal. The strength increased after this breakdown and we were later able to reach 45 kV without breakdown. Tests are continued. The results do not seem to predict very safe operation under the conditions intended by Siemens ; on the other hand they agree with the data Siemens had available when making their estimates.

The diode characteristics of the valve show a current of 53 A at 750 V, 66 at 1 kV. This seems lower than the values expected, especially when considering that grid current is included in these figures. With zero grid bias a cathode current vs. plate voltage curve was obtained which follows the voltage$^{3/2}$ law only up to 40 A. Above that value there is a pronounced saturation effect. These tests seem to indicate that the Siemens values for emission are somewhat optimistic.

Finally Achermann reported on recent ideas about the building lay-out for the linac. The building for the linac proper was originally conceived as a two-storey wing with a false floor carrying the linac. In this case the liner, which has to keep very close alignment tolerances, would have required supports separate from those of the false floor and the tank. In order to save excavation it was later decided to make the level of the linac only about half the width of the wing. In this way we have the possibility to found the linac directly on solid ground and to avoid vibrations due to traffic along the structure. This basement is supposed to accomodate pumps, amplifiers plumbing and a certain amount of electronics.

In the hall for the DC generator, filter stack, ion source etc., the base ment will be at the same level as in the wing. The same is true for the roof. This gives sufficient height to accomodate the DC set + 1.6 m safety clearance all round. In this hall only a small strip will not be excavated. This serves as an unloading area. Two 5 t cranes can pick goods off a lorry here and transport them into the wing. The control desk is situated on the linac level, but rests on a steel construction. Cables from the main building and to the wing can enter the desk from below. The cables are carried on a light wall in the basement, which separates the DC set area from a safe area outside, which has connection to the basement of the wing, and via staircases, to the upper floor.

A. Citron