

NOTES ON A 600 MeV. PROTON ACCELERATOR

METROPOLITAN
Vickers

Works: Trafford Park, Manchester, and Sheffield.

600 MeV. PROTON ACCELERATOR FOR HARWELL

The following notes give technical information obtained during discussions at Harwell and intend to supplement the notes by D.W.Fry.

Stage 1.

The ion source and 1/2 MeV. H.T. set. This would be dealt with by Harwell and Phillips as stated in Fry's notes.

Stage 2.

0.5 MeV. to 10 MeV. This would use an Alvarez type structure with grid focussing, operating frequency would be 200 Mc/s. and would largely be a copy of the Berkeley Bevatron injector. This would be contained in a tank 20 ft. long and would use oil diffusion pumps rather than mercury as at Berkeley.

Stage 3.

A further length of Alvarez type accelerator but possibly using alternating gradient focussing, frequency still 200 Mc/s. This section would be continued up to the energy at which the drop in efficiency justifies a change to higher frequency.

Mullet showed curves indicating that this would probably occur at about 60 MeV. This stage of the accelerator would then conveniently take the form of two tanks each say 40 ft. long and with appropriate pumping.

Stage 4.

This covers the remainder of the accelerator and would take the form of π mode guide using pillbox resonators with posts giving uniform acceleration and alternating focussing would be used. Frequency would be 400 Mc/s. Convenient lengths of section would be used say 30-40 ft. and these would be pumped and energised as units with each section capable of being separated for servicing.

Pumping.

The accelerator would be evacuated by a number of 20" oil diffusion pumps, backed by Kinney type 8101 rotary pumps. In stages 2 and 3, one pump would be required for the 20 ft. long tank, but two pumps would probably be required for each of the

40 ft. tanks. In stage 4 it was hoped that one pump would deal with two tanks. It was intended that refrigerated baffles should be used and a working pressure of 5×10^{-6} mm. of mercury was required.

Valves for R.F. power supply.

A.E.R.E. have a grounded grid triode for 200 Mc/s. at an advanced stage of development, a sample is almost complete with an oxide coated cathode. It is hoped to try this with short pulses early next year. Although English Electric have shown interest in the valve, it is expected that Harwell could, in view of the reduced demand for 200 Mc/s. equipment, deal with the production of these valves themselves. It should be noted that operating conditions have to be 200 μ s. pulse at 50 p.p.s.

For the higher frequency C.V.D. is expected to place a contract with English Electric for a 400 Mc/s. grounded grid valve to operate at 40 kV. As insurance, the possibility of a 400 Mc/s. klystron would be investigated but this would require H.T. of 100-125 kV.

Modulators.

Modulator design is, of course, dependent on valve design but it can be said in general that each modulator will take 15 kV. D.C. from a central supply and will provide an output of 10 MW., 200 μ s. pulse at 50 p.p.s. D.C. charging and an ignitron switch would probably be used. Large ignitrons by B.T.H. may be used. (Note: it is the writer's opinion that the standard B.K.24, B.K.44 or 5822 should be capable of this duty and would, of course, be much cheaper).

After discussions with Redfearn (M-V.), Snowden (A.E.R.E.) stated that he was confident that pulse transformers for the long pulse length could be made and that, if necessary, the large ratio required for the klystron could be dealt with.

As alternative type of modulator, it was suggested that Carruthers (A.E.R.E.) had a scheme for a 10-15 MW. modulator using a series triode.

Building.

A building has been designed and it will be essential that the equipment be designed to fit this and to conform to the present ideas of control and servicing arrangements. The accelerator is to be housed in a long tunnel-like building, pumping plant will be fitted in a trench running alongside the accelerator and

modulators with the R.F. power supplies will be distributed at intervals along the length of the tunnel. At intervals along the length of the tunnel stations will be provided for the extraction of the beam at reduced energy. D.C. for the modulators will be provided from a detached substation. At the input end of the accelerator will be a control room and facilities for measurements using the machine.

Controls.

All controls required for day to day operation of the equipment are to be located in the control room. It is to be possible to run each section of the accelerator and each modulator separately. Individual operation of the vacuum equipments is required. Control of R.F. tuning and phasing would also be required. It was emphasised that the control system would require considerable overall planning.

Time Scale.

It was required that the equipment should be producing particles at 10 MeV. in 2 years and at 60 MeV. in 3 years. This would complete stages 1 to 3 and as at present envisaged would be dealt with by Harwell themselves as far as the accelerator itself was concerned. Presumably, however, contractors would be involved in modulators, pumping plant, etc. and co-operation would be required on control planning.

Stage 4 - the extension to 600 MeV. would be expected to follow in various stages, the whole being completed in a total time of 5 years.

Design of Accelerating Structures.

As regards the Alvarez type of structure, information is expected from America, although Harwell are looking into improved focussing. Harwell are investigating general efficiency and would specify energy at which change from 200-400 Mc/s. operation takes place.

As regards structure for stage 4, little if any information is available and it cannot be too strongly emphasised that an enormous amount of work both theoretical and experimental is involved. Methods of tuning, coupling and phasing have to be considered and the mechanical construction to accommodate the alternating gradient focussing arrangements and water cooling has to be dealt with. Harwell have a small team doing some preliminary work on this but it is intended that the problem should be contractor's responsibility.

Particle dynamics and focussing.

There are many problems involved and these cannot be divorced from those of the accelerating structures. Both axial and radial stability require consideration and the question of tolerances becomes very important. Although π mode is at present favoured, operation as a travelling wave with or without feedback is not completely ruled out. Harwell intend to continue consideration of these problems but again much responsibility rests with contractor. In these problems it is clear that the M-V. computer can be of considerable use.

(Signed) C.W.Miller

Radiation Laboratory,
RESEARCH DEPARTMENT.

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600 MeV. PROTON ACCELERATOR - PROGRAMME

Although no detailed programme can be made until further technical discussions with A.E.R.E. have been held it can be decided that certain parts of the project can be started almost immediately.

The general scheme appears to be fairly concrete as regards diameter and overall layout although final lengths are not yet known. Thus, general planning of vacuum envelopes, pumps and vacuum valves, etc. could be started even though some details may have to be changed later.

Much of the modulator development work could be started immediately and it might be possible to deal with some of the R.F. power components such as R.F. bridges and power monitors.

General control arrangements would have to wait further development but obviously both vacuum and modulator control arrangements would become clearer as these items progressed.

As regards R.F. structures for Stage 4, work on coupling and tuning with associated determination of shunt and series impedance would take the form of both theoretical and experimental work and could start at once. Much of the experimental work could probably be done by scaling to 10 cm. and this would allow time to build up test equipment on 400 Mc/s. Problems of particle dynamics can best be dealt with by the analogue computer. The Mk.1 computer could possibly deal with some preliminary problems but the major effort would require the completion of Mk.2. This later machine would deal with the axial stability and tolerance problem of Stage 4, but the radial stability and focussing problem would require further additions which have not yet been fully considered. An increased effort on the computer would appear to be essential.

Details of the R.F. generators would obviously await valve development, although even here consideration might be given to driving arrangements. It should be noted that these latter were not discussed with A.E.R.E.

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As regards the Stages 1 to 3/be handled by Harwell it is not clear how much would be expected of contractor. It may well be, however, that design information from Harwell would soon be available and that pumping equipment and possibly modulators would be required quickly.

It would seem logical to start work on the design of the equipment as though making an empty accelerator or at any rate one with very tentative accelerating structures, but detailing vacuum system and modulators. In parallel, work on the accelerating guide structure should be given all possible effort.

It is impossible at present to specify a time scale but it is clear that several engineers, physicists and draughtsmen could be fully employed almost immediately. Tentatively, certain particular items could be scheduled, as follows:-

1. Vacuum pump (20"), Valves and Control Equipment.

Development to start immediately, target date for prototype equipment 18 months. Manufacture of about 20 of these at the rate of 1 each 6 weeks.

2. Layout of Vacuum System and Envelopes.

Tentative layout to start almost immediately, details would await design of R.F. structure. Target drawings finalised in about 2 years followed by manufacture of sections of envelope at rate of 1 per month.

3. Modulators.

Design to start immediately, target for prototype 18 months. Manufacture of 20-30 at 1 per month.

4. Pulse Transformers.

As Modulators.

R.F. Power Supply.

This will await valve development, say 18 months - 2 years. Target should be prototype in 3 years, manufacture 20-30 at 2 per month.

Accelerating Structure.

Development to start immediately, coupled with dynamics and stability considerations. A target of 18 months - 2 years for full information is desirable to allow manufacture of say 30 ft. sections (all different) at rate of 1 per month.

This is one of the heaviest commitments in the contract and considerable effort will be required to meet the development and manufacturing programmes.

To carry out the development work, the Mk.2 analogue computer should be completed in not more than 9 months and the modification for radial stability calculations in 12 months.

Installation and Commissioning.

Installation of Stage 4 should start in 3 years' time and continue until the equipment is complete in 5 years. Certain parts would be installed earlier than 3 years and if pumping plant and modulators are supplied for earlier stages, some installation would be required in 18 months.

As regards commissioning, this would be in collaboration with A.E.R.E. and the major effort would be required in the 4th and 5th year. If, however, the greatest advantage in 'know how' is to be obtained very close collaboration is required throughout the whole programme.

(Sgd.) C.W.Miller.

Radiation Laboratory,
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