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NOTE ON THE FINAL PARAMETERS OF THE 4 GeV ELECTRON SYNCHROTRON.

by

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The design of the machine is now approaching its final form and to date a number of parameters have finally been fixed. The machine will certainly consist of twenty units of the type

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and the lengths of the straight sections have been fixed at 1.0 m and 3.5 m. The Q value has been fixed at 5.25. The circumference of the machine and hence the lengths and, most important of all, the field gradiant of the magnets will depend on the final choice of linac frequency and the subharmonic number of the accelerating radio frequency. There are two possible linac frequencies corresponding to wavelengths of 10 cm and 10.5 cm., and two subharmonic numbers 6 and 7 are being considered. It is probable that some considerable time will elapse before the linac frequency will be finally decided. Since it is important that the magnet profile calculations should get under way as soon as possible the possibility of designing a single machine which would accommodate any of the four combinations of linac frequency and subharmonic number has been investigated. This implies that the circumference of such a "universal" machine must simultaneously be an integral number of wavelengths of all four possibilities of the accelerating radio frequency. Also suitable stations for the R.F. cavities must be available. It is envisaged, at the moment, that five stations will be required. If we denote the linac wavelength by λ and the subharmonic number by k, then the circumference of the ideal orbit, $c = \text{integer} \times k \times \lambda$.

Enumerating the possibilities we have

$$\begin{aligned} c &= h_1 \times 6 \times 10 \text{ cm} \\ &= h_2 \times 6 \times 10.5 \text{ cm} \\ &= h_3 \times 7 \times 10 \text{ cm} \\ &= h_4 \times 7 \times 10.5 \text{ cm.} \end{aligned}$$

where h_1, h_2, h_3 and h_4 are integers. These equations will be satisfied if

$$\begin{aligned} h_1 &= 21 \times \ell_1 \\ h_2 &= 20 \times \ell_1 \\ h_3 &= 21 \times \ell_2 \\ h_4 &= 20 \times \ell_2 \end{aligned}$$

where ℓ_1 and ℓ_2 are integers such that $\ell_1 / \ell_2 = 7/6$.

Possible values are

1) $\ell_1 = 7, \ \ell_2 = 6$

2) $\ell_2 = 14, \ \ell_2 = 12$

3) $\ell_3 = 21, \ \ell_2 = 18$ etc.

Case 2) gives a circumference of 176.4 m and a magnetic radius ρ of 13.9 m (remembering that in all cases the straight sections are kept at 1.0 m and 3.5 m.) Case 3) gives a circumference of 264.6 m and a magnetic radius ρ of 27.8 m These magnetic radii correspond to fields which are respectively too high and too low to be practicable. We must therefore abandon the idea of a universal machine.

Another possibility is to assume that the subharmonic number will be known in the near future and to design two machines, one for each subharmonic number, either of which will be suitable for both linac frequencies.

7'th subharmonic.

There are two practical possibilities

1) $h_3 = 294$ (21 x 14)	2) $h_3 = 315$ (21 x 15)
$h_4 = 280$ (20 x 14)	$h_4 = 300$ (20 x 15)
$\rho = 18.4$ m	$\rho = 20.77$ m

The second value would allow the 5 R.F. stations to be placed symmetrically around the machine in the long straight sections since both integers are divisible by 5. The lower value for ρ would allow symmetrical placing of the cavities only for the 10.5 cm linac wavelength. If the linac of 10 cm wavelength were used the cavities would either have to be placed asymmetrically around the machine or suitably phased. For these and other reasons, the machine with magnetic radius $\rho = 20.77$ m is preferable.

6'th subharmonic.

There is only one practical possibility, the others yielding values of ρ which are too small or too large. This is

$h_1 = 357$ (21 x 17)

$h_2 = 340$ (20 x 17)

$\rho = 19.77$ m.

Assuming 5 R.F. stations, since 357 is not divisible by 5, the R.F. cavities would have to be either suitably phased or asymmetrically spaced if the linac had a wavelength of 10 cm. A linac of wavelength 10.5 cm would allow symmetrical placing of the cavities.

SUMMARY.

We have designed two machines, one for each subharmonic number. The parameters are listed below

	$\bar{O}$	= 3.5 m	$\bar{O}$	= 3.5 m
	O	= 1.0 m	O	= 1.0 m
	ρ	= 19.77 m	ρ	= 20.77 m
Magnet length	ℓ	= 3.105 m	ℓ	= 3.2625 m
	c	= 357 x 6 x 10 cm	c	= 315 x 7 x 10 cm
		= 340 x 6 x 10.5 cm		= 300 x 7 x 10.5 cm
		= 214.2 m		= 220.5 m
	n_F	= -44.995	n_F	= -46.169
	n_D	= 45.995	n_D	= 47.169
Field gradiant		= 2.28% per cm		= 2.22% per cm
Subharmonic number		= 6		= 7
	Q_r	= 5.25	Q_r	= 5.25
	Q_z	= 5.25	Q_z	= 5.25

It should be noted that for the 7'th harmonic number symmetrical placing of 5 R.F. stations is possible for either linac but for the 6'th harmonic with the 10 cm wavelength linac the accelerating cavities will have to be suitably phased or unevenly spaced. In this last case the cavities would still be placed in every fourth long straight section but would not be in the same relative position with respect to the centre of these straights.

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