Design studies for an ultra-thin septum extraction channel for the modified NEVIS synchrocyclotron*

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ABSTRACT

Extensive computer studies of different current configurations for a magnetic extraction channel have been performed. A configuration has been found which gives an average field of 5 kG, and a radially focusing gradient of 1 kG/in. By the use of a thin current sheet perpendicular to the median plane of the synchrocyclotron the step from no field to full channel field can be limited to less than 0·06 in. The distortion of the main magnetic field outside the channel is less than 100 G and subtracting, so it can be compensated by additional iron shims. The total power dissipated in the channel is about 200 kW.

1. DESIGN PARAMETERS

The extraction system for the modified Columbia University Nevis Synchrocyclotron consists of peeler-regenerator and a time-varying magnetic bump which provides a long duty cycle external beam. Details of this system have been given earlier.[1] Preliminary studies of a magnetic extraction channel indicated that a 4 kG reduction of the main magnetic field over a length of 40 to 50 cm is sufficient to lead the beam out of the machine. Further investigations however, considering the desired direction of the external beam and the optical properties of the fringing field, showed that we need an average field of 5 kG and a radial gradient of 0·4 kG/cm inside the channel. In addition, we expect the radial width of the beam to be larger than the final turn separation of 2 cm, due to the betatron and phase oscillations. Therefore, the maximum obtainable extraction efficiency is

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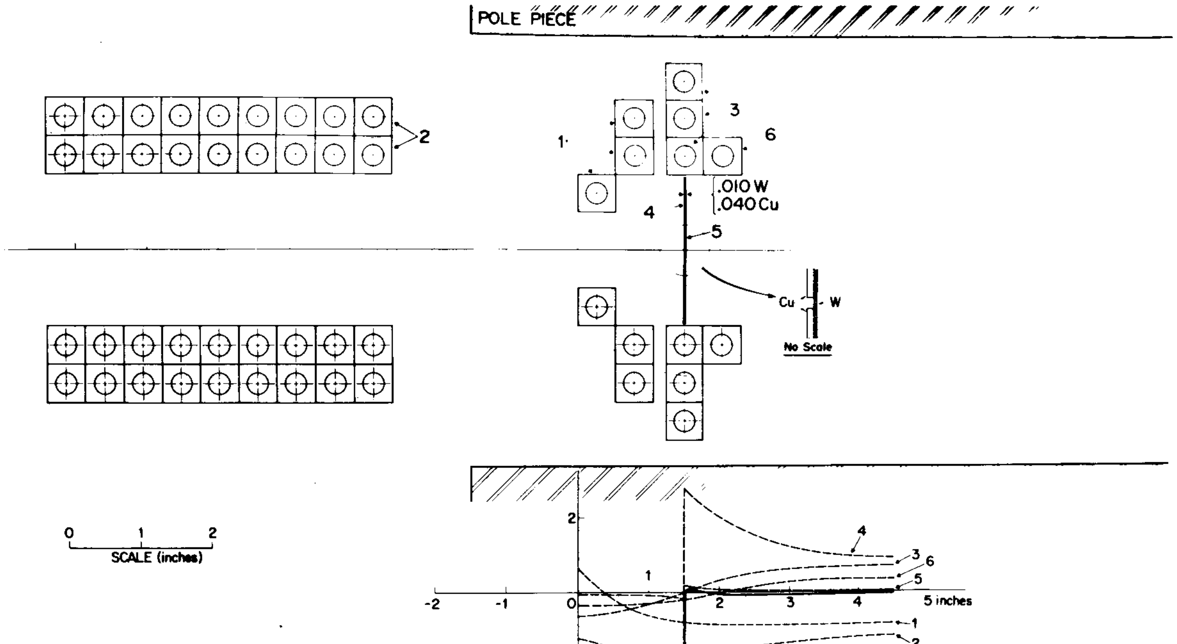

	Material	I(A)	W(kw)
1	Cu	−4150	7
2	Cu	−4150	42
3	Cu	+3450	5
4	Cu	+12000	93
5	W	+465	1
6	Cu	+4450	3
			151

Fig. 1. Conductor configuration and resulting magnetic fields. There are six groups of conductors. The field produced by each group is depicted in dashed lines. The solid line gives the total channel field. The currents and the power dissipated in each group are given.

determined by the ratio of septum thickness to turn separation. A main part of our studies was therefore concentrated to decrease the septum thickness as far as possible.

2. DESCRIPTION OF THE CURRENT CONFIGURATION

The magnetic fields of different current configurations were calculated on a computer and a configuration acceptable for our purposes is given in Fig. 1. It consists of six sets of conductors. The magnetic fields produced by these six sets of conductors are also depicted separately in Fig. 1.

The function of the number 1 conductors is to provide the radial gradient inside the channel; number 2 conductors provide part of the average field; number 3 conductors increase the average channel field and cancel part of the outside perturbation. The number 4 and 5 conductors form the septum and give the sharp step, while number 6 conductors cancel the outside distortion and round off the shape of the channel field. For the curves given, the septum consists of 1-mm thick copper sheets (number 4 conductors) and a sheet of 0·25 mm tungsten (number 5 conductors), which is needed to provide mechanical strength against the magnetic forces. The currents giving the fields of Fig. 1 and the power consumed in the conductors are also given in the figure. The power dissipated inside the magnetic channel is 151 kW, which gives a total power consumption of about 200 kW when return paths and leads are included.

3. CONCLUSIONS

The calculations indicate that a current configuration giving a magnetic field with all desired properties can be found. The total power consumption is high, but it is conceivable that the field of number 2 conductors may be produced by a piece of iron thus reducing the power considerably. This would have to be tested experimentally. The septum thickness is essentially determined by the mechanical strength of the materials used and the ability to provide adequate cooling. If we relax the requirements on step size and on septum thickness we can reduce the power consumption significantly.
Our plans call for the building of a model to study the possibilities to reduce power consumption, the cooling problem and all aspects of the mechanical and electrical construction.

REFERENCE

1. *I.E.E.E. Trans. Nucl. Sci.* **NS-16**, 434, (1969).