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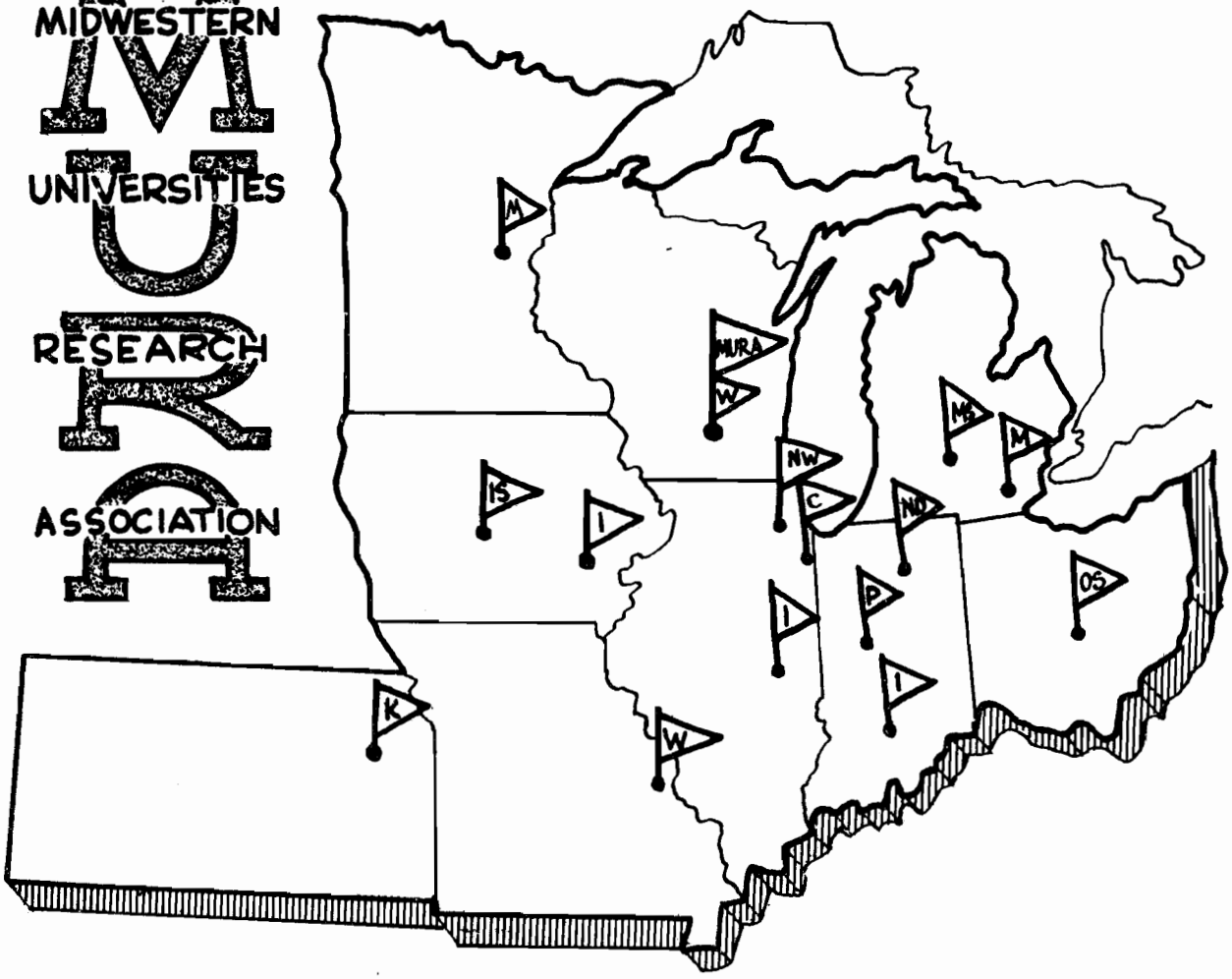

ON A REVERSED FIELD SPIRAL SECTOR ACCELERATOR

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ON A REVERSED FIELD SPIRAL SECTOR ACCELERATOR

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ABSTRACT

A preliminary study is made of the magnetostatic properties of a spiral sector FFAG accelerator whose magnets are alternately positive and negative. Thus in a scaling manner, a larger gap to sector ratio may be obtained in part of a non-reversed field spiral sector accelerator.

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**Summer particpant from the Ohio State University.

I. INTRODUCTION

It is suggested that a scaling spiral sector FFAG accelerator[1] may be constructed with magnets which are alternately positive and negative. This may be done in such a way that the median plane field is essentially the same as in a non-reversed field spiral sector accelerator. Since the field is everywhere scaling, one can readily change magnet structure as a function of azimuth or radius from a reversed field spiral sector to a non-reversed field spiral sector accelerator. Thus at the injection radius, where circumference factor is of no concern, one can employ reversed sections to enlarge the gap and so increase the space charge limit which is most severe at injection. The advantage of this proposal over the spiral sector-radial sector transition machine is the complete scaling of this structure and hence the ability to design it with existing digital computer programs. Employing reversed field sectors at certain azimuths may allow sufficient vertical aperture for radial accelerating cavities. This would remove the presently unsolved problems associated with spiral cavities, but at the expense of circumference factor.

In this report a study of the magnetostatic problem is undertaken with the aid of the MURA IBM 704. The investigation is considered to be of a preliminary type and consequently was carried out employing a two-dimensional Laplace Equation approximation to the three-dimensional problem. The error due to this approximation is of the order of a few per cent and hence completely negligible.

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[1] Symon, Kerst, Jones, Laslett and Terwilliger, Phys. Rev. 103, 1837 (1956).

No study has been made of particle dynamics in these structures, such studies being necessary if the additional gap is to be used for particle trajectories.

II. COMPUTATIONS

Calculations were performed for the magnet structure indicated in Fig. 1.[2]

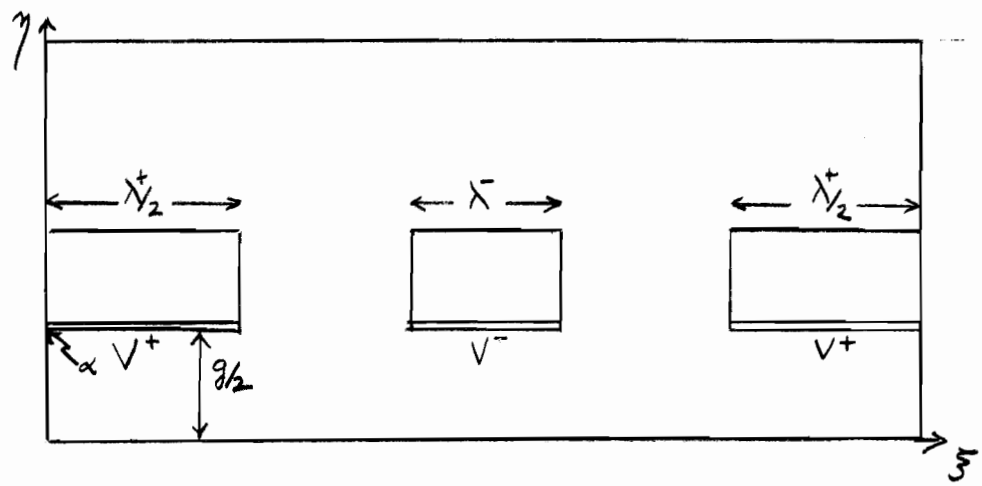

Fig. 1

One sector in the $\xi-\eta$ plane, indicating the pole configuration, potential distribution (when not indicated, $V = 0$).

The flutter $f = \sqrt{2\left[\frac{\langle B^2\rangle_{\eta=0}}{\langle B\rangle^2_{\eta=0}} - 1\right]}$ was arbitrarily held fixed at the value unity. The magnetic field in the median plane was allowed to be only slightly negative for a few values of ξ in order to insure that the field was closely sinusoidal as a function ofthe azimuthal angle.

Digital computation was made for various gap to sector ratios and λ^+/λ^- ratios, in order to determine the $\left|V^-/V^+\right|$ ratio needed to give a flutter of one. The results are indicated on Graph I where the half-gap to sector ratio is plotted

[2] Notation is the same as in reference 3, which should be consulted to determine the relevance of the $\xi-\eta$ plane.

as a function of $\left| V^-/V^+ \right|$ for various magnet configurations. Points have been limited to values for which the median plane field is sinusoidal to good approximation.

The half-gap/sector ratio for a non-reversed field spiral sector accelerator with no negative magnet and $\lambda^+/_{sec} = 14/40$ is indicated on Graph I.[3] The very large increase in gap available at the expense of straight section and ampere turns is thus readily noticeable.

One can take as a convenient (i.e., dynamics independent) measure of the circumference factor the ratio of the magnetic field at the positive pole (point α on Fig. 1) to the average magnetic field for $\eta = 0$, in the $\xi - \eta$ plane.[4] Values are listed in Table 1, where an average value for each curve is given, the variation along each curve being about one unit.

Curve	Average Circumference Factor
A	2.4
B	2.5
C	3.0
E	5.3
F	6.5
S.S.	2.0

Table 1. Average circumference factor for the curves of Figure 1.

III. ACKNOWLEDGMENTS

The authors are indebted to Mr. P. Morton for help and suggestions concerning the computations, and to Dr. C. E. Nielsen for some helpful discussions and valuable suggestions.

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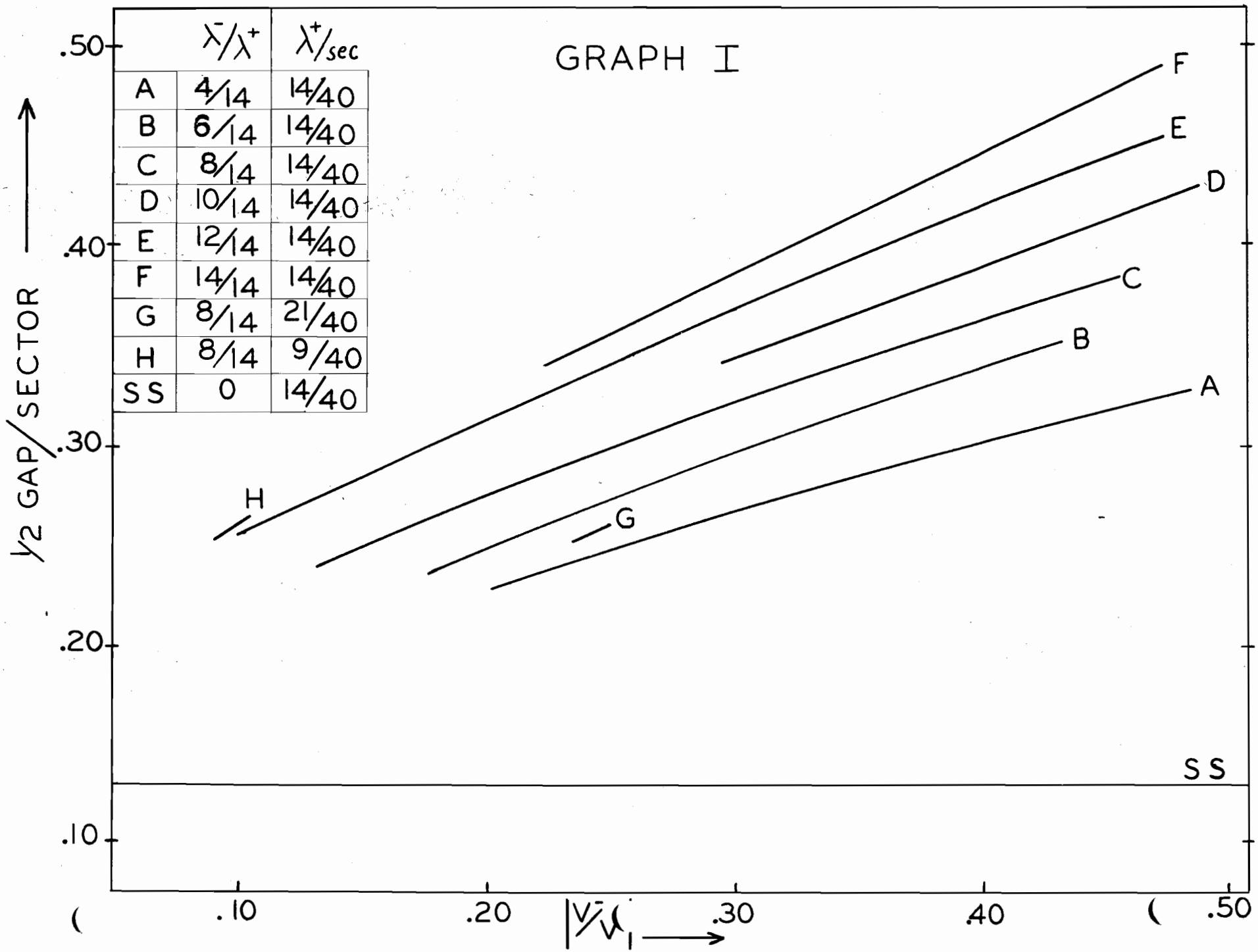
[3] P. Morton, On the Design of Spiral Sector Accelerators, MURA-336.

[4] This yields a value smaller than the usual definition[1] by about 10%.


GRAPH I
λ⁻/λ⁺
λ⁺/sec
A 4/14 14/40
B 6/14 14/40
C 8/14 14/40
D 10/14 14/40
E 12/14 14/40
F 14/14 14/40
G 8/14 21/40
H 8/14 9/40
SS 0 14/40
.50
.40
.30
.20
.10
1/2 GAP/SECTOR
.10
.20
.30
.40
.50
|V⁻/V|
F
E
D
C
B
A
H
G
SS