SLIDING CONTACTS IN RF CAVITIES.

T. Waites.

The Svedberg Laboratory, Box 533, S-751 21, Uppsala, Sweden .

The Gustaf Werner cyclotron RF systems are designed for frequencies ranging from 12.3 to 24.6 MHz. Because of this wide range the RF systems often require re-tuning to exploit the many beams available. This puts a great deal of stress on the RF contacts. Until recently the systems have utilised a combination of Be/Cu fingers, in low current areas, and Sn-plated braided air-hose where current levels are higher. Although these solutions have performed well, the high friction inherent in the designs resulted in excessive mechanical wear, requiring constant maintenance, replacement and adjustment to avoid failure. The systems also proved tricky to tune and susceptible to temperature fluctuations. Over the last three years the old contacts have partially been replaced with new, low-friction contacts utilising Cu/C brushes with Be/Cu springs doubling as leaders. These new contacts have proven to be highly reliable and maintenance free, showing no appreciable wear and with an estimated 30% of the friction of the older type despite, in some applications, a 250% increase in contact area.

1 Introduction

The Gustaf Werner cyclotron underwent a major rebuild in the late 1970's and early 1980's, enabling operation in both a constant frequency, continuous wave (C.W.) isochronous mode and a frequency modulated (F.M.) synchrocyclotron mode, with the acceleration being performed by two diametrically opposed RF systems. In C.W. mode the RF frequency can be tuned in the range 12.3 to 24.6 MHz with the ratio between RF frequency and ion revolution frequency being 1, 2, 3, or 4, F.M. mode being used only when accelerating protons at more than 110 MeV or ^{3}He to more than 250 MeV. This flexibility permits the acceleration of a wide range of particles at varying energies.

2 The Problems

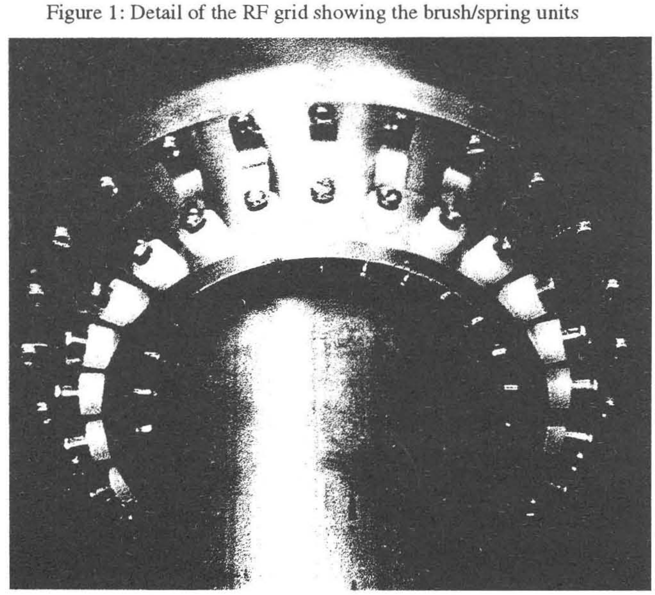
Because of this wide range and flexibility frequent re-tuning of the RF systems is required to exploit the many and varied beams available - sometimes two or three totally different operational modes being required within a three shift period. This puts a great deal of stress on the RF contacts within the cavities, as well as on the operator! Until recently the RF systems have utilised a combination of Be/Cu contact fingers in low current areas, and Sn-plated braided air-hose in areas were current levels are higher. Although these solutions have performed well, the high friction inherent in the designs resulted in excessive mechanical wear, requiring constant maintenance, replacement and adjustment to avoid failure. The systems have also proven tricky to tune and susceptible to temperature fluctuations, as well as introducing unhealthy Be/Cu particles into the environment.

3 The Solutions

3.1 Low current areas

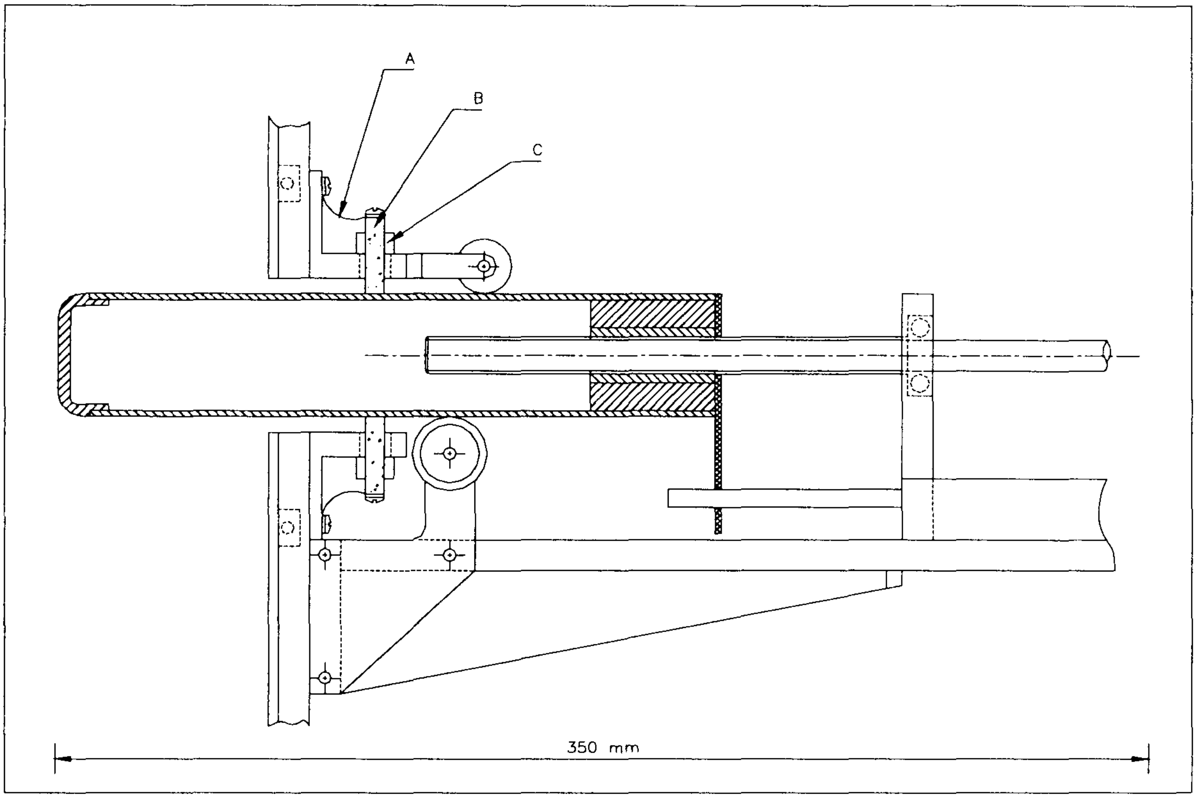
In areas with RF current density lower than 10 A/cm a new type of sliding contact is being introduced. Over the last three years the old Be/Cu fingers have partially been replaced with a new, low-friction design utilising ∅6 mm Cu/C brushes, and 8 x 33 mm Be/Cu springs of 0.125 mm thickness which also double as leaders. By using brushes 25 mm in length, a nominal contact pressure of approximately 120 kPa is achieved, which allows for surface irregularities of up to ±3 mm and a wear limit of 2 mm before the brushes require replacement. After a brief flirtation with a woven Bakalite material a PVDF plastic bushing was chosen to act both as a guide for the brush and as insulation from the aluminium holder. The threaded plastic bushing is screwed directly into the aluminium holder to ease replacement. Each brush and spring unit is mounted separately and also easy to replace.

Figure 1: Detail of the RF grid showing the brush/spring units



Already installed in both the grid (figure 1) and fine-tuning areas (figure 2) of both systems, these new contacts have proven to be highly reliable and maintenance free, with an estimated 30% of the friction of the older type despite, in some applications, a 250% increase in contact area. To date these contacts have shown no appreciable wear and a lifespan of at least 5 years can reasonably be expected. It is planed to install these new contacts in one of the main cavities during the summer of 1998, with subsequent installations being made as time allows.

Figure 2: The RF fine-tuning unit: A=Be/Cu spring. B=Cu/C brush. C=PVDF guide.



3.2 High current areas

In areas with current levels higher than 10 A/cm a system utilising Cu/Ag brushes is being developed. Tests have been made with 10x10x30 mm brushes and wider Be/Cu springs mounted in guides manufactured of PEEK plastic. To date current levels of 25 A/cm have been achieved, but there is still some way to go before the required level of 50 A/cm is attained. In this area future developments may well tend towards a separation of the current carrying capabilities and spring requirements, although there is still a great deal of experimentation to be done with different Be/Cu alloys and brush combinations.

One of the major advantages of these modifications when fully implemented will be the ability to change frequencies and energies without the need to shut down the RF power supplies. Fully developed, this could allow for one button tuning of the RF systems and automatic re-tuning during extreme temperature fluctuations.

4 Conclusions

The aim of this project is to produce a RF system as reliable, maintenance free and user friendly as possible, and using readily available components wherever possible. In the areas modified so far this goal has been achieved. Weekly adjustments and servicing have at best been reduced to a once a year inspection. These modifications have also been extremely cost effective - the project budget to date being less than 30,000 SEK, or $3750, over a 3 year period.

Inexpensive modifications such as these rapidly pay for themselves, and the resultant reduction in start-up and beam-loss time no doubt played its part in TSL achieving a new beam-time delivery record in 1996, with a total of 524 8-hour shifts - 96% being delivered according to schedule.[1]

References

[1] TSL Progress Report 1996-1997.