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**Bipolar Current Power supply for the Steering Beam of the Main Line of
the CV-28 Cyclotron**

por

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Bipolar Current Power supply for the Steering Beam of the Main Line of the CV-28 Cyclotron

Introduction: The beam transport system used in the CV-28 cyclotron has a main line and seven secondary lines. The main line is connected from the exit of the cyclotron chamber to the switching magnet, and from there to the secondary lines. The objective of the beam transport system is to make the accelerated particles reach the targets with specific characteristics and with the desired quality optics, so it is necessary to use remotely commanded devices, such as collimators, quadrupoles lenses and steering magnets. The steering magnets are used to produce small deflections in the beam, around ± 2 degrees, both ways, vertically and horizontally. These steering magnets are driven by bipolar current power supplies (BCPS), which can be adjusted to deliver currents in the range from -5 to +5 A. These values can produce suitable electromagnetic fields in the steering magnets, maintaining the best alignment between the beam and the geometric center of the pipe (collinearity) inside the main line of the beam transport system. The older BCPS are not regulated and have mechanical components (as a variac, for example) to allow current adjustments, which show problems such as instability and electronic noise. Trying to avoid these problems and to have the best beam adjustment, we used an analog/digital simulation to develop an electronic project using two variable BCPS of ± 10 A, pre-adjusted to vary from -5 to +5 A, enough for getting a deflection from -2 to $+2$ degrees when accelerating alpha particles of 28 MeV.

General Description: To guarantee continuous variation from -10 to +10 A, we used a complementary symmetry amplifier (push-pull) (ALLEY and ATWOOD, 1962) (MILMMAN and HALKIAS, 1972) in output power stage with Darlington transistors that can dissipate up to 240W.

Measurements of current are shown in a 3- $\frac{1}{2}$ -digit display, providing more comfort during the operation and making it easy to reproduce the adjustment. The BCPS units are mounted in a 19-inch rack, one of them steering the horizontal and the other one the vertical directions in the main line of the beam transport system. The prototype of the BCPS is shown in Figure 1.

Electrical features:

- Current Stability: 10^{-3}
- Input Voltage: Three-phase in 220 VAC
- Maximum Current: ± 10 A

- Maximum Output Voltage: 10 VDC
- Limited Output Current (pre-adjusted)



Figure 1. Current power supplies top view.

Conclusion: This project assures good stability of current allied to simplicity. The archetype was manufactured with components that can be easily bought in the national market facilitating its manufacture at low costs. The new BCPS were installed in a rack in the CV-28 control room and are already in operation for reliability tests. This project provided ability to develop, in a near future, projects of medium and high power supplies for the CV-28 cyclotron.

The tests showed more precision and comfort to adjust the beam direction and better reproducibility in the steering of the beam.

Further works: The experience achieved in this work allows the development of new projects concerning current power supplies up to 500 A, largely used in particle accelerators.

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