B52 THE SYNCHRO-CYCLOTRON ION SOURCE: THE ELECTRONIC SYSTEM

For its dimensions, the ion source supplies a very high ion current (see Technical Note). This means that the setting values undergo rapid change depending on the specific mode of operation.

The change may be of two types:
- involuntary, because certain components of the source are modified during operation (filament, collimator aperture, anti-cathode) without it being possible to control them,
- deliberate: to obtain an extracted beam of constant intensity and emittance, other parameters may be varied in order to compensate the changes in operation due to the uncontrollable parameters.

Furthermore, adjustment of the operating mode to obtain a given brilliance requires, on each occasion, a successive three-parameter approximation; this is always difficult and sometimes leads the operator towards operating areas which are unacceptable for the source.

The reason for the aura which surrounds ion sources lies in their highly multi-parameter characteristics. Apart from the geometric parameters which are more or less perfectly defined during design, but which remain fixed, the problem is to establish simple basic relationships between the physical parameters (voltage, current, temperature, pressure) so that optimum operation is possible.

In this equipment, the relationships are as follows:
- automatically regulated on loops consisting of one (e.g. gas flow-rate) or several parameters (e.g. filament current versus $I_{ARC}$, $V_{ARC}$ function, gas, etc.).
ION SOURCE ELECTRONICS (SCHEMATIC)
- or programmed - e.g.: co-ordination of principal parameters \((V_{\text{ARC}}, I_{\text{ARC}}, \text{gas})\) as a function of the desired brilliance,

- or in the form of recommendations given to the operator - e.g.: filament positioning in accordance with wear, choice between 2 stable arc operating modes, etc.

The equipment makes extensive use of digital electronic techniques in the fields of measurement and control. The principal comparators are of the analog type, but digital comparators are used for the adjustable limits of the parameters.

Regulation of the power supplies is effected on the primary winding by variacs controlled by step-by-step motors.

Problem: The coupling, within the ion source (also an excellent source of oscillations (!)), of the parameters \(V_{\text{ARC}}\) and \(I_{\text{ARC}}\), which have independent regulation loops, also induces oscillations between the two loops; the only solution to this problem was to use the possibility of making a clear separation between the two time constants.

There are certain more specific items of equipment.

The pulse generator \((500 \text{ V} - 5 \text{ A} - 5 \text{ to } 500 \mu\text{sec})\) is of the thyristor type.

The gas equipment regulates the flow rate on the basis of the indication of an electronic differential pressure gauge (Data Instruments), which detects the downstream/upstream pressure differential at a diaphragm, and by means of a precision motorized valve (GRANVILLE-PHILLIPS). Mention should also be made of the transfo-shunt sensor (L.E.M.), for measuring heavy current \((500 \text{ A})\) in a circuit carrying a pulsed high-voltage current. This tricky problem has been solved in the equipment by measuring the current of a coil which compensates (magnetic zero) the magnetic field produced by the heavy current in a very low resistance bar. Similarly, the pulsed-arc current is measured by means of a current probe (TEKTRONIX). Associated equipment: sequential relays, interlocks, display, remote control, recording, programming, timing, ...

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