ECONOMICAL POWERING OF A LARGE MULTIPLICITY OF SPUTTER-ION PUMPS*

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The AGS accelerator, which is currently being converted into a high intensity machine, will contain approximately 280 sputter-ion pumps distributed in a somewhat uniform manner around its half-mile circumference. Each pump will have a nominal rating of 100 to 150 l/s.

If these pumps were to be powered in the conventional manner, using reactive current limiting, approximately 0.7 Mvar of installed power-handling equipment would be required. Most commercial pumps require 25 var of input power for each liter per second of pump rating. While this reactive power does not appear on the power bill and does not generate heat, it still represents a capital expenditure in the form of installed hardware and lowers the laboratory's over-all power factor.

The vacuum in any accelerator is hard most of the time. In this hard state, the power requirements of the sputter-ion pump are very small. The large power-handling capacity of the supply equipment, which was needed only for starting, lies idle.

If the starting function and the holding function of the supply equipment are separated and special equipment is designed for each function, many advantages result.

It should be noted that this separation of function is made practical in systems with many pumps. It is not practical to separate the starting and holding functions in the power supply of a single pump. This fact gives us our present commercial designs.

All the pumps in a large accelerator need not be started simultaneously. Instead, they may be started in groups. In the specific case of the converted AGS, 24 subgroups are planned, each occupying a half superperiod. These groups can be isolated by vacuum valves, and only a group at a time opened to air.

Three starting units are planned, mostly to provide an operating back-up in the event of equipment failure. In general, it will be possible to start three separate vacuum groups at the same time.

The total installed electrical capacity is reduced by this sharing of starting equipment. In the case of the converted AGS, this reduction in installed capacity is approximately a factor of 8, neglecting the very small holding power required.

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The pump starting equipment can be designed specifically for that function; to facilitate this design, the characteristics of two commercial sputter-ion pumps were measured. The interrelated parameters studied were voltage, current, pressure, and normalized pumping speed. Figure 1 shows the resulting relationship for a 150 l/s Hughes pump, which is typical of all sputter-ion pumps.

It is clearly noted that the pumping speed is a strong function of the operating point (volt-ampere coördinate). The locus of operating points as a function of pressure is determined by the characteristic of the electrical supply. The desired locus lies through the region of greatest pumping speed. This locus cannot be approximated by any straight line; therefore, no simple series impedance, resistive or reactive, will provide a good supply characteristic for the starting unit. A straight line through the region of good high vacuum pumping speed carries the pump into a region of poor pumping speed as pressure goes higher, and a more complicated supply characteristic is desired.

The two intersecting straight lines shown (Fig. 1) do pass reasonably well through the region of best pumping speed. With this locus line, the pump will have reasonable pumping speed for all pressures below 5 μm. This locus line represents the characteristics of the simplified circuit shown in Fig. 2, with the added refinement of a maximum voltage clamp (diode 2).

Pumps powered by this circuit have good pumping speed for all pressures less than 5 μm, and therefore pump down in less time, do not overheat when pumping against a leak, and continue pumping through gas bursts as long as the pressure is below 5 μm.

The circuit of Fig. 2 is easily expanded to handle a number of pumps in a group. Each pump is associated with its respective resistors and diodes, and the group is powered from a common power source replacing the batteries of Fig. 2.

A reactive system having similar characteristics could be designed with each pump in a group associated with two diode-coupled reactive power supplies. Such a system is more expensive to build but cheaper to operate.

Brookhaven has chosen to build the resistive system for the converted AGS in the belief that the total operating hours of the starting equipment will be small. The dissipated heat from the resistors will be ventilated to the outdoors by forced air cooling.

The holding supply unit which powers the pumps after the starting equipment has pumped them to hard vacuum is much simpler in design than the starting unit. In the high vacuum region, the greatest pumping speed occurs with the highest voltage. The pump should, therefore, be operated at its voltage maximum. In the event of a vacuum leak or other failure of the pump, current must be limited. To accomplish this, the simplified circuit of Fig. 3 is suggested. The maximum current is limited by R_1 and the maximum voltage by supply V_1. Again, the V_1 and V_2 are power supplies common to many pumps which are isolated by their respective resistors and diodes.

Sputter-ion pumps operating on the holding supply units would not possess the same desirable pumping characteristic as pumps operating on the starting supplies in the poor vacuum region. It is, therefore, necessary to return the sputter-ion pumps to the starting supply units when the pressure rises excessively. This can be accomplished with the appropriate interlocks and high voltage relays.

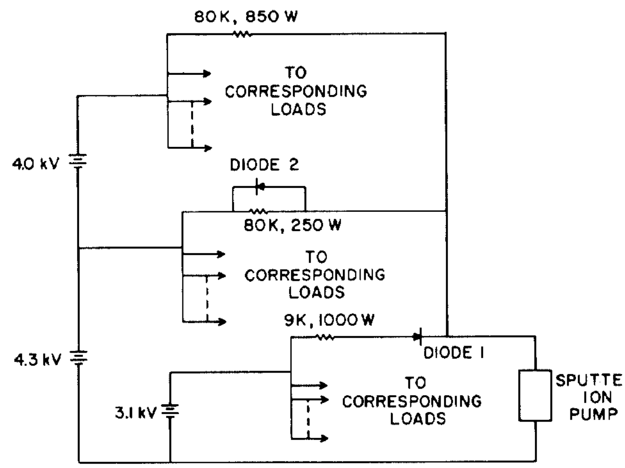

Fig. 2. Simplified schematic of starting unit.

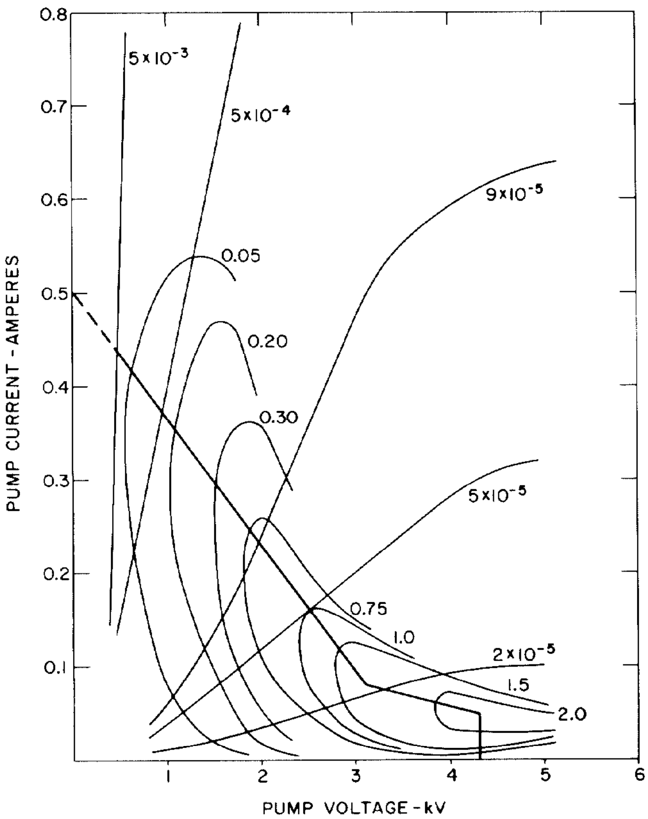

Fig. 1. Typical starting characteristics.

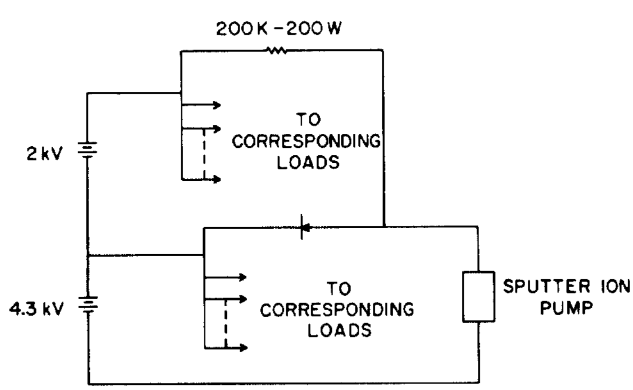

Fig. 3. Simplified schematic of holding unit.