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THE LARGE HOMOPOLAR GENERATOR AT CANBERRA

INITIAL TESTS

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THIS laboratory has been engaged for some time in the design and construction of a large homopolar generator¹. The generator was intended to provide a pulse of current, of roughly sinusoidal shape, into the orbital magnetic field coils of an ironless proton-synchrotron for 10 GeV., the peak current being 1.6 million amp., and the initial potential difference 800 V., while the stored energy at 900 r.p.m., in the two rotors, each weighing 40 tons, is 5×10^8 joules. The current is collected from the rotors by continuous sheet jets of liquid metal (sodium-potassium alloy) impinging radially around the periphery of each steel disk at a radius of $69\frac{1}{2}$ in., and vertically along the magnetic field (16,000 gauss) at a radius of 24 in. The generator is filled with pure nitrogen at about atmospheric pressure.

Fig. 1 shows diagrammatically the arrangement used in these initial tests, which were designed to test the ability of the jets and machine to withstand the effects produced by drawing the full current. The bottom rotor is clamped solidly in position. The lower disk of the upper rotor is driven as a Faraday disk by a current from a rectifier, flowing radially between a set of four equally spaced jets of sodium-potassium, 2 mm. in diameter, on a circle of radius 24 in., to four similar jets making contact with the periphery. A driving current of 1,200 amp. gave adequate acceleration to the limited rotational speeds used in the tests. The pulse of current was drawn from the upper disk only, and was conveyed to an electrolytic load by a system of aluminium conductors. The load was an arrangement of interleaved steel plates, spaced about $\frac{3}{4}$ in. apart, which could be immersed in a tank of sodium hydroxide solution when this was raised hydraulically from below.

The admission of sodium-potassium alloy to the current-collecting jets on the top disk, and the variation in the resistance of the electrolytic load, were programmed to give the required pulse shape. Fig. 2 shows how the flow of alloy through a jet varied with time in relation to a current pulse. The jets were established before the circuit was closed by entry of the caustic soda solution between the plates of the electrolytic load.

A series of pulses of up to 10^6 amp., with a half-second width at half current, has been delivered to the load at potential differences up to 66 V. The electrical energy agrees with the change in mechanical energy, within the errors of observation, so that the internal losses are small.

It was intended to observe several pulses with peak current of about 10^6 amp. before proceeding to the current of 1.6×10^6 amp. for which the generator has been designed. However, on the second such pulse, the unbalanced electromagnetic forces between the plate assemblies of the electrolytic load, due to uneven separations or current distribution, pushed these into contact, so that the current rose sharply to a peak of 1.8×10^6 amp. as shown in Fig. 2. The jets, running at less than full flow, appeared to have carried this current satisfactorily, and measured deflexions of the magnet and the jet structure were

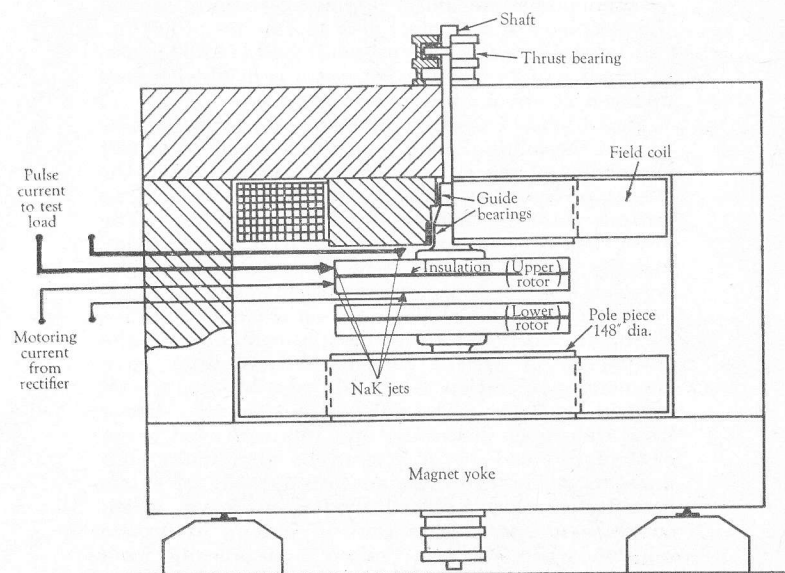


Fig. 1

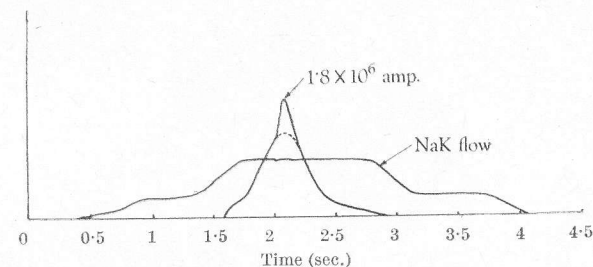


Fig. 2

within the tolerances allowed. The current reacts on the magnet with a torque of 2,000 ft.-tons.

These results are very encouraging, indicating that the design analysis is not seriously in error, and that the various assumptions made about the behaviour of the current-carrying jets are justified. It is now reasonable to believe that the complete generator will behave as planned. A stored energy of 5×10^8 joules will then be available for a wide variety of physical experiments, including the production of large magnetic fields over considerable volumes, such as are desirable for work in plasma physics.

There remain many questions to which answers must be obtained before all aspects of operation are understood and the generator is working reliably at full power. Solutions to many of these problems have been worked out. Continuation of the present series of tests will yield information about the validity of these solutions, and will inevitably indicate other problems which have not yet been envisaged. However, progress should now be rapid.

The tests have provided some interesting observations of the behaviour of liquid conductors moving in a magnetic field. These are in general accord with what would be expected from simple magneto-hydrodynamic considerations. The liquid metal exhibited a high degree of stability and tended to remain continuous, rather than to break up into streamers and drops. Further work is planned on these phenomena.

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¹ Blamey, J., *CERN Symp. High Energy Accelerators*, 1, 344 (1956).