The principle adopted in ZETA is to pass a large electric current through the deuterium gas. This current sets up an electric discharge in the gas (analogous to the discharge in a neon advertising sign) which heats it and also produces an intense magnetic field around the column of hot gas. This magnetic field causes the discharge to become constricted and hence get heated still more. Since it also causes the discharge to wriggle about, this field by itself is not enough to keep the discharge away from the walls. The wriggling has been suppressed by applying an additional steady magnetic field parallel to the axis of the tube.

In ZETA the discharge chamber is a ring-shaped aluminium tube or torus of 1 metre bore and 3 metres mean diameter, containing deuterium gas at low pressure. The tube is linked (*i.e.*, encircled over part of its length) by the iron core of a large pulse transformer. A current pulse of electricity is passed into the primary winding of the transformer from a bank of capacitors capable of storing 500,000 joules of energy. This pulse in turn induces a very large unidirectional pulse of current in the gas, which forms a short-circuited secondary for the transformer. Peak currents up to 200,000 amperes have been passed through the ionised gas for periods up to 5 milliseconds. The current pulse is repeated every 10 seconds. Emission of neutrons throughout the current pulse is observed regularly in routine operation of ZETA with deuterium; there are up to 3 million neutrons emitted per pulse.

The temperature of gas discharges may be determined from measurements on the light emitted by the gas atoms but measurements of this kind in these experiments present problems because, at the temperature of the discharge, the hot deuterium atoms are completely stripped of their electrons and therefore do not emit a line spectrum. One method of solving this problem is to mix with the deuterium a small quantity of some heavier gas, such as oxygen or nitrogen, the atoms of which are not stripped of all their electrons under these conditions, and to study the spectral lines emitted by this impurity; the random motion of the high energy impurity atoms which make many collisions with the deuterium atoms and so reach the same energy causes the spectral lines to broaden, owing to the Doppler effect, and the amount of broadening is a measure of the ion energy. Many measurements by this method have indicated temperatures in the region of 2 to 5 million degrees centigrade. Whilst temperatures in this range are required to explain the observed rate of neutron production on the basis of a thermonuclear process, electric fields in the gas arising from instabilities, can also accelerate deuterium ions and lead to nuclear reactions. Such a process was described by Academician Kurchatov in his lecture at Harwell in 1956.* Experiments are continuing to study the details of the neutrons producing processes.

In order to obtain a net gain in energy from the reaction it would be necessary to heat deuterium gas to temperatures in the region of 100 million degrees centigrade, and to maintain it at this temperature long enough for the nuclear energy released to exceed the energy needed to heat the fuel and lost by radiation. Lower temperatures would suffice for a deuterium-tritium mixture. The high temperatures achieved in ZETA, and the relatively long duration for which the hot gas has been isolated from the tube walls are the most important experimental results obtained so far. Whilst a much longer time (perhaps several seconds) is required for a useful power output, there appears to be no fundamental reason why these longer times, together with much higher temperatures, cannot be achieved. There are, however, many major problems still to be solved before its practical application can be seriously considered and the work must be expected to remain in the research stage for many years yet.

* Therefore it is not altogether certain that the observed neutrons come from a thermonuclear reaction.

FIRE-PROOFING OF JUTE

A NEW permanent fire-proofing treatment for jute fabric has been developed by the British Jute Trade Research Association in its Dundee Laboratories. A patent (B.P. 785, 610), has been filed by the Association. The process consists of treating the fabric with a water dispersion containing antimony orthophosphate and a chlorine-containing vinyl plastic resin.

Fabric treated in this is claimed to be resistant to flaming and to afterglow. It is stressed that the fire-proofing is permanent, being retained even after the treated cloth has been weathered outdoors and immersed in sea-water for a considerable period. It also improves the cloth's resistance to abrasion.