SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

SOME ASPECTS OF THERMONUCLEAR RESEARCH

DR. T. E. ALLIBONE discusses in his presidential address to Section A (Mathematics and Physics) some aspects of thermonuclear research.

If the fusion of deuterium ions is to yield a useful amount of energy, the temperature of the gas must be maintained in excess of 100 million degrees, and it therefore follows that the hot gas must not be in contact with the walls of the vessel containing it. A large current passed through the gas will heat it ohmically and the magnetic force associated with the current will constrict the discharge and draw it away from the walls, thereby compressing it and thus augmenting its temperature. Many investigators have pursued this line of research; British investigators have mainly used toroidal discharge tubes in which a pinched ring discharge is created by electromagnetic induction, whereas American and Russian investigators have used straight discharge tubes, thereby choosing to ignore, for the time being, end losses at the electrodes.

Very large electric currents lasting for short times were readily produced in the straight tubes and bursts of neutrons were detected several years ago. The fact that the bursts of neutrons lasted for only a few tenths of a microsecond and occurred only two or three times throughout a 10-microsecond current pulse was surprising; moreover, the rate of release of neutrons was far higher than could be accounted for. It did not rise appreciably as the discharge currents were increased, and it diminished rapidly if impurities were present. Further study revealed the fact that the discharge developed instabilities in a few microseconds, and at localized constrictions of the discharge, ions were given energies far higher than their mean energy. It was the collisions of these locally accelerated ions which produced the fusion reaction yielding the observed neutrons.

The toroidal discharges studied in the Atomic Energy Research Establishment at Harwell and at the Research Laboratory of Associated Electrical Industries, Ltd., at Aldermaston were maintained for times of the order of a millisecond, during which other forms of instability developed. To a certain degree it was found that these instabilities could be reduced by the application of a steady magnetic field parallel to the discharge path. As the discharge is constricted in the presence of this axial field, currents circulate around the cross-section of the discharge, thus enhancing the field within the discharge and reducing the field outside it. It was found that with optimum values of applied axial magnetic fields the toroidal discharges yielded neutrons over a large fraction of the total duration of the current pulse, both in the apparatus ZETA at Harwell and in SCEPTRE at Aldermaston. Moreover, measurement of the Doppler broadening of some of the spectral lines of impurity elements in the gas indicated ion temperatures corresponding to several million degrees, at which true thermonuclear fusion should yield neutrons comparable in number with the observed neutron flux.

In recent months it has been proved that neutrons and protons released in the fusion reaction in the same direction as the ions in the discharge have energies a little higher than those emitted in the opposite direction; the difference is due to the forward velocity of the deuterium ions at the moment of fusion. This velocity has been found to be appreciably in excess of the mean velocity of deuterium at the temperature estimated spectroscopically. It may be that the spectroscopic measurement is in error, for the discharge, though reasonably stable, can be seen to be moving about rapidly within a confined volume on the axis of the torus, and some of the Doppler broadening may be due to lateral velocity of the beam. To resolve some of the anomalies and uncertainties, ZETA and SCEPTRE are being modified to operate at higher temperatures.

Some of the other ways of attaining high gas temperatures appear to be very promising. Following disclosure of the Russian linear pinch discharge, the Atomic Weapons Research Establishment, Aldermaston, has developed an even faster linear pinch which has produced neutrons; preliminary indications are that these do not arise from instabilities of the discharge. The most recent American and Russian work will be discussed in Geneva on September 4 and may not be commented upon at this moment. Several novel methods of containment of a plasma have been described in recent American literature, but the Russians have disclosed nothing since 1956.

THE CHEMISTRY OF THE TRANSURANIC ELEMENTS

PROF. H. J. EMELÉUS, in his presidential address to Section B (Chemistry), states that it was a natural result of Fermi's observation of the n,γ reaction, whereby an element such as gold could absorb a neutron and by subsequent β-decay be converted into a mercury isotope

$$\left({}^{197}_{79}\mathrm{Au} \xrightarrow{n,\gamma} {}^{198}_{79}\mathrm{Au} \xrightarrow{\beta} {}^{198}_{80}\mathrm{Hg}\right)$$

that similar experiments should be done with uranium in the hope of making isotopes of a then unknown element 93. Irradiation of natural uranium actually gave both fission of uranium-235 and neutron-capture by uranium-238. From this confused start, however, clear-cut methods for producing the transuranic elements have now emerged. These are, in brief: (1) bombardment with artificially accelerated particles; (2) neutron bombardment; (3) multiple neutron capture; (4) bombardment with heavy