There is considerable variation in the length at which smolts migrate. In the Rivers Liffey and Lee they migrate at an average length of about 16 cm., whereas in other rivers they may migrate at lengths of less than 12·5 cm.

The fastest-growing fish in each river appear to migrate first, and there is generally a slight increase in the average length of the smolt as the smolt ages are ascended.

Spring fish which have spent two or three years feeding in the sea predominate in some Irish rivers such as the Liffey and Lee, whereas on the other extreme some are virtually grilse rivers; that is to say, the fish have spent less than two full years feeding in the sea. In rivers which have no lakes on their systems and with intensive commercial fisheries the proportion of previous spawners is low. This is the case of the Rivers Liffey, Lee, Inny and Kerry Blackwater. In most rivers having lakes on their systems the proportion of previous spawners is high. For Ireland as a whole the proportion of previous spawners ranges from 1 to 15 per cent, depending on the river and to some extent on the year, with an average of about 5 per cent. Most of the previous spawners have only a single spawning mark on their scales, a smaller proportion, about 3 per cent, have two; a few have three such marks on their scales. Fish with three spawning marks have only been identified on six occasions out of a total of nearly fifty thousand sets of Irish salmon scales examined to date.

Thus by using the scales a considerable amount of information has been compiled about the salmon of Irish rivers; but as Miss Twomey pointed out, other methods have to be employed to investigate other aspects of the life-history of Irish salmon.

Mr. E. D. Toner in his paper, "Movements of Salmon in the Sea around Ireland", then described the progress made in investigations in the open seas around Ireland since 1948 when the experiments were initiated. Live salmon taken in commercial nets were tagged with the Lea hydrostatic tag and released at several places around the Irish coast, namely: Baginbun, Co. Wexford (south-east coast); Rath, Co. Kerry (south-west coast); Achill, Co. Mayo (west coast); Streedagh, Co. Sligo (north-west coast); Portbraddan and Carrick-a-rede, Co. Antrim (north coast) and Carnlough, Co. Antrim (north-east coast). Altogether, 3,246 salmon and grilse were so tagged and 930 tags, or 28·6 per cent, were recovered. From Baginbun the predominant movement was westerly, but a small proportion of fish moved eastwards and then northwards, two proceeding long distances, one to the River Fane on the east coast of Ireland and one to the River Tay in Scotland more than eight hundred miles away. Movements from Rath were mainly to local rivers, but a few fish proceeded a hundred miles or more northwards up the west coast. Most of the recaptures from Achill were made in rivers within fifty miles of the tagging stations, though some fish made long journeys to places on the north coast of Ireland and west coast of Scotland. Individual fish went to Rhyl in North Wales and to the Conon River on the east coast of Scotland. Movements from Streedagh were mainly to local rivers. In the stations on the north coast of Ireland the predominant movement was westwards towards the River Foyle. A small proportion of fish, however, moved to the east coast of Ireland, to the west coast of Scotland and one even to the east coast of Scotland. From Carnlough on the north-east coast the movements were again predominantly towards the west, but there were substantial movements to the west coast of Scotland, and two fish travelled to the east coast of Scotland, one to the River Tweed.

As to the speeds of travel, the maximum apparent speed recorded was thirty-three miles a day, and only ten fish out of the eight hundred or so for which information was available reached their destinations after travelling at speeds of twenty miles a day or more.

Mr. Toner concluded that salmon approach the Irish coasts in a haphazard fashion, and only when they are close inshore do they make a definite search for the river of their origin.

Mr. Arthur Swain, in his paper "Factors affecting the Downstream Migration of Salmon and Sea Trout", pointed out that the 'departure stimulus' has always been associated with floods, but as long ago as 1926 H. O. Bull showed that this was not true, although Bull concluded that the initiation of the run of smolts was associated with rainfall.

For a number of years salmon and sea trout, smolts and kelts have been caught and tagged in the River Coquet at Warkworth in Northumberland at a specially constructed set of traps. Data relating to the downstream movement of the smolts and the temperature of the water, etc., were collected during 1952–57 inclusive. During these years many thousands of smolts were caught, a very high proportion in the hours of darkness, especially the first three or four hours. Few smolts were taken in March in the years 1953–56, when the temperatures were low, but in 1957 during that month a mild spell of weather resulted in a fairly large number of smolts being caught. As a rule, large numbers of smolts appeared from about the third week in April onwards, continuing well into May, and the numbers generally began to fall off at the end of May or early June.

Mr. Swain concluded that the migration of smolts was clearly seasonable, but within the migration season it appeared that the immediate stimulus for migration is either a rise in temperature, or some factor associated with a rise in temperature, acting on fish which have attained the proper physiological condition. The stimulus which causes the kelts to move downstream, on the other hand, is clearly associated with floods, and the rate of flow and turbidity of the water encouraged them to drift downstream. There is also some evidence that they are influenced by temperature and that a rise in temperature, as in the case of smolts, stimulates them to move downstream. A. E. J. WENT

IONIZATION PHENOMENA IN GASES

THE impressive history of rich contributions to the structure of contemporary physics presented by that branch concerned with the conduction of electricity in gases is well known. An indication of one reason why work in this field is at present in one of its more flourishing phases is contained in the name 'gaseous electronics'. This is a recent fashion which—though perhaps offensive to some—does recognize the extent to which the advances of the

past decade or so have depended on developments in refined ultra-high-frequency and high-speed electronic instrumentation, very-high-vacuum and gas-handling techniques, stable high-voltage sources and so on. Moreover, the actual exploitation of improved technical facilities of this kind has been accelerated by several influences, notably the persisting need for more quantitative information on fundamental collision processes, not only in laboratory discharge-physics but also in fields such as ionospheric research and astrophysics, and also by the hope that studies of the extreme conditions which exist in heavily loaded plasmas may assist ultimate achievement of controlled nuclear fusion.

The present vigour of the field under review was amply demonstrated by the scope of the Third International Conference on Ionization Phenomena in Gases, arranged at Venice during June 11–15 by the Società Italiana di Fisica, under the presidency of Prof. G. Pulvani. This conference continued a series of biennial meetings initiated by A. von Engel at Oxford in 1953, followed by a meeting at Delft in 1955. A total of some forty papers was presented in the general sessions, and ninety in three parallel specialized sessions. It is thus obvious that the present review cannot do individual justice, since a mere catalogue of titles would consume much of the available space. This account is, therefore, restricted to details of general-session reports, with some remarks on special-session papers, principally in connexion with fundamental collision processes and spark breakdown, together with a broad coverage of papers on very high temperature plasmas, pulsed discharges, and plasma theory, since these topics received special emphasis owing to their relevance to thermonuclear reactions. This selection, however, leaves unnoticed many important contributions, particularly the numerous papers on glows, electrode actions, counter processes and technical applications.

After addresses of welcome by representatives of the several host organizations, the Conference opened with an invited paper by Prof. W. Lochte-Holtgreven (Kiel), on "The Emission of Spectral Lines from a Plasma". Characteristic of the well-known work of the Kiel school on heavily loaded arcs and other discharges has been the wide exploitation of spectroscopic methods. Prof. Lochte-Holtgreven compared current theoretical interpretations of spectral line-profiles with results of recent experimental work on lines of atomic hydrogen, helium I and helium II. There has been steady progress, during the past few years, towards better understanding of the relative contributions of plasma electrons and (slower) positive ions to the shapes of the emitted lines.

Prof. L. B. Loeb (Berkeley) was, unfortunately, prevented by illness from reading a second invited paper; the sympathy and greetings of the Conference were telegraphed to Prof. Loeb, whose substantial contributions to discharge physics are well known.

Atomic and Ionic Collision Processes

The general sessions opened with a paper by R. Varney (St. Louis) on "Ionization of Gases by Positive-ion Impact", in which, in continuance of earlier work, new results were reported on efficiencies and threshold energies of ionization by positive ions of alkali metals in various gases, obtained with apparatus of greatly improved sensitivity. J. Sayers (Birmingham) reviewed ionic reactions in gases, with special reference to work at Birmingham on electron recombination, in which—by a combination of Langmuir-probe and mass-spectrometer-probe techniques—the attempt is made to account for electron loss from an afterglow in terms of capture by the specific types of positive ion detected.

Important results on photo-ionization cross-sections of gases and photoelectric-yields of solids, investigated by improved vacuum-ultraviolet methods, have emerged from several laboratories in recent years. The work at Los Angeles described by G. L. Weissler included a number of new results, one point of particular interest being the high yields of photo-ionization found in several polyatomics—five to ten times those typical of simpler gases.

Some techniques of great elegance, including very sensitive optical-absorption methods, have been developed at Westinghouse Laboratories, Pittsburgh, for studies of concentrations and interactions of excited and particularly metastable atoms; some new results were reported by A. V. Phelps. Other experiments, also of great beauty, were described by L. M. Branscomb (Washington), in a paper entitled "Photodetachment Studies of Negative Ions". In this work, a mass-analysed beam of negative ions is intensely illuminated by light selected by an interference filter, the current of photo-detached electrons is measured, and cross-sections are derived. A related paper was that of V. Dukelsky (Moscow), on "Formation of Negative Ions and Atomic Structure"; the existence of negative ions of many elements was reported, the more stable forms often being molecular. An interesting problem is posed by the mechanism of formation of the ion He^- which, although of negative electron-affinity in its ground-state, has been shown by recent theoretical work to have a stable doubly-excited quartet state of long life-time.

Papers by R. L. F. Boyd and J. B. Hasted related to different aspects of the substantial programme of collision studies and discharge investigations at University College, London. Apart from a general review, the first of these described a method of performing electrically the (Druyvesteyn) analysis of probe curves, which gives greatly improved accuracy in determinations of the energy distribution among the plasma electrons. The second paper described apparatus for collision studies—especially of ionization by positive ions, with simultaneous check by mass-spectrometer of the fragmentation products in the processes of ionization and charge-exchange.

A valuable paper, presented by L. Goldstein (Urbana) on "Charge Interactions in Gaseous Discharge Plasmas", was concerned with experimental and theoretical results on the interaction processes which occur both within an electron-gas and between electrons and ions in a plasma. Experiments on the heat-propagation properties of plasmas were said to indicate that the electron/electron interaction, for which no satisfactory theory yet exists, is important even in plasmas of low ion density.

Spark Breakdown

The subject of the mechanisms of spark breakdown was introduced in reviews by J. M. Meek (Liverpool), "Recent Researches in Spark Breakdown", and H. Raether (Hamburg), "Townsend and Streamer Mechanisms". The first stage of breakdown in a gap occupied by a uniform field consists of a rapid growth

of ionization by electron-impact, initiated by the acceleration of a single electron away from the cathode region (electron avalanche). The essential feature of the Townsend mechanism for building up the current in the gap lies in the development of fresh avalanches, in rapidly increasing numbers, as a result of the operation of one or more possible secondary processes, for example, emission of secondary electrons from the cathode due to bombardment by positive ions. Though such mechanisms have long been recognized as affording an adequate explanation of sparking phenomena for low values of the product (pressure × gap-length), until very recently severe difficulties existed at high values of that product. The streamer theory, associated with the names of Loeb, Meek, Raether, met such difficulties, at least qualitatively, by emphasizing the part played by photo-ionization of the gas and the distortion of the field produced by accumulated space-charges. However, an obviously unsatisfactory dichotomy persisted, with the employment of two widely differing theories for high and low values of the product (pressure × gap-length), leaving more or less untreated a large and ill-defined intermediate region. The most recent work has led to the belief that objections to Townsend mechanisms in spark gaps occupied by uniform fields near the critical sparking voltage have previously been over-estimated. While the subject is still very fluid, the vigour of current investigations encourages the hope that a comprehensive theory may be reached, possibly embodying a transition from 'Townsend' to 'streamer' breakdown with changing conditions.

Several other laboratories which have been active in this work were represented at the Conference. Thus, L. H. Fisher (New York), whose work on formative time-lags has been very significant, reported further results on pre-sparking phenomena in gases in uniform and non-uniform fields. F. Llewellyn-Jones (Swansea), describing some recent investigations on micro-arc discharges, dealt with breakdown mechanism and subsequent characteristics of a discharge such as that produced by the opening of an electrical contact; this work has obvious technical importance, and also faces difficulties from the small-scale nature of the phenomena. Other work at Swansea was described by C. Grey-Morgan, under the title "Electrode Ionization Phenomena in Gases". Detailed studies of the temporal relations of voltage, current and the intensity and propagation-velocity of the luminosity in over-volted impulse-sparks were reported by J. K. Theobald (Los Alamos).

The interpretation of the lightning-stroke—the extreme example of breakdown under conditions in which (pressure × gap-length) is large—is a continuing challenge to laboratory discharge physics; the value of new observational material, obtained by improved methods now available, was recognized from a paper by H. Norinder (Upsala) on "Some New Results on the Mechanism of Lightning Discharges".

In recent years much experimental and theoretical effort has been devoted to the breakdown processes in a gas subjected to an applied field at microwave frequencies. A laboratory which has been especially prominent in this respect is that of S. C. Brown (Cambridge, Mass.), who, under the title "Microwave Gas Discharge Breakdown in the Presence of Magnetic Fields", summarized the most recent results in this field.

Arcs and Glows

A number of general session papers were concerned with features of arc and glow discharges. D. J. Rose (Murray Hill), in a paper on secondary mechanisms of the glow discharge, described interesting results on the relative contributions of two processes of electron-ejection from molybdenum cathodes in hydrogen, deuterium, and neon, namely, ejection by incident positive ions and by photons. K. G. Emeleus (Belfast), in a paper with B. Love, gave an extended treatment of the complex of phenomena involved in the classification and stability of striations, and emphasized the likely value of detailed spectroscopic study of the several forms observed.

Three major papers on arc-discharges were read. In the first, H. Maecker (Erlangen), under the title "General Description of Electric Arcs and its Application to some d.c. Types", presented an amply illustrated review of the utilization of the electrical and spectral characteristics of several forms of arc channel, including uniform-cylindrical, free-burning (convection-stabilized), and high-current forms. In the second paper, on high-pressure discharges in gas mixtures, P. Schulz (Karlsruhe) discussed effects on field strength, light output and spectral distribution, in gas-arcs, in terms of relative excitation- and ionization-potentials and collision cross-sections, of the atoms of a binary gas mixture. In the third paper, on "The Anode-Drop in Low-Pressure Discharges and High-Current Arcs", K. H. Höcker (Stuttgart) distinguished the details of the processes of ion generation, supposed to be operative in the anode region of these two discharge types.

An interesting paper by A. E. Robson (Oxford), on the evaporating cathode and the Tanberg effect, was concerned with the anomaly presented by simultaneous measurements of the evaporation-rate from the molten cathode of a metal arc, and the force of reaction produced on that electrode by the evaporating atoms; these measurements have previously led to estimates of the velocities of the latter, which correspond to improbably high values for the temperature at the cathode, around half a million degrees. The explanation now suggested for this so-called 'Tanberg effect' is that the number of evaporating atoms has been greatly under-estimated, by neglect of the fact that the majority—typically 95 per cent—of those leaving the surface are scattered back again by collisions in the cathode-layer.

Of the remaining papers on arc-discharges, space permits mention of only one, by H. Edels (Liverpool), on "Glow to Arc Transition in the Column and at the Cathode of a Hydrogen Discharge", describing experiments by both electrical and spectroscopic techniques, aimed at clarification of the complex processes involved in such transitional regions.

High Temperature Plasma and Pulsed Discharges

Contributions in this and allied sections showed that work in many laboratories is centred on the problems posed by the pinched discharge, in which constriction of a plasma column results from self-magnetic pressure. A. A. Ware (Aldermaston), one of the original workers in this field, described experiments with a toroidal discharge-tube. The ions and electrons are found to be pulled in rather slowly by the pinch-effect, with the development of a central region of high pressure, from which emerges a shock wave

travelling outward. Within the shock-front the discharge passes in a narrow irregular channel. Similar irregular helical channels in toroidal discharges were reported by T. K. Allen (Harwell); during a long square current pulse (200 μsec., 4,000 amp.), rotation of the helix about the toroid-axis is indicated, at velocities 2–7 × 10^5 cm./sec., in argon and neon. P. Reynolds (Harwell) reported work with J. E. Allen, in which measurements of electron- and ion-temperature were made by several methods, using an apparatus similar to that of Ware; oscillatory currents of 15–20,000 amp. gave ion-temperatures of 5,000–40,000° K. A. N. Dellis (Harwell) described the use of microwave noise in the determination of plasma electron-temperatures; the noise at a wave-length of 8·5 mm. from a hydrogen discharge yielded electron-temperatures up to 2 × 10^5 °K.

A highlight of the Conference was the report of S. A. Colgate, of work on pinched discharges in deuterium, by a group at Livermore in the United States. These important investigations were made some years ago but have, unfortunately, remained classified until recently. As in the case of similar work done in the U.S.S.R., and reported by I. Kurchatov at Harwell in 1956, copious bursts of neutrons were obtained, which, however, are not likely to have been of true thermonuclear origin. The most significant results of the Livermore experiments leading to the latter conclusion are: (*a*) the neutrons arise in the gas, uniformly along the discharge-axis, where the temperature should be highest, (*b*) application of a small axial magnetic field quenches the production of neutrons, (*c*) the deuterons colliding to produce neutrons, by the reaction $^2D_1 + {}^2D_1 \rightarrow {}^3He_2 + {}^1n_0$, have axial velocities corresponding to energies of 200–300 kV. The suggested mechanism for the production of neutrons is that the pinched discharge becomes unstable, the uniform column splitting into 'droplets' along the axis of the tube, possibly leading to high axial electric fields in which the deuterium ions are accelerated. Quenching of the yield of neutrons by the small magnetic field is then attributed to the effect of the field in limiting the axial instability.

R. F. Post (Livermore), in a paper on problems of research into controlled fusion, amplified and revised the useful appreciation he contributed to "Reviews of Modern Physics" in 1956. The results of his latest work were given in the form of new limits for temperature, density, size and magnetic field. The need for great purity of the reacting gases was emphasized.

The production and study of heavy-current discharges were described by C. Breton *et al.* (Saclay). The apparatus used consisted of a torus, similar to those used at Aldermaston and Harwell, in which a high gradient of electric field could be induced by an oscillatory condenser discharge. The occurrence of shock-waves was demonstrated, and pulses of γ-rays of 150-kV. energy were detected. The spectroscopy of the discharges was discussed in a companion paper.

R. J. Bickerton (Harwell) described theoretical and experimental work on the effect of a stabilizing magnetic field on a toroidal discharge. Theoretically, limited regions of current and magnetic field are expected, over which the discharge should be stable, without the pinch-effect being seriously modified by the applied magnetic field. Experimental tests, using pulsed currents and fields, more or less support the theory, and ionic- and electron-temperatures of order 500,000° K. have been estimated.

Later in the Conference, three further papers on condenser discharge work were presented. The first was by K. Siegbahn (Upsala), who reported detection of neutrons in a 60-μF., 50-kV. discharge in deuterium. The other two papers, by S. Curran and K. W. Allen, related to work at Aldermaston, employing a circular arrangement of 144 condensers, connected by short leads to a centrally placed discharge-tube. Novel features, however, were the use of a separate triggered gap on each of the condensers used, and the application of a pre-ionizing pulse to the gas in the discharge tube. Pulses of up to 10^5 neutrons were obtained, and it may well be that the mechanism of production of these was different from that suggested by Colgate, since the yield of neutrons was found to be much less sensitive to concentration of nitrogen impurity and to an axial magnetic field. A paper by P. C. Thonemann and A. Gibson (Harwell) discussed the production of run-away electrons in toroidal discharges. With a stabilizing axial magnetic field of 1,000 gauss, such electrons were detected by the X-rays they produced; the energy of the electrons was estimated to be 25–30 kV., and the yield approximately one-sixth of that expected from elementary theory. H. Dreicer (Los Alamos) also discussed the run-away electron phenomena from a theoretical point of view.

M. O'Day (Cambridge, Mass.) reported work with W. G. Chace and E. W. Cullington on the explosion of wires by discharges from heavy condensers. Instrumentation, under the conditions of extreme interference which necessarily exist, presents much difficulty, and the equipment installed is probably as advanced, as regards design and screening, as any yet devised. An impedance match was achieved between the bank of condensers and the wire specimen. No pinch-effects had been observed in either solid or vapour, but it was hoped that these would be found on further increasing the rate of increase of current.

Plasma Theory

The papers presented on plasma theory covered an extremely wide field, extending from studies of distribution functions, to calculations concerning the stabilities of particular discharges. In the first session, M. Delcroix (Paris) discussed the work of a group at the École Normale Supérieure, leading to an expression of the velocity distribution function in a lightly ionized gas as a series of eigenfunctions of the collision operator. H. Schirmer (Berlin) gave a detailed account of the calculation of the electrical conductivity of a partially ionized gas, with special reference to a high-pressure xenon discharge, which was used to check the calculations. R. Jancel and T. Kahan (Paris) discussed, in two papers, the distribution function for a partially ionized gas subjected to oscillating electric and steady magnetic fields, and also the problems of wave-propagation in such a plasma. G. Schmitz (Aachen) gave an account of a method of solving the energy-balance equation for a cylindrical plasma channel, in which the thermal and electrical conductivities are known functions of temperature.

The second session, which was mainly concerned with the fundamentals of plasma stability, was opened by M. Kruskal (Princeton), well known for his pioneer work with Schwarzschild on the stability of a pinched discharge. Two papers were presented, both con-

cerned with invariants of motion in ionized gases. The first dealt with the spiralling of charged particles of small ratio (ε) of mass to charge. An adiabatic invariant, which has been discussed by H. Alfvén, for the case $\varepsilon = 0$, was generalized to all powers of ε. The second paper, with I. Bernstein, E. Frieman and R. Kulsrud, gave an energy principle for examining the stability of a discharge channel of more general application than the customary 'normal-mode' approach.

The group at Göttingen, L. Biermann, K. Hain, R. Lüst and A. Schlüter, also reported a detailed study of the problems of hydromagnetic stability. In addition, a novel method of heating a plasma was proposed, in which an isolated mass of ionized gas is subjected to a cyclically varying magnetic field. Arguments based on equipartition of energy show that the temperature of the plasma is thereby raised.

A paper by M. Rosenbluth (San Diego) was one of several theoretical studies concerned with the stability of the pinched discharge, one of which has been mentioned earlier. Rosenbluth treated the problem of a cylindrical discharge with axial magnetic field and conducting boundary, and gave conditions for stable operation. H. L. Jordan (Aachen) also discussed the stability of pinched discharges.

In the final session, the same topic was treated by R. J. Tayler (Harwell), who gave the results of 'normal mode' calculations of stability in pinched discharges. For a system in which the current is confined to the surface of a cylindrical column of gas, he showed that no stability is possible for the first-order 'mode' for any external magnetic field if the discharge tube has an insulating wall. With a conducting boundary of not too great a radius, image forces can remove the residual instability, so that complete stability is possible. For the more general case of a volume distribution of current the situation is complex, but complete stability is not very likely.

W. B. Thompson (Harwell) considered the transition between low-current discharges controlled by diffusion and the high-current pinched discharge. H. Margenau (New Haven) presented a paper on the conductivity of plasmas with respect to microwaves in which the distribution function was assumed to have one of several simple forms and was perturbed only slightly by the microwave field. He also reported work with D. C. Kelly on power absorption from microwaves at the cyclotron resonance by electrons of low energy in a discharge. From the half-width of the resonance curve the collision frequency could be deduced.

Two papers were presented by J. G. Linhart (Geneva) and D. C. de Packh (Washington) on the problems arising in the production of electron beams with neutralized space-charges first discussed by Bennett[1] and Budker[2]. In the first paper by Linhart the theory of the production of such beams was considered. In the second, read by A. C. Kolb, the possibility of additional focusing of electrons by external magnetic fields was taken into account, leading to a reduction in the stabilizing proton-core and to conditions which are rather easier to realize in practice.

Two general addresses remain to be mentioned. These were by Prof. V. Gori (Rome) and Dr. A. von Engel (Oxford), and took the form of tributes to the life and work of the late Prof. Giorgio Valle.

The success of the Venice meeting lay largely in the presentation, in many of the papers, of much really new material and in the evidence thus provided of intense activity on a wide front. The next conference of the series is to be held in Upsala in 1959.

W. R. S. GARTON
R. LATHAM

[1] Bennett, W. H., *Phys. Rev.*, **45**, 890 (1934).
[2] Budker, G. J., *Cern Symposium Proc.*, **1**, 68 (1956).

DUTCH–NORWEGIAN JOINT ESTABLISHMENT FOR NUCLEAR ENERGY RESEARCH

REPORT FOR 1955–56

THE Joint Establishment for Nuclear Energy Research (J.E.N.E.R.), situated near Oslo and operated jointly by the Norwegian Institutt for Atomenergi (IFA) and the Dutch Stichting Reactor Centrum Nederland (RCN) through a commission consisting of three Dutch and three Norwegian members, has recently issued its fifth annual report*, covering the period from July 1, 1955, to June 30, 1956.

The natural-uranium reactor, JEEP, which is moderated and cooled with heavy water and has now been in operation for nearly five years, is the main piece of research equipment at the Establishment. Its total energy release during the period under review was about 70 MW.-days, compared with 50 MW -days for 1954–55. The reactor had a major shut-down during February 26–March 12, 1956, for the installation of a new heat-exchanger, the final stage in the introduction of a new cooling system. This heat-exchanger, which transfers the heat from heavy to ordinary water, has five times the surface area of the old exchanger, and the ordinary water is circulated from it through a cascade-type cooling tower to a reserve tank. With the new cooling system the reactor may be operated at a much higher power-level than previously, and, in addition, the operation is entirely independent of the prevailing weather conditions. The fuel elements were inspected twice, during August 1955 and March 1956, and the inside of the reactor tank once, during August 1955; their conditions were found to be satisfactory and no replacements were made.

During the year the number of shipments of radioisotopes from the Establishment totalled 614, only a small increase on the previous year's total of 579. The shipments were mainly to Norway, Sweden, Denmark and Holland. An additional 204 irradiations were made for use within the Establishment. Although the demand for radioisotopes is steadily increasing, no increase in production can be expected until the completion of the construction of the new buildings, for which plans have already been made. The report includes a list of the various isotopes produced, the number of shipments and their destinations, and the main fields of application.

New research equipment has been installed in both the metallurgy and physics laboratories, where a wide range of experimental work is being carried

* Fifth Annual Report, July 1955–June 1956, of the Dutch–Norwegian Joint Establishment for Nuclear Energy Research. Pp. iv + 32. (Lillestrøm: Joint Establishment for Nuclear Energy Research, 1957.)