ROCKETS

THE subject of rockets is one that has attracted considerable popular attention during the post-war years, but on which very little reliable technical information has been available. It was, therefore, an attractive and interesting topic for a discussion meeting on April 24 at the Society for Visiting Scientists. Introductory talks were given by the chairman, Prof. A. D. Baxter, Mr. I. Lubbock and Dr. A. C. Merrington, all of whom have had long experience in the rocket field, and afterwards a general discussion ranged over a wide variety of problems of scientific interest.

In opening the meeting, Prof. Baxter emphasized the propulsion side of the subject and reviewed the relationship of rocket propulsion to other forms of power plant. The major distinction is that the latter are air-swallowing; but the rocket motor is practically independent of the atmosphere. Consequently, the propelling force developed by piston engines, gas turbines and ram jets falls off as the altitude increases, whereas the rocket motor force actually increases slightly. At the same time, the dimensions of a rocket motor are very much less for the same thrust, and its compactness gives it advantages of low weight and air resistance. These are offset to some extent by the large consumption of propellant resulting from the need to carry its own oxidant. Such features make the rocket motor eminently suitable for short-duration propulsion at extreme speeds and altitudes; hence its role in aircraft, guided weapons and, in the future, space-craft. Because of the high fuel consumption, it is probable that new flight techniques will evolve as, for example, the use of a combined ballistic and extended glide path. These would introduce new problems—how to deal with the very high skin temperatures of the rocket at high speeds, the cabin air-conditioning for passengers, the physiological effects of prolonged accelerations and periods of weightlessness and so forth.

Mr. Lubbock, who followed, gave an account of the early methods of designing liquid propellant rocket motors, which were contrasted with those using solid propellants. The selection of an oxidant was made from the three best known: liquid oxygen, hydrogen peroxide and nitric acid. All three were used by the Germans during the Second World War and each has problems peculiar to itself. Liquid oxygen is attractive in many ways; but its low boiling point introduces engineering problems of storage and transfer to the combustion chamber. Conditions in the latter are much more severe than in other internal combustion engines—the gas pressure is at least 300 lb. per sq. in. and the temperature is of the order of 3,000° K., compared with the normal gas turbine maximum pressures and temperatures of approximately 80 lb. per sq. in. and 1,150° K. respectively. The thermodynamics of rocket combustion is therefore complicated by dissociation, and heat transfer calculations demand data well beyond the limits of experimental knowledge.

From this point, Dr. Merrington followed with an explanation of rocket motor testing and research procedure. Contrary to the usual ideas, he said, the greater part of the testing and development is done statically, and only in the later stages is it necessary to consider flight testing at one of the rocket ranges. As in most experimental work, some risk of component failure exists with new developments, and proper precautions have to be taken. The risks arise mainly from the concentrated potential energy of an unburnt propellant mixture. This energy is of the same order as in high explosives, and if its liberation is not controlled, explosion can occur. To reduce the consequences of this, static testing is carried out in reinforced concrete cells. Measurements of thrust, propellant flow-rate, and the associated liquid and gas pressures are made, but no satisfactory methods of measuring the high combustion temperatures have been devised. Because of the rapid rates of change in the quantities to be measured, especially during starting, electronic recording is frequently adopted. In flight, the operation of the motor is studied chiefly by telemetry, the main information required being obtained indirectly in the form of pressures recorded graphically.

In the discussion which followed, a variety of points were made and questions asked. There was a natural interest in any possible uses of rockets other than for warlike purposes. The best known has been the life-saving rocket, in operation for more than a hundred years, which carries a line from shore to ships in distress. Among others enumerated were the mail-carrying rocket which had been tried in places where the topographical features encouraged it, such as across mountain ranges or stretches of water, high-altitude sounding rockets for studying upper atmosphere conditions and, at the other end of the speed and height-scale, assisted take-off rockets for transport aircraft operating from short runways or in conditions where the main engines could not give sufficient thrust. Mention was also made of rocket techniques applied to the drilling of oil bore-holes, the shaping of metal articles, and the operation of wind tunnels; the last relies on the ejector pump action of the high-velocity rocket exhaust gases entraining air from the tunnel. Such a tunnel would be expensive to operate frequently, but would save capital outlay on conventional electric motors and fans if only required intermittently. The principle has been applied to boundary-layer suction from aircraft wings to improve lift during take-off and landing. Another case of intermittent use requiring short periods of high-pressure gas generation is in driving small gas turbines used as engine starters.

The noise emitted by rocket motors was discussed at some length. This noise is made up from two sources—combustion and exhaust jet. Combustion noise is common to all types of engine in greater or lesser degree, and its level is dependent upon variables such as mixture ratio and combustion chamber loading. No satisfactory explanations relating the observed results in different forms of engine has yet been offered. Exhaust noise is a function of the shear velocity gradient between the jet and the atmosphere. Attempts to reduce this usually cause a loss of thrust. In cases where burning of fuel continued in the exhaust jet after leaving the motor, the suppression of this after-burning has produced a noticeable reduction in noise-level. Finally, it was remarked that, in most cases, rocket noise would be only of very short duration before the source would reach a height at which it would not be a serious trouble to ground observers.

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The reliability of rockets, bearing in mind the *V*2 firing failures, was queried; but it was stated that there is no fundamental reason why they should not be perfectly safe, and a number of aircraft applications were quoted in support. The problem of jettisoning assisted take-off or booster rockets in flight without damage to the motors or the populace below was also considered. A suggestion that rocket motors might be used for assisting gliders to extreme heights so that observations of meteorological interest could be made without the corrections necessitated by the transient conditions inherent in the sounding rocket was considered impracticable. An alternative proposal was a balloon with some rocket thrust available for directional control. Among other facts brought out was that the present maximum altitude reached by a rocket is 240 miles.

The chairman summarized the discussion by stating that rocket motors could give advantages wherever simplicity is needed, wherever high energy for short periods is demanded and wherever other power plants could not operate because of lack of air. The meeting then concluded with a short colour film of some rocket motor tests, both in flight and on the ground.

RADIOISOTOPE TECHNIQUES IN INDUSTRY

THE wide use of radioisotopes in medical research has received considerable publicity; but their field of application is by no means limited to medicine, and consultations between nuclear physicists conversant with radioisotopes, and workers in other branches of science and engineering soon reveal numerous important problems that can be tackled successfully by the use of these substances. The international conference on radioisotopes held during July 16–20, 1951, at Oxford, under the auspices of the Atomic Energy Research Establishment, Harwell, is an outstanding example of the value of such consultations. In all, ninety-eight papers were presented, grouped under the main headings of therapy and diagnosis, biochemistry, agriculture, and industrial and allied research applications, and divided into thirty separate sessions. The complete text of the proceedings of this isotopes techniques conference, including the chairmen's addresses, the papers presented and the discussions on them, is to be published in two volumes, the first of which, Vol. 2, covering Sessions 21–30 inclusive and devoted to industrial and allied research applications, has now appeared*.

For the first two Sessions, 21 and 22, dealing with general and metallurgical applications, Dr. B. Goldschmidt, of the Commissariat à l'Énergie Atomique, Paris, was in the chair, and in his opening remarks he expressed gratitude to Great Britain for the liberal policy adopted with regard to the release and distribution of radioisotopes for industrial purposes to foreign countries; in addition, he paid tribute to Dr. H. Seligman, the head of the Isotopes Division at Harwell, for initiating the conference. Of the seven papers presented in the two sessions, the two main ones were by Dr. Seligman on types of applications of radioisotopes, and by Dr. R. W. Cahn on radioisotopes applied to metallurgical research. Dr. Seligman briefly reviewed the various industrial applications, mentioning, in particular, gamma radiography, static eliminators and thickness gauges. He pointed out that tracers have not been used as extensively as they might have been, particularly in problems of process control. Dr. Cahn distinguished between what he called microscopic applications in metallurgy (such as tracer methods for the measurement of self-diffusion in metals, and autoradiography for the determination of tracer elements in alloy sections) and macroscopic applications, in which the normal experimental or industrial procedure is followed, but where, at some stage, tracer elements are introduced.

Session 23 was devoted to gamma radiography, and Mr. W. N. Blacklock, of the Ministry of Supply Aeronautical Inspection Directorate, who presided, referred to the prominent part taken by radiography in non-destructive testing. He stated that the present relatively inexpensive and abundant supply of radioisotopes largely eliminates the need for heavy and costly X-ray equipment for the testing of heavy metal components. Five papers dealt with gamma radiography tests of iron and steel castings and inspections of metal welds. These were preceded by an interesting short paper by Mr. W. S. Eastwood on the handling of radiographic sources, in which he mentioned that, in addition to radium and radon, only three radioisotopes—cobalt-60, tantalum-182 and iridium-192, all metals—are in current use. They are prepared by the Atomic Energy Research Establishment, Harwell, in the form of small cylinders of standard sizes. Shorter-lived isotopes are also obtainable; but these are irradiated to order at Harwell in the size required and to the necessary activity. With regard to transport of the strong sources, it has to be remembered that the limits of radiation at a package surface set by British Railways are even more stringent than those of airline companies, and thus radiographic sources are transported inland by motor-car and are sent to Continental users sometimes by sea.

Mr. B. Schuil, who spoke about radioisotopes in radiography and measurements of wall thickness, made an interesting reference to the psychological effect that radiographic control of welds has on welders who are working far away from their workshops. With radioisotopes, control and test of pipe welds are possible in the field even under the worst conditions, and it was found in Holland that when welders were aware that a radiographic inspection was in force the percentage of bad welds fell from 80 to 20 per cent. Finally, to wind up the Session, Dr. J. S. Blair described some of the safety precautions that are necessary when radioisotopes are handled.

In Session 24, on counting techniques, Dr. S. G. Cohen and Dr. D. Carmi described counters with thin plastic walls for the detection of X-rays, and Mr. H. Herne showed how, by the use of the commonly known, but not commonly employed, property of radioisotopes—namely, the random nature of the radioactive disintegrations themselves—the isotopes could be used in an analogue computer for stochastic problems. Mr. J. L. Putnam then discussed the very important but somewhat thorny problem of the absolute measurement of the activity of radioisotopes. He stressed the need for generally accepted standards of radioactivity and mentioned some of the intercomparison measurements and absolute measurements which are being made in

* Ministry of Supply. Radioisotope Techniques: Proceedings of the Isotope Techniques Conference, Oxford, July 1951, sponsored by the Atomic Energy Research Establishment. Vol. 2: Industrial and Allied Research Applications. Pp. iv+177+33 plates. (London: H.M.S.O., 1952.) 25s. net.

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