Passing on to discuss education, Dame Kathleen thought that scientific training was inadequate if decisions have to be made on inadequate information. A broader education was needed for scientists. Few of them required a specialized education, and in any event they should only specialize after a broad education. The Soviet Government regarded the training of scientists as its key problem. Scientists received high pay and there were no problems of grants for research and scientists had plenty of trained assistants. There was, however, a dearth of the latter in under-developed countries.

Turning to the social responsibility of scientists in a democracy, Dame Kathleen said that it was normal for scientists to sit on the fence because they were not sure of the facts. This, however, plays into the hands of bureaucrats and dictators. One cannot renounce personal responsibility in a democracy, and scientists have the duties of citizens. She thought that the preservation of freedom and sanity owes much to the obstinacy of scientists. She mentioned the need to break down barriers between scientists and the lay public, and referred to the good work in this respect which was done by the British Association, the Royal Society, the Royal Institution and the science correspondents of the Press.

The last speaker was Mr. Anthony Smith, science correspondent of the *Daily Telegraph*, who spoke on the "Deployment of Scientific Personnel", or, as he preferred to put it in common-sense language, "Where do scientists go ?" His main conclusion was that it does not matter where they go so long as there are scientists. He mentioned the useful careers of men who had read scientific subjects and then entered the world of commerce, law or the arts. In general, the information acquired by an undergraduate at the university was not important, but the training of the mind should fit him for a large variety of occupations. Turning to the question of relations between scientists and the public, he said that he was astounded by the ignorance of a large proportion of newspaper readers on scientific and technical matters. Most of them have considerable influence in the country by virtue of their votes, and it is essential that somehow they should have an understanding of the factors which contribute to the power which their country wields. To-day few people understand the places where power lies, and there is considerable pride in not understanding science. What is worse, there is a longing to have nothing to do with science. People with a scientific education should go into all walks of life, and there might then be a hope of resolving some of the problems he had mentioned.

Dr. C. C. Hall (Royal Institute of Chemistry) took over the chair for question time and brought this most interesting evening to a close.

LONG-DISTANCE RADIO PROPAGATION ABOVE 30 MC./S.

On January 28 a symposium was held by the Institution of Electrical Engineers in London, at which there were presented more than twenty papers dealing with recent British contributions to the study of long-distance radio-wave propagation at frequencies above 30 Mc./s. This is a field in which important developments have taken place in two respects in the past few years. It has been found first that it is possible, by the use of high radiated powers and directive transmitting and receiving aerials, to communicate over distances of about 1,000–2,000 km. on frequencies exceeding the maximum usable frequency (M.U.F.) ; and it is known that the transmission occurs via the E-region of the ionosphere by a scatter mode of propagation depending upon fluctuations of the electron density in this region. Ionospheric scatter propagation is of particular interest in the frequency band of approximately 25–70 Mc./s.

The second development is concerned with long-distance propagation through the troposphere. It has been known for some thirty years that the transmission of very short waves is not necessarily limited to horizon ranges, as had originally been anticipated. The first examples of beyond-the-horizon propagation of such waves were clearly connected with the existence of abnormal conditions in the troposphere, conditions now generally described by the term super-refraction. More recently, with the use of greater effective radiated powers, it has been found that at all times the field-strength well beyond the horizon is much greater than would have been expected on the basis of standard atmospheric refraction and diffraction around the Earth. The mechanism responsible for this phenomenon is thus not one due to super-refraction in any of its forms, and it is, in fact, ascribed to some kind of scatter propagation which is dependent upon ever-present fluctuations of the refractive index of the lower atmosphere. Long-distance tropospheric propagation, whether due to abnormal refraction or to scattering, is primarily of interest for frequencies in the range of about 30–30,000 Mc./s. ; though practical applications of scattering are likely to be restricted to frequencies of 300–5,000 Mc./s., and to distances of up to perhaps 1,000 km.

The first session of the symposium, held in the morning, was devoted to a consideration of research on ionospheric scattering. An introductory paper by F. A. Kitchen and G. Millington gave a survey of recent experiments, with special reference to observations in England on transmissions from Gibraltar at frequencies in the band 37–70 Mc./s. There then followed several papers dealing with special aspects of the studies of the Gibraltar transmissions. D. Williams described a detailed analysis of the structure of scatter signals in which measurements were made of the amplitude distribution, lateral correlation, diversity effects and teleprinter error rates ; and it was concluded that a markedly non-Gaussian signal occurs at times. A further analysis of ionospheric scatter signal recordings was presented by G. A. Isted, who discussed diurnal and seasonal effects and the variation of the intensity of the scatter signal with frequency ; he also introduced another paper on the subject of interference, both natural and man-made, and stressed its importance in impairing the usefulness of ionospheric scatter communication circuits in view of the low level of signal which often occurs.

Of the papers concerned with terminal equipment, one, by E. Fitch and R. Ruddleston, dealt with the problem of the correct choice of aerial height, and another, by D. H. Shinn, contained an examination of the kind of radiation patterns required by the aerials for the best use to be made of ionospheric scattering for communication purposes. It has been demonstrated that, if the optimum aerial height, for a given range, is determined on the assumption that the received signal is coherent, then the same height is also correct for the degree of coherence normally encountered with ionospheric scatter signals; furthermore, the effects of the probable variations in the height of the scattering layer and of tropospheric refraction are unimportant for links up to some 1,800 km. in length. As regards the shape of the aerial radiation patterns, there appears to be not much advantage in reducing the horizontal half-power beam-width to less than 30°; and the vertical directivities should be such that the lowest lobes from each terminal overlap well. A paper by P. H. Cutler and D. Williams described a scatter signal analyser capable of being used with rapidly fading signals.

There has been much argument for some time concerning the relative importance of contributions to the residual background signal of scattering due to meteoric ionization and fluctuations of electron density arising from turbulence in the lower E-region; and papers by R. W. Meadows and W. C. Bain brought fresh light to bear on this problem. These papers described respectively directional measurements, using the Gibraltar transmissions, on the signal bursts generally considered to be caused by the larger meteors and on the background signal. As a consequence of the scattering process, the radiation arriving at the receiving point is spread over a small range of angles, and it has been found that the mean bearing of the energy distribution of the background signal varies with the time of day in much the same manner as does the direction of arrival of signals from the larger meteors. This provides a clear indication that small meteors contribute considerably to the background signal for much of the time; though, since the mean bearing of this signal relative to the great circle path between the transmitter and the receiver is zero in the middle of the day, a propagation mechanism depending upon the total electron density of the E-region and turbulence is certainly not excluded at such times.

Whereas most workers in this field have considered that the short bursts of enhanced signal are due to reflexions from the ionized trails of relatively large meteors, another view has been expressed by G. A. Isted, namely, that many of these bursts are caused by reflexions from transient patches of ionization in the E-region produced by upward electrical discharges from thunder clouds. An investigation described by G. S. Kent, in which observations were made on the short bursts of signal received at Cambridge from the television transmitter at Kirk o' Shotts, over a path of 480 km., has now provided strong evidence that the majority at least of the bursts must be attributed to reflexions from meteor trails.

The final paper in the first session, presented by P. J. Brice, was concerned with the amplitude of very-high-frequency signals reflected from the sporadic-E layer in north-west Europe. The importance of this matter lies in the fact that scatter communication circuits normally operate with a relatively weak signal, and, if the frequency is appreciably less than 50 Mc./s., there are often times when sporadic-E ionization will support transmission by a regularly-reflected propagation mode, thus leading to the possibility of serious interference between common-frequency transmissions—an eventuality which it may not always be possible to prevent even by the use of highly directive aerials. Under such conditions the likelihood of mutual interference is not limited to ionospheric scatter links; other services sharing the same frequency-band, for example, television, may also be involved.

Among the topics most prominent in the discussion at the end of the first session were the nature of the scattering mechanism responsible for the background signal, the variation of the scattered power with frequency, the cause of the larger bursts of signal and the problem of interference. On this last point, in addition to the troubles caused by sporadic-E ionization, attention was directed to the difficulties due to the delayed signals which can arise at times when the density of ionization in the $F2$ region is high; and mention was made of round-the-world propagation observed with transmissions from Gibraltar on 37 Mc./s. Some speakers also discussed the practical applications of ionospheric scattering to communication, and the view was expressed that such applications, at any rate in the civil communication field, seem to be few since the transmission capacity is small—limited, in fact, to quite a few telegraph channels—and the quality of telephony is poor. It would appear that the main applications are in the field of military and strategic communications systems.

The afternoon session began with a historical note by G. A. Isted describing pioneer work carried out by G. Marconi during the years 1928–36 on propagation through the troposphere at metre and decimetre wave-lengths. These experiments were made in the Mediterranean area, a region well known to experience widespread and frequent super-refraction; and it seems likely that the long-distance transmissions observed by Marconi were mainly due to this cause, and not to tropospheric scattering as it is now generally understood. The remainder of the papers at this session were concerned with various aspects of the tropospheric propagation of metre waves.

An important feature of long-distance metre-wave propagation is the bearing it has on the problem of interference between common and adjacent channel broadcasting transmitters as used, for example, for television. In this case the interest is in the highest fields, which are reached for only relatively small percentages of the time, and these—at the distances of importance—may be said in general to be due to one or other of the forms of super-refraction, including well-defined elevated reflecting layers. A paper presented by R. A. Rowden, L. F. Tagholm and J. W. Stark gave a survey of investigations carried out over a number of years to provide data from which the minimum spacing of common and adjacent channel very-high-frequency stations may be determined, after the tolerable degree of mutual interference has been defined. Similar work was also described by J. K. S. Jowett: in this paper consideration was given in addition to the effect of path profile on the median field-strength levels and on the range of fading, and curves of metre-wave field strengths exceeded for various percentages of time between 1 and 99 at distances up to 600 km. were included.

Two other papers were read at the second session. These described investigations aimed at determining the mechanism of propagation responsible for the permanent residual fields at metre wave-lengths far beyond the horizon. B. J. Starkey, W. R. Turner, S. R. Badcoe and G. F. Kitchen have made field-strength measurements in this region on a frequency of 90 Mc./s. in an aircraft flying at a height of some 3,000 m. They maintain that their results—and other experimental results, too—can be explained more readily on the assumption that the mechanism of propagation over such distances is one of reflexions from discrete discontinuity layers in the atmosphere up to the height of the tropopause rather than one of scattering depending upon turbulent fluctuations of refractive index. On the other hand, F. A. Kitchen, E. G. Richards and I. J. Richmond, in discussing results they obtained in experiments on transmissions at 86 and 203 Mc./s. out to ranges of 700 km. over the sea, directed attention to the complexity of metre-wave propagation. They conclude from this work that it is not yet possible to determine whether the residual signal is due entirely to scattering caused by atmospheric turbulence, or to the addition of a small number of coherent signal components of random relative phases, such as would be produced by discrete layers.

In introducing the evening session of the symposium, at which a further six papers on tropospheric propagation were presented, mainly concerned with the long-distance propagation of centimetre waves, J. A. Saxton stressed the point that scattering, in the broadest sense, is fundamental to all propagation through media in which changes of refractive index take place, whether in the form of abrupt discontinuities or as variations in gradient. If a number of scattering centres are involved the signal as observed at a given receiving point may be either coherent at one extreme, or incoherent at the other, depending upon the size of the centres in relation to the wave-length and their spatial configuration. In the strict sense the theory involving the hypothesis of multiple partial reflexions at layer-type irregularities may be regarded as a scatter theory just as much as the theory based on turbulent fluctuations of refractive index, whether isotropic or anisotropic.

B. C. Angell, J. B. L. Foot, W. J. Lucas and G. T. Thompson gave an account of experimental studies of propagation over a path of 280 km. at a frequency of 3,480 Mc./s. The manner in which the characteristics of the signal had varied during a year's observations was described, and an attempt made to associate variations in signal-strength with general trends in the weather. It appeared that the signal tended to be enhanced in foggy weather but depressed during periods of rain. In the presence of fronts across the path the signal was usually higher than average for the time of the year. Some measurements were also made of aerial gain degradation with scatter signals.

The paper presented by G. C. Rider dealt with transmissions on a frequency of 858 Mc./s. over paths of 160 and 320 km. Height-gain and space-diversity investigations were described, and also a comparison of the signals received at four sites of very different aspects within the same locality. This work has shown that the dominant siting requirement for a tropospheric scatter terminal is a low skyline; and it appears that an elevated site offers no advantage other than a greater likelihood of satisfying this condition.

Long-range propagation at wave-lengths of 3 and 10 cm. formed the subject of two papers by W. R. R. Joy, in both cases the transmission paths studied being entirely over sea. An important feature of this work is the discovery that, although the observed signal attenuation rate with distance at 3 cm. wave-length is similar to that expected for a scattered field, the average level of the signal is some 10–15 db. lower than that which would be predicted from current scatter theories based on turbulence. Evidence was also produced that the existence of extensive marked anticyclonic conditions results in relatively low scatter fields. The paper on propagation at 10 cm. wave-length was of particular interest in that it amplified previous accounts of the pioneer work in this field of the late E. C. S. Megaw.

The two remaining papers of the final session were concerned with the theory of tropospheric scatter propagation. M. A. Johnson gave a review of the present state of this theory and its application to experiment: while he made mention of other mechanisms and the circumstances under which they may be operative, he stressed mainly the turbulence hypothesis and proposed a formulation for a comprehensive scattering theory based on this concept. A paper by E. G. Richards was devoted to an estimation of transmission loss in the trans-horizon region, which was based on an expression for the scattering cross-section derived by G. K. Batchelor. It was suggested that experimental results at frequencies of 86, 3,000 and 10,000 Mc./s. indicate that mean-square variations of the refractive index of the atmosphere may be independent of height up to about 650 metres, and that above this they may then vary with the inverse square of the height.

It was not surprising that arguments for and against the turbulence and layer theories figured prominently in the discussions after both of the sessions on tropospheric propagation; and among the points emphasized was the difficulty of distinguishing between the applicability of the two theories purely from the characteristics of the signals received far beyond the horizon. It is obvious that more detailed knowledge of refractive index variations in the troposphere must be obtained by direct observation before a better understanding of the propagation mechanism can be reached. There was considerable discussion also concerning the usefulness of tropospheric scattering for practical communication purposes. On one hand, it was maintained that, for communication within any one country, scatter links are unlikely to be able to compete with conventional radio relay systems in channel-carrying capacity; while other speakers said that scatter circuits were already in use in some countries, though it appeared that they were primarily for military purposes and carried only a relatively small number of communication channels. On the issue of practical applications, several speakers directed attention to the difficulties in communication which may be caused by reflexions from aircraft flying in or near to the aerial beams.

The day's proceedings were summed up by R. L. Smith-Rose, who emphasized that, while experimental investigations of propagation served well to assist the engineer to plan practical communication systems in the areas where the research had been carried out, it was not always easy to use the same data for engineering purposes in different geographical regions. It is clearly not practicable always to make pilot investigations before every engineering application, and the aim must therefore be to achieve the best fundamental understanding of the propagation phenomena from those experiments which are made, and thus so far as possible to ease the task of extrapolation.

The papers presented at the symposium and the discussion are to be published in a special issue of the *Proceedings of the Institution of Electrical Engineers* (**105**, B; 1958). J. A. SAXTON

MACHINES AS MODELS IN BIOLOGICAL EXPERIMENTS

IN May 1957 the Laboratory Animals Bureau arranged a symposium on humane technique in the laboratory. In a paper now available separately*, Dr. W. Grey Walter showed how machines could be used as models in biological experiments.

Walter first showed how the classical method of demonstrating physiological laws and principles are derived from those worked out for the physical sciences. The essence of these methods is the isolation of a single variable and the observation of this variable in various experimental conditions. In order to achieve this situation with living creatures, some sort of preparation is required. This involves dissection, mutilation or anæsthesia, often all three, and in this way a whole animal can be transformed into a working model of some particular function. For example, the Sherringtonian approach to reflex action of the spinal cord depended upon decerebration of a complex animal such as a cat and the restriction of attention to one, or occasionally two, reflex circuits. The results obtained in this way form the basis for much thinking about the nervous system, but it is now realized that the general picture of central nervous action derived from these studies of isolation, though admirably clear, lacks perspective and detail when related to animal behaviour.

If it is accepted that animal preparations are essentially models of working hypotheses, it follows that such hypotheses may as legitimately be embodied in machines as in mutilated animals. The use of machines may even present certain advantages: the components of a mechanical system can be accurately enumerated and specified, and the principle of parsimony, so important to fertile thinking, can be adhered to without inconvenience. For example, it is difficult to prove that a spinal cord preparation contains only those components necessary for the reflex action under investigation, but it is quite simple to demonstrate that a reflexive machine contains only essential elements.

The principles to be observed in the construction and use of animal models may be summarized as follows: (1) the system to be modelled should contain more than one variable; (2) the model must contain no redundant components, in order to maintain parsimony; (3) the behaviour of the model should exhibit more features of behaviour than were originally planned or foreseen. Applying these principles, a number of models of animal function and behaviour have been constructed and are in frequent use both for the design of fresh experiments and for teaching purposes. These are:

(1) NERISSA—A Nerve Excitation, Inhibition and Synaptic Analogue. This demonstrates particularly the relationship between the various parameters of nervous action such as finite propagation-rate, excitation threshold, all-or-none conduction, strength-duration curves of excitability, refractory periods, Wedensky inhibition, synaptic facilitation and inhibition, inhibitory escape and rebound, transmission or information by pulse-interval modulation, and anomalies of 'inhibition of inhibition' and 'inhibition of inhibition of inhibition' during rhythmic as opposed to sustained stimulation.

(2) IRMA—Innate Releaser Mechanism Analogue, demonstrating the exclusive action of an excitatory state maintained by a cascade of neuronic elements and the effect upon this condition of variations in excitatory level.

(3) ELMER—Electro-Mechanical Robot, containing two elements equivalent to synaptic junctions, with two receptors and two effectors, to demonstrate the complexity of behaviour arising from the interaction of two reflex circuits coupled to a complex environment. The behaviour patterns observable include goal seeking, obstacle avoidance, discrimination between immediate and remote goals, choice between two equivalent goals, tendency to seek optima rather than maxima and elements of self- and social-classification.

(4) CORA—A Conditioned Reflex Analogue, demonstrating the action of selective and storage mechanisms in the establishment of a contingency association between signals on a basis of statistical significance.

Such models provide both student and experimenter with an opportunity to classify observations of real animals and to design crucial experiments.

* Laboratory Animals Bureau. Collected Papers, Vol. 6, 1957. Pp. 81. (London: Laboratory Animals Bureau, M.R.C. Laboratories, 1957.) 10*s*.

EDIBLE LIZARDS

ALLAN R. HOLMBERG, of the Department of Sociology and Anthropology of Cornell University, has described how natives of the north coast of Peru capture small lizards called cañanes partly for their nutritive but especially for their curative and aphrodisiacal properties*.

The lizards, *Dicrodon hoombergi*, are found in the Chao Valley and dig their holes in the desert sand around clusters of the guarango tree (*Prosopis juliflora*)—called algarrobo in Viru—the fruits of which constitute their sole means of subsistence. They are not gregarious, but hundreds of pairs of them make their homes around nourishing stands of algarrobo. The full-grown males are bluish in

* Fieldiana Anthropology, **36**, No. 9. (Chicago Natural History Museum, 1957.) 75 cents.