section entitled "Some Aspects of Medical Research", which is also published separately under the title *Current Medical Research* (H.M.S.O. 5*s.* 6*d.*). This particular section is this year made up of eleven articles, the range and content of which can be only briefly indicated here.

The first article, entitled "The Genetic Code", includes in its scope the work on this subject for which four members of the Council's staff, Dr. M. F. Perutz, Dr. J. C. Kendrew, Dr. F. H. C. Crick and Prof. M. H. F. Wilkins, were, together with Prof. J. D. Watson, awarded Nobel Prizes for 1962 (see *Nature*, **196**, 319, 519; 1962). The second article, entitled "Chemical Mutagens", discusses chemical substances which may produce mutations and their mode of action and their specificity. The third article is on cell transformation by tumour viruses, with special reference to the polyoma virus which is being studied under the direction of Prof. M. G. P. Stoker in the Council's Experimental Virus Research Laboratory at the University of Glasgow. Next comes an article on "Cancer in the Tropics", and this is followed by a discussion of "River Blindness" caused by the parasitic nematode worm, *Onchocerca volvulus*, in tropical Africa, an article on the demyelinating diseases, and another on the central nervous control of the endocrine glands and the influences exerted by hormones on the central nervous system. Then follows a valuable article on the relationship between mental retardation and chemical abnormalities in the body. Two articles discuss the metabolism of plasma protein and the biosynthesis of sterols, and finally there is an article on biological engineering, a term of which the author of the article apparently does not fully approve. It refers to the various ways in which engineering techniques are nowadays applied to medicine and the biological sciences, and includes such devices as radio-pills and other 'miniaturized' instruments, the whole-body plethysmograph, the conicycle, which measures the content of respirable dust and other aerosols in the air, the breath-alcohol detector, and the remarkable prostheses which are now available as artificial limbs and other artificial aids, such as plastic heart valves, artificial kidneys, heart–lung machines, and aids for the blind and deaf. The value of this whole section is increased by photographs of a molecular model of deoxyribonucleic acid, of polyoma virus particles and cells transformed by this virus, of a radio-pill and a prosthesis for the arm.

The rest of the report, apart from the details it gives of the finance and administration of the Council's work, pays a well-deserved tribute to the work of Sir Charles Harington, who retired on July 31, 1962, from his post as director of the National Institute for Medical Research, after serving in that capacity for twenty years (see *Nature*, **195**, 228; 1962). During this period the Institute's scientific work was greatly extended, the number of its staff increased from 35 to 125 and the Council enjoyed the great benefit of Sir Charles's advice on both research and policy. Everyone interested in the Council's work will be glad to know that Sir Charles will still be available as consultant adviser to the Council's secretary.

In another section on the Council's Advisory Boards it is explained that knowledge and research have become so complex that the Council, which has always been averse to "any arrangement which implies that one single body should bestride the field of clinical or any other type of research", has devised a system of Boards which are, in effect, sub-councils. The first of these, the Clinical Research Board, was appointed in 1953. Afterwards, a Tropical Medicine Research Board was established, and in 1962 a Biological Research Awards Committee was created. By means of these Advisory Boards, which enable the Council to benefit from the advice of many experienced specialists, the Council is able to decentralize effectively the ever-increasing complexity of its work.

No one can doubt, after reading these well-written and closely reasoned pages, that here we have an organization of scientists working together and directing their own work free from Governmental control, which ensures, as no other kind of organization can do, that all the sciences, whether they are primarily medical or not, are effectively integrated together for the benefit of man and other animals. Long may it continue to produce the remarkable results that, year by year, are recorded in its reports.

G. LAPAGE

THE LIQUID STATE

THE Institute of Physics and the Physical Society held a conference on "The Liquid State" at the Imperial College of Science and Technology, London, during September 9–13.

The study of the structure and properties of liquids, like many branches of classical physics, is a subject in which real progress is now slow and irregular. There was a burst of activity after the Second World War in which the implications of the integral equations for the distribution functions of Yvon, Kirkwood, Born and Green were studied and in which the limitations of Kirkwood's 'superposition' approximation came to be appreciated. This was followed by an advance in 'experiment' when, in the 1950's, computers were used to calculate the pressure and rate of approach to equilibrium of systems of simple molecules by, for example, the solution of the equations of motion of a small representative assembly. This work gave an impetus to the study of simple models, and the past two years have seen the development of at least two new sets of integral equations and for one of them, the equations of Percus and Yevick, their exact solution in closed form for a system of hard spheres. Meanwhile, there have been substantial advances in the theory of transport properties, although there is still argument about the legitimacy of some of the steps that are necessary to relate these properties to the intermolecular forces. These developments were reflected in many of the 68 papers presented at this conference, and a selection of these are described briefly in this report.

The first day was a discussion of methods of determining structure. In the opening review, Dr. P. A. Egelstaff (Atomic Energy Research Establishment, Harwell) emphasized the power of the method of neutron-scattering. Thermal neutrons can show shifts of both wave-vector and energy when scattered by liquids and so can be used to supplement the information from X-ray diffraction and light-scattering experiments. Dr. S. J. Cocking (Atomic Energy Research Establishment, Harwell) illustrated this in outlining his investigations of the motion of atoms in molten lead. Dr. J. A. Elliot, Prof. H. E. Hall and Dr. J. M. Williams (University of Manchester) described the use of the Mössbauer effect for the study of diffusion in glycerol, and Dr. J. G. Powles (Queen Mary College, London) has used nuclear magnetic resonance to examine rotational relaxation.

Prof. J. D. Bernal and Miss S. V. King (Birkbeck College, London) reported further experimental studies of random close-packed arrays of steel balls, and suggested that such arrays often showed long ordered lines of particles. This point was taken up the next day when Dr. B. J. Alder (Livermore, California) discussed his computer calculations on the transition from ordered to fluid phase in a two-dimensional array of hard disks. He suggested that melting might start when lines of molecules could slide past each other. Hitherto Bernal's studies have had little contact with more conventional theories of liquids, but an attempt to bridge this gap was made by Prof. R. Fürth (Birkbeck College, London).

At the end of the first day, Prof. D. H. Everett (University of Bristol) showed a film of the motion-in-a-plane of an array of cork balls agitated by a stream of air. Again, co-operative motion in lines and rings could be seen.

The longest session of the conference was on the equilibrium properties of pure and mixed liquids and occupied the second and third days. It was introduced by Prof. J. de Boer (University of Amsterdam), who set out the present position both of lattice theories and of calculations of the pair distribution function. In the latter he outlined the 'hyper-netted chain' approximation on which he and other groups have been working recently. In the papers that followed, only Dr. J. A. Barker (Commonwealth Scientific and Industrial Research Organization, Melbourne) used the lattice model for liquids, in a version which he calls the 'tunnel' model. He uses the fact that combinatorial problems in one dimension present little difficulty to choose a model in which the molecules have complete freedom of motion in one direction only. His comparisons of theory and experiment were outstandingly successful.

The mathematical properties of the distribution function and some inequalities that they must satisfy were set out by Dr. J. L. Lebowitz (Yeshiva University, New York), Dr. J. K. Percus (University of New York) and Dr. O. Penrose (Imperial College of Science and Technology). The first author also presented his solution of the Percus–Yevick equations for mixtures of hard spheres. Prof. J. S. Rowlinson (Imperial College of Science and Technology) has obtained numerical results for this model and showed that the excess Gibbs energy is always negative and hence that phase separation cannot occur. This conclusion was consistent with the calculations of Mr. M. Rigby and Dr. E. B. Smith (University of Oxford) on the fourth virial coefficients of mixtures of hard spheres. The extensive cancellation of cluster integrals that characterizes both the hyper-netted chain and the Percus–Yevick approximations was, to a degree, justified by the calculations of Dr. H. N. V. Temperley (Atomic Weapons Research Establishment, Aldermaston) for molecules with Gaussian repulsions. Dr. J. Walkley (Imperial College of Science and Technology) discussed the quantal treatment of a cell model of an assembly of hard spheres.

Papers on the two-dimensional lattice gas were presented by Dr. D. M. Burley (University of Sheffield) and Dr. M. E. Fisher, Dr. D. S. Gaunt and Dr. J. Stephenson (King's College, London). In some cases such a fluid appears to show a second-order transition to an ordered state.

Three of the experimental papers of this section aroused much interest. Mr. A. T. J. Hayward (National Engineering Laboratory, Glasgow) has started measurements of the equation of state of liquids under tension and is repeating the more common measurements of the maximum tensions that liquid can bear. Dr. G. Casanova and Dr. A. Levi (University of Genoa) showed that their measurements of the isotopic separation factor at a liquid-vapour equilibrium can be used to measure $\nabla^2 U$, where U is the configuration energy of the liquid, and it was suggested in discussion that their measurements provided also a means of testing intermolecular potentials without any assumptions about the structure of the liquid. Dr J. J. M. Beenakker, Dr. M. Knoester and Dr. K. W. Taconis (University of Leyden) have developed a flow calorimeter for the direct measurement of the heat of mixing of compressed gases, a quantity that has hitherto been obtained only indirectly.

The properties of mixtures of linear hydrocarbons are of interest because they are regular functions of the chain-lengths. Prof. D. H. Everett (University of Bristol) and Dr. Th. Holleman and Dr. J. Hijmans (Royal Dutch Shell, Amsterdam) extended correlations of theory and experiment to high temperatures where the heats of mixing are negative. Dr. I. A. McClure and Dr. F. L. Swinton (Royal College of Science, Glasgow) reported volumes of mixing from some well-chosen systems in which the size ratios of the molecular pairs were close to 2 : 1.

Transport properties were discussed on the fourth day. The introductory paper was by Prof. I. Prigogine and Dr. P. Résibois (University of Brussels), who summarized the statistical mechanics of irreversible processes and, in particular, its application to ionized systems. They emphasized the difficulty of treating thermal diffusion in such systems. This paper was followed by a substantial contribution from Prof. R. Eisenschitz and his colleagues (Queen Mary College, London) in which they tested both the theories of Kirkwood (that is, the introduction of a 'friction constant') and of M. S. Green. The former was confirmed by calculations on a simple harmonic model of a crystal with a temperature gradient. Rice and Allnatt have suggested that the fundamental dynamical event in a liquid can be represented as a 'hard-core' repulsion of a pair of molecules, followed by their Brownian motion in the field of their neighbours. Dr. S. A. Rice and Dr. E. G. Wilson (University of Chicago) tested this assumption by comparing its predictions with four of the transport coefficients of the rare gases. Dr. E. McLaughlin (Imperial College of Science and Technology) emphasized the importance of the coefficient of thermal expansion of a liquid in determining the temperature coefficient of the thermal conductivity. He illustrated this by calculations on simple models.

Two experimental papers were on the subject of nucleation. Dr. L. O. Roellig (Wayne University, Detroit) showed that the probability of a particle of ionizing radiation destroying a super-heated state can be related to the amount of energy it can transfer to a small volume of liquid. Dr. E. R. Buckle (Imperial College of Science and Technology) showed, by means of a cloud-chamber, that the freezing of super-cooled ionic melts is critically dependent on temperature, a dependence which he ascribed to the threshold effect of spontaneous nucleation. The final paper of this session was by Dr. T. A. Litovitz (Catholic University, Washington), who compared the dielectric (or rotational) time of relaxation with the ultrasonic (or structural) time. He showed that the former was the longer and that both changed from a single time to a distribution of times in liquids in which the viscosity did not show a simple exponential dependence on temperature.

A widespread dissatisfaction with the present theoretical basis of many of the approximations that are used in discussing the transport properties of liquids led to an unscheduled discussion of fundamentals on Friday afternoon. The principal speakers were Dr. Résibois, Prof. Eisenschitz and Dr. Lebowitz.

Liquid metals were discussed on the last day, and, of necessity, most of the papers in this part of the conference were concerned with specifically electronic (and hence quantal) effects. Dr. S. F. Edwards (University of Manchester) reviewed the present state of the theory of electrons in liquid metals. He applied methods adapted from field theory to the calculations of momentum and energy distributions in disordered potentials, and demonstrated that, while at present there can be no detailed comparison of theory with experiment, this goal is coming within reach. Experimental work on soft X-ray spectroscopy, transport and optical properties, positron annihilation, and electron spin resonance all have a part to play. An alternative route to some of Edwards's conclusions was provided by Dr. D. Libermann (University of California).

Two of the papers of this section sought to extend to liquid metals concepts which have been useful in non-electrolytes. Dr. W. B. Mott (Atomic Energy Research Establishment, Harwell) examined Hildebrand's rule for the calculation of mutual solubility of two liquids. He was able to modify it to produce qualitative agreement for most metallic systems. More ambitiously, Dr. E. Morris (Atomic Weapons Research Establishment, Aldermaston) attempted the calculation of the critical properties of metals from the principle of corresponding states. The agreement with experiment for mercury was only fair.

Three experimental papers from the University of Birmingham by Dr. J. R. Wilson, Dr. G. H. Laurie and Dr. J. N. Pratt revealed the anomalous dependence on temperature of the resistivity and partial molar properties of the systems Hg + Tl, Mg + Pb, and Sn + Pd + Ag. These were ascribed to variations of the degree of local order with temperature, and to the formation of intermetallic compounds. Dr. R. V. Hodgson (University of Birmingham) measured the resistivity of five binary semiconductors and showed the change towards metallic properties at high temperatures. Finally, Dr. D. T. J. Hurle, Dr. J. B. Mullin and Dr. E. R. Pike (Radar Research Establishment, Malvern) described the growth of single crystals of semiconductors by a zone-melting process in which a d.c. electric current passed along the bar.

The chairman of the Organizing Committee of the conference was Dr. H. N. V. Temperley. The proceedings are not to be published as a separate volume.

J. S. Rowlinson
E. R. Buckle

OBSERVED TRIPLICATION OF *PKP*

By Dr. R. D. ADAMS and M. J. RANDALL

Seismological Observatory, Department of Scientific and Industrial Research, Wellington, New Zealand

Details of the variation of seismic velocity near the boundary of the inner core have always been uncertain, and so, correspondingly, has the theoretical travel-time curve of *PKP* in the distance range immediately beyond 143°. On the model of Jeffreys and Bullen[1], a short branch extends beneath the PKP_2 curve from the cusp at 143° to 147°. The tables of Gutenberg and Richter[2] incorporate a similar branch extending to 169°, with arrival times between those of PKP_1 and PKP_2 for distances greater than 150°. No observations have been reported in confirmation of either of these branches.

Bolt[3] has recently reconsidered the velocity variation near the boundary of the inner core, with a view to accounting for Gutenberg's observations of early arrivals of *PKP* at epicentral distances in the range $125° < \Delta < 140°$ (ref. 4). His preferred solution shows a branch of the *PKP* travel-time curve, labelled *GH*, which not only includes these early arrivals but also continues to a cusp *H* at $\Delta = 156{\cdot}5°$; for distances greater than about 146° the travel times are between PKP_1 and PKP_2. We have recently found arrivals which confirm the latter part of the *GH* branch. These arrivals, which for convenience we have called PKP_3, have been taken from the seismological bulletins of stations which lie in the distance range $148° < \Delta < 156°$ from certain New Zealand earthquakes. New Zealand stations have also recorded the triplication of *PKP* from earthquakes at appropriate distances. On these records PKP_3 is a stronger arrival than PKP_1, being comparable with PKP_2. Three branches of *PKP* have also been reported by Hai[5] from deep-focus earthquakes near Fiji.

Table 1. Earthquakes used

No. of earthquake	Date	Time h	m	s	Epicentre Lat. S.	Long. E.	Depth (km)
1	Mar. 23, 1960	01	32	19·8 ±0·4	39° 03′ ±4′	174° 52′ ±8′	607 ±4
2	Mar. 23, 1960	01	36	55·7 ±0·9	39° 06′ ±7′	175° 04′ ±12′	612 ±9
3	Mar. 27, 1960	23	28	27·1 ±0·6	39° 03′ ±6′	174° 55′ ±11′	228 ±6
4	May 10, 1962	00	27	12·0 ±0·5	41° 39′ ±2′	171° 19′ ±5′	12
5	May 17, 1962	02	19	52·2 ±0·3	41° 48′ ±1′	171° 18′ ±3′	12

Table 2 Geocentric Distances to Stations recording PKP_3 (Degrees)

Station	Earthquake 1	2	3	4	5
Tromsoe				148·8	148·9
Helwan			148·8		
Kajaani				149·3	149·4
Kiruna				149·4	
Poulkovo			149·6		
Simferapol			150·5		
Istanbul				151·9	
Umea				152·2	152·3
Helsinki	151·5	151·5		152·3	152·4
Nurmijarvi		151·5		152·3	152·4
Reykjavik			153·0		
Skalstugan	153·2		153·3		155·0
Sida			154·0		
Uppsala			154·7	155·6	

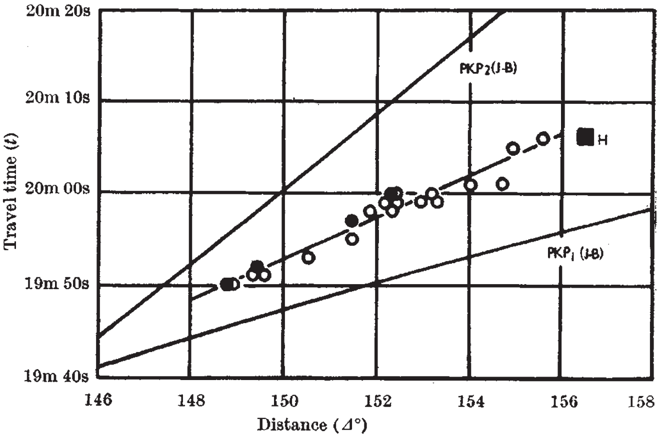

Fig. 1. Observed travel times of PKP_3. Solid circles represent two arrivals. The position of Bolt's cusp *H* is shown

Additions to the New Zealand network of seismograph stations have enabled the foci and origin times of recent New Zealand earthquakes to be determined with improved accuracy. PKP_3 arrivals have been identified from five New Zealand earthquakes for which we have obtained foci and origin times by least squares from numerous observations. Table 1 lists these earthquakes and gives the standard errors of the solutions. Table 2 gives the epicentral distances to the stations at which PKP_3 has been found; the increased number of stations now operating in Scandinavia provides more observations of *PKP* in the relevant distance range. Arrivals reported from stations at distances less than 148° have been discarded because one cannot be certain which *PKP* branch they belong to.

Fig. 1 shows the travel times of the PKP_3 arrivals, adjusted so as to correspond to a surface focus. The Jeffreys–Bullen travel-time curves for PKP_1 and PKP_2 are also shown; many arrivals corresponding to these branches were also reported for the same earthquakes. All but three of the PKP_3 arrivals have been reported as impulsive, and the standard errors of the epicentral distances and origin times are such that there seems no possibility of these arrivals being either PKP_1 or PKP_2. At some stations there are arrivals corresponding to each of the three branches; for example, Skalstugan reports three impulsive arrivals from earthquake 3, with travel times of 19 min 53 sec, 19 min 59 sec and 20 min 13 sec. Uppsala also reports triplication of *PKP* for the same earthquake. The largest distance at which we have identified PKP_3 is 155·6°; the branch does not appear to extend as far as 157·5°, where some stations have reported PKP_1 and PKP_2, but not PKP_3. The position of Bolt's