a rock garden more and more popular in these days.

Attached to this garden is a Herbarium where are kept in classified order, in its three spacious wings, dried specimens of plants occurring in different parts of the globe (Fig. 5),—More than

Fig. 5.
The Herbarium, Royal Botanic Garden, Kew.

4 million sheets represent the whole plant kingdom. Specimens for determination and numerous enquiries pour into the Herbarium and form the major part of the work of the Systematists. The naming of plants grown in the Garden, their distribution, economic uses, etc., are all dealt with at this sanctuary of Systematic Botany where flock in specialists from all over the world to solve their doubts with the help of the type sheets and the literature—the richest in the world, available here. Anatomical investigations are also carried on in the Jodrell Laboratory by a small band of workers.

The Head of this great British Organisation is Sir Arthur Hill, K.C.M.G., M.A., SC.D., D.SC., F.R.S., F.L.S., F.R.N.Z., V.M.H., of world-wide reputation. To him I offer my grateful thanks for giving me every possible facility to study various problems of gardening, to carry on my researches in the Herbarium, and for his permission to publish some of the photographs of the Garden.

The Herbarium,
Royal Botanic Garden,
Kew. London,
August 16, 1937.

The Liquid State of Matter.

THE Sixty-fifth General Discussions of the Faraday Society centred round not any special recent discovery, but about a most common and general phenomenon, *viz.*, the nature of the liquid state. As is well known the striking aspect of this condensed state of matter is its obvious isotropic character and the consequent very suggestive close resemblance to a gas. This suggestion has indeed been so strong, and has been so much supported by the Van der Waals theory and by the initial successes of the osmotic theory of solutions, that until recently, the significance of other equally important characters of the liquid state was overlooked. For instance the molecules in the liquid state are usually just only ten per cent. less densely packed than in a crystalline solid, *i.e.*, with but a three per cent. increase in the order of intermolecular distance. One should expect from this, that the forces between the molecules must be nearly of the same order as in the crystalline state and should therefore lead to some structural arrangement with more or less permanent neighbours, while at the same time this arrangement cannot possess the regularity which characterises the crystalline

state. Indeed the modern concept of a liquid is closely related to that of crystals, and various physical and mathematical methods have been brought to bear on this problem to determine what one may call " the dynamic structure of liquids ", and correlate the same with the observed physical properties.

The group of papers presented in the symposium have been broadly divided into two sections for convenience, the first dealing with the structure and molecular forces in the pure liquids and the second with those in solutions. The subject-matter of all the papers and discussions has been cogently summarised by Dr. Butler in the compass of about three and a half pages towards the close of the book, and provides a broad survey of the whole proceedings.

In the two opening papers of the first section, one by Prof. London on the nature of the forces between atoms and molecules in liquids and the other by Dr. Bernal on a geometrical theory of the liquid state, the mathematical aspects of the liquid condition are discussed in a very lucid manner. Dr. Bernal has attempted to define the structure of a liquid in terms of a small number of variables, his formula for the distribution function containing but three, *viz.*, r the mean distance of closest approach of molecules, N the number of close neighbours of any molecule, and λ the irregularity of their distribution. With changes in temperature and pressure the equilibrium values of these variables and therefore the configuration, change, thus accounting for a greater specific heat and compressibility in the liquid state.

Among the other interesting papers in this section, attention may be drawn to the discussions by Simon and Frenkel as to how far the transition from the crystal to the liquid state should be continuous or abrupt and the attempts by Barthalome and Eucken and by Brillouin to correlate the observed specific heat of liquids with the possible molecular movements under thermal agitation. Brillouin suggests that the transverse vibrations of the solid are gradually replaced with rising temperature by rotations in the liquid, a limiting value [2 R] for the specific heat being regularly reached at the critical point. This smoothing out of finite crystal characters on passing into the liquid state leads frequently to great similarities particularly between the simple liquids in some of their physical properties. Frequently, with a suitable reduced temperature scale properties such as compressibility or functions of them for a large number of liquids fall on the same curve.

Recently, apart from X-rays, the experimental techniques of Raman spectra, infra-red spectra, and ultrasonics have also been successfully employed in throwing some light on the structure of liquids. Thus, Magat, as also Gross and Vuks observed that certain Raman lines with low frequency shifts have their origin not in the usual intra-molecular frequencies, but are caused by the inter-molecular vibrations in the liquid or crystal structures. Magat concludes from a discussion of the origin, and character of these lines, that the structural arrangement in the liquid state is more of a quasi-crystalline nature exhibiting a regularity in the mutual orientations and distances of the neighbouring molecules only, but rapidly decreasing with increasing distance. The alternative hypothesis of micro-crystalline aggregates floating in a random assembly of molecules is not supported by Raman spectra observations. In the methods of ultrasonics, opportunities are provided for the study of such characteristics as viscosity and compressibility for very quick changes of state of frequencies of the order of 10^7 per second. No decisive conclusions can however yet be drawn from these observations.

The second part of the discussions opens with an excellent introductory paper on the inter-molecular forces in solutions by Hildebrand. The problem here is even more complex, since the inter-molecular potential and structure are not easily separable factors and the differing kinds of molecules in solution offer different centres of association or clustering. This clustering may be caused by a mere difference in non-polar field strengths, by dipole association, by hydrogen bond formation, etc., consequently, the behaviour of solutions, as a whole, cannot be generalised under one head, and the objective, *viz.*, to account for and predict the deviations from an ideal mixture law for any given molecular mixture cannot be realised. It is found difficult to take completely into account the different possible variables. Thus Guggenheim has attempted by statistical methods to find what further conditions are necessary for a mixture of two species to be perfect, if it is already assumed that they mix in all proportions at constant temperature and pressure without heat effect or volume change. He finds that the mixture law is a good approximation provided the molecular volumes do not differ by more than 25%, but for greater differences in size it is not possible to predict anything. A certain amount of light is thrown upon this problem of solutions by studies of the entropy of mixing, since unequal molecular fields tend to produce aggregation and therefore a non-randomness of mixing. Scatchard, Evans, Butler, and others have contributed to this aspect of the problem. Other phenomena such as complex formation, effect of ionic forces in solutions, heats of mixing, etc., form the subjects of the other contributions to this intriguing problem of solutions.

On the whole this symposium of the Faraday Society has served in no small measure to pool together the fruits of different lines of investigation on this live problem of the molecular physics of the liquid state. A careful study of this publication will no doubt amply repay the active workers in the field with important suggestions for further work, and otherwise encourage them in their efforts. To those not specialising in this field, this book will at the same time give an admirable account of the present state of our knowledge of this problem. The book is priced at 12 *sh.* (paper cover ; 282 pp.) and is of wonderful value for the fare it offers.

M. A. GOVINDA RAU.