completion. A third chair, that of textile technology, has now been instituted in the Department, and the research school in the Department of Colour Chemistry and Dyeing has been further strengthened by the appointment of an Imperial Chemical Industries, Ltd., Research Fellow. The graduates of both Departments are in keen demand by many branches of industry. In textile physics further work has been carried out on the examination of fibre surfaces by replica methods, and a study of the fine structure of keratin fibres disintegrated by various techniques has shown that super-contraction is molecular rather than fibrillar in origin. A study has been made of the pigment granules isolated from various wools and hairs, and of their location in the fibres. In textile chemistry good progress is reported in the synthesis of polypeptides and related compounds, and in the search for new cross-linking agents it was found that reductone undergoes a unique type of polymerization in aqueous solution and that the polymer so formed is deposited inside the fibres. Further work was carried out on the initiation of the polymerization of vinyl compounds inside wool fibres with persulphates, on the formation of polyacrylonitrile in wool and on suint and wool wax ; a strikingly novel approach has been developed to the problem of dimensional stability, and a mixture of fluorescent dyes has been devised which gives different colours with wool, cellulosic fibres, cellulose acetate, nylon, 'Terylene' and 'Orlon'. In textile engineering, work continued on the development of the new type of cap designed to give uniform spinning tension, on the drying of wet fibrous materials and theoretical studies on the use of felts in removing water in the manufacture of paper. In textile technology the electronic mule was being used with great success for studying the behaviour of fibres during the drafting of condensed slivers, and a comprehensive investigation was in progress on the effects of weaving tensions on cloth characteristics with special reference to rayon fabrics. Changes occurring in the setting of nylon were being studied, and further progress has been made in work on the proofing of viscose rayon against bacterial attack.

The Department of Colour Chemistry and Dyeing made further progress in its studies of the basic reactions of anthraquinone chemistry, completing the direct hydroxylation of *peri*-naphthalimide and the quinoxaline derived from acenaphthenequinone, and pyranthrone, *amphi-iso*pyranthrone, and 6-phenyl-*meso*benzanthrone. Other work has related to the mode of formation of the anthraquinone carbazole dyes from derivatives of 1 : 1′-dianthraquinonylamine, the reactions involved in the reconversion of sulphuric esters of reduced forms of vat dyes into the parent compounds, and on the nature of the products formed by the 'over-reduction' of indanthrone. Work on the action of Grignard reagents and dialkylcadmiums on alkylquinolinium salts was completed, and a relation found between the basic strength of anions and their orientation in nuclear substitution reactions. Work on the properties of the N-methyl-derivatives of anthraquinone–acridine dyes, the chemistry and dyeing properties of hæmatin, the colouring matter of logwood, and quantitative studies on the dyeing characteristics of chlorinated wool continued, while the dyeing of blends of wool and 'Fibrolane', and the dyeing characteristics of wool–nylon, wool–'Ardil' and nylon–'Ardil' for mixtures of acid and pre-metallized acid dyes were also investigated. Lists of publications are included.

HIGH-ENERGY PARTICLE ACCELERATORS IN THE UNITED STATES

ONE of the most noteworthy features of the International Conference on the Peaceful Uses of Atomic Energy held in Geneva last August was the series of evening lectures delivered by distinguished scientists. In particular, Prof. E. O. Lawrence's talk on August 11, in which he outlined the research programme in the United States concerned with the production of large currents of high-energy sub-atomic particles by means of accelerators, was especially interesting and provoked much discussion. The illustrated article, "High-Current Accelerators", which is contributed by Prof. Lawrence to the December 9 issue of *Science* (122, 1127 ; 1955), is based on his talk to the Geneva conference, and in it he emphasizes the importance of the problem of the production of intense beams of high-energy particles for future progress in nuclear physics. This is illustrated by the remark that the particle current has steadily decreased as the energy has increased—milliamperes for the 1940 cyclotron, microamperes for the 1943 synchrocyclotron, millimicroamperes for the present cosmotron and bevatron—and that, extrapolating on this basis, currents of only two protons per hour will be produced by accelerators giving particles of 10^{16} eV. energy. Reference is made to the work of L. H. Thomas and to the later approaches of V. Veksler and E. M. McMillan to the problem of a suitable magnetic field for a high-energy cyclotron. The basic similarity between the solutions in providing an azimuthal variation in the magnetic field to achieve focusing of the particles is pointed out.

Prof. Lawrence then describes briefly experiments that have been carried out in the Radiation Laboratory of the University of California, Berkeley, where he is director, with an electron model of a clover-leaf (this refers to the shape of the magnet pole-pieces) cyclotron. The model operated in complete agreement with theoretical expectations and showed that the Thomas-type field can provide the necessary axial and radial stability and that the accelerated electrons can stay in phase with the constant-frequency accelerating voltage. In addition to producing high currents of high-energy particles, equivalent to 300-MeV. deuterons, with very low voltages on the accelerating electrodes the clover-leaf cyclotron possessed the admirable property of easy extraction of the beam. Mention is also made of recent novel approaches that have been suggested to the problem of adapting cyclotrons and betatrons to produce high currents of high-energy particles, and these are now being put to practical test by the accelerator design group of the Mid-western Universities Research Association under the direction of Prof. D. W. Kerst.

During the past four or five years, along with the development of the clover-leaf cyclotron, the Radiation Laboratory has concentrated much effort, in collaboration with the California Research and Development Co., on the construction of a linear accelerator of the cavity-resonator type devised by L. W. Alvarez. The objective is to produce a particle accelerator capable of delivering thousands of kilowatts of high-energy protons. Details are given by Prof. Lawrence in his article of this *A*-48 linear accelerator, including the ion-injector, the beam focusing and steering magnet, the 24-Mc./s. buncher

and quarter-wave accelerator already completed, and the two 48-Mc./s. resonant-cavity accelerator sections, each 20 ft. long, which are still under construction. The injector consists of an arc source, in a solenoidal magnetic field, mounted on insulators in a vacuum envelope, and a focused ion beam of up to $\frac{3}{4}$ amp. has been obtained. Deuterons are accelerated by the quarter-wave machine from 140 keV. to about 1 MeV., at which speed they enter the two resonator-cavity sections. It is hoped finally to obtain an output from the complete accelerator of $\frac{1}{4}$ amp. of 7·8 MeV. deuterons, and it is expected that the accelerator will be in operation early this year.

EFFECT OF UREA ON TRYPSIN AND ALPHA-CHYMOTRYPSIN

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MANY simple organic substances such as urea are known to modify the specific stereochemical configuration of protein molecules in aqueous solution, and it is now well established that the increase in intrinsic viscosity encountered when native globular proteins are dissolved in concentrated urea solutions may be interpreted in terms of an increased molecular asymmetry associated with the unfolding of polypeptide chains from their specific 'native' configurations[1]. Viscosity measurements carried out in urea solutions have thus been frequently used as an experimental index of protein denaturation[1]. A more complete characterization of such a complex and ill-defined phenomenon is, however, obtained when viscosity changes are correlated with changes in other and entirely different properties of the protein molecule measured in the same chemical environment[2]. Although such an opportunity presents itself in the case of the biologically active proteins, a survey of the literature dealing with the effect of urea on a number of proteolytic enzymes reveals that in many instances the measurement of enzymatic activity has been used as the sole criterion of denaturation[3–7].

The assumption that protein denaturation and enzymic activity are mutually exclusive phenomena can be valid only if activity measurements are carried out under conditions which are not in themselves conducive to denaturation or to a reversal of a previously established denaturation effect, and although this crucial condition was stated by Anson and Mirsky[8] in their classical studies on the reversible denaturation of proteins, it has not always received the attention that it deserves. Thus in some cases the effect of urea on an enzyme has been evaluated on the basis of activity measurements carried out by the addition of an aqueous solution of the enzyme to a substrate dissolved in urea[3,9], and in others, urea solutions of an enzyme have been assayed under conditions which involve a dilution of the urea concentration in the assay medium[3–7]. These experimental procedures frequently lead to equivocal conclusions, since the possibilities that the 'active centre' of an enzyme molecule may be shielded from urea denaturation by formation of a stabilized enzyme/substrate complex, or that an inactivated denatured molecule may be subject to reversible reactivation, are not taken into consideration.

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The crucial importance of relating changes in enzymic activity to changes in one or more of the physical properties of the enzyme protein measured in the same chemical environment received further emphasis when it was shown in this laboratory[2] that urea-denatured ribonuclease retains the catalytic functions of the native enzyme. Alternative explanations therefore become possible for the results obtained in previous studies on the action of urea on chymotrypsin[3], papain[4], pepsin[5], catalase[6] and trypsin[7]. For example, in a recent communication, Viswanatha and Liener[7] report that trypsin forms a stable active system in the presence of 8·3 *M* urea at *p*H 7·6; in an endeavour to explain this apparent retention of activity, it was postulated that the native active trypsin molecule is prevented from unfolding by formation of a stable protein/urea complex. The alternative possibilities, that the enzyme retains activity in an unfolded form, or that it is reversibly unfolded in 8·3 *M* urea, are not considered, despite the fact that activity was always measured under conditions which involved a five-fold dilution of the urea concentration. In view of such considerations, the effect of urea on the enzymic activities of trypsin and α-chymotrypsin has been re-investigated.

Freshly prepared 1 per cent solutions of a dialysed, recrystallized preparation of trypsin (obtained through the courtesy of the Novo Terapeutisk Laboratorium) in the appropriate concentrations of urea (A.R. grade, recrystallized from aqueous ethanol before use, and dissolved in glass-distilled water containing 0·1 *M* potassium chloride) at *p*H 4·0, were subjected to viscosity studies in a capillary viscometer maintained at 20° (± 0·01) C. Aliquot portions of the same freshly prepared solutions were diluted twenty times with the corresponding urea solution and assayed[10] against α.N-toluenesulphonyl-L-arginine methyl ester (0·005 *M*) (*a*) in the appropriate concentration of urea, and (*b*) in aqueous solution, at *p*H 7·8 and 25°. Activities expressed as zero-order velocity constants were calculated from the initial slopes of alkali uptake curves automatically recorded by means of a Jacobsen–Léonis *p*H-stat[11]; for purposes of comparison the activity of a control aqueous trypsin solution (1·72 m*M*/min./mgm. trypsin nitrogen) is expressed as 1. The results obtained are summarized in Fig. 1.

The intrinsic viscosity of trypsin increases as a function of the concentration of urea and approaches a maximum value in 8 *M* urea; and a corresponding decrease in enzymic activity is observed when assays are carried out in the presence of the appropriate concentrations of urea. Thus, contrary to previous results[7], trypsin is not active in 8 *M* urea; and furthermore, an aqueous solution of trypsin is rapidly inactivated (75 per cent inactivation during 2 min.) in 8 *M* urea at *p*H 7·8 even in the presence of α,N-toluenesulphonyl-L-arginine methyl ester. In 4 *M* urea, where the viscosity increase is 55 per cent of the maximal, trypsin retains 48 per cent of its initial activity, and similar correlations between increase in viscosity and loss of activity are observed at other concentrations of urea. When assayed in aqueous solution, however, urea solutions of the enzyme are found to regain full activity (Fig. 1).

These results suggest that at each concentration of urea a mobile equilibrium exists between native active trypsin and unfolded inactive trypsin (cf. refs. 12 and 13); equilibrium is rapidly attained at 20° and *p*H 4, is independent of trypsin concentra-