chapter X. This is an excellent chapter, giving a sort of initial survey of the Raman effect and including several beautiful photographs of Raman spectra. Then comes the theory—more advanced this time—and even the author himself suggests that some of this may judiciously be omitted at a first reading. Some may prefer to take chapter XV, an excellent account of experimental technique, immediately after chapter X. The self-contained character of these chapters makes this possible.

The last three chapters are also of great interest. They deal with the Raman effect as a means for the elucidation of chemical problems. They presuppose, of course, a knowledge of much of the earlier part of the book, but are very readable and largely non-mathematical. They contain a wealth of experimental material. The book ends with seven appendices on mathematical topics.

In a book of this kind there is not much ground for criticism. The experts may differ, as they always do, about the choice of material, but in so vast a field it is clear that selection is inevitable. The ordinary reader would probably have valued a select bibliography, even though the author explains that such have been given elsewhere. The references are actually fairly numerous, but they occur somewhat sporadically in footnotes. An index of the chemical compounds mentioned would increase the value of the book as a work of reference. Compared with the general excellence of the book, these criticisms are of a minor kind. The English throughout is clear and direct, and scarcely anything more serious than an occasional slip in punctuation has been noticed. The printing is in a large clear type on good paper, and there are remarkably few misprints. One curious feature is that each chapter begins on a right-hand page, even though (as at the end of chapter X) this involves leaving practically two whole pages blank.

Every physicist whose work is connected with the scattering of light will want a copy of Prof. Bhagavantam's book on his table, and it should find a place in every Physics library. If the chemists can also be induced to buy a copy, so much the better, for no branch of Physics throws more light on the problems of Chemistry than this. It is on all accounts a book to be warmly welcomed.

H. J. TAYLOR.

REGIME FLOW IN INCOHERENT ALLUVIUM*

DESIGN of non-silting canal sections was first attempted by Mr. Kennedy; based on data collected from Upper Bari Doab Canal he derived the empirical equation $V_0 = 0{\cdot}84D^{0{\cdot}64}$ where V_0 is the critical mean velocity at which a canal neither silts nor scours and D is its depth over a nearly horizontal bed. In 1919, Lindley put forth a relation of bed width to depth of $B = 3{\cdot}80D^{1{\cdot}61}$. Several formulæ of the form $V = C\,D^n$ were subsequently introduced satisfying a particular set of conditions with varying values for C and n. According to these formulæ, a given discharge and silt charge uniquely determined depth width, and slope of a regime channel.

Mr. Gerald Lacey's work* on regime flow in incoherent alluvium is of great value to irrigation engineers. In 1930, he proposed the equation $P = 2{\cdot}668Q^{1/2}$ connecting the wetted perimeter of a stable channel with its discharge. Starting with the idea that in a silt transporting channel a constant discharge tends to transport a fixed "regime" silt charge, Lacey concludes that a constant discharge, carrying silt of a given grade and flowing in an alluvial plain of the same grade tends eventually to assume a gradient solely determined by the discharge and silt grade, and that the mean velocity, hydraulic mean depth and wetted perimeter tend to unique determination.

From an analysis of the data from the Upper Doab Canals and Madras-Godaveri Western Delta, Lacey derives the relation $V = c\,R^{1/2} = K^1 m\,R^{1/2} = K\,f^{1/2}\,R^{1/2}$ where f is a silt factor, K a numerical constant, $m = \frac{V}{V_0}$ critical velocity ratio, and R is the hydraulic mean radius. Lacey concludes that $\frac{V}{R^{1/2}} = C$ is a function of the grade of alluvial material transported when the channel is active,

* *Regime Flow in Incoherent Alluvium*. By Gerald Lacey. (Central Board of Irrigation Publication No. 20.), 1940 p. 65.

the material is incoherent, and there is a balance between silting and scouring, the value of c at all times indicating the degree of turbulence and eddying motion in the water. From the Lindley Lower Chenab Branch data Lacey derives the relations $R^{1/2}S = c'$ and $c = 16\ c'^{1/3}$ and from these he gets $V = 16R^{2/3}S^{1/3}$ as the general regime equation.

Lacey further states that the rugosity of a channel or the coefficient of a regime channel flowing in alluvium depends on the average size of the materials of the boundary and introduces what he calls an absolute rugosity coefficient N_a based solely on the average size and density of the transported and moving bed material. $V = 16R^{2/3}S^{1/3}$ written in the form $V = 64\left(\frac{R}{V}\right)^{1/2}\sqrt{RS}$ makes the Chezy coefficient $C = 64\left(\frac{R}{V}\right)^{1/2}$. When V is replaced by $V = K\,m\,R^{1/2}$, C becomes equal to $\frac{64R^{1/4}}{K^{1/2}m^{1/2}}$ which can be written as $\frac{R^{1/4}}{N_a}$ in metric units or as $\frac{1\cdot3458}{N_a}R^{1/4}$ in foot units. Kennedy takes the Upper Bari Doab Canal silt with a critical velocity ratio of unity as standard silt. Lacey writes $N_a = \cdot0225m^{1/2}$ and takes the standard grade of silt as having $N_a = \cdot0225$ when the H.M.D. is one metre. Equating $\frac{64}{K^{1/2}m^{1/2}}$ to $\frac{1\cdot3458}{N_a}$ gives K a value of 1·145. To obviate the difficulty experienced in assigning values to the rugosity coefficient, Lacey gives N_a a value appropriate to the bed material and the equation is written as $V = \frac{1\cdot3458}{N_a}R^{3/4}(S - s)^{1/2}$ where s is a suitable deduction made from the gross slope to account for the errors in the determination of correct slope and H.M.D. and for the shock encountered due to bends, irregularities and condition of the channel.

From Kennedy's data, Lacey derives the relation $V = 1\cdot17R^{1/2}$ and from Kennedy, Madras, and Lindley data he gets $Af^2 = 3\cdot8V^5$ where A is the area of the cross-section. From these two equations he gets $P = 2\cdot668Q^{1/2}$, or $P = (2\cdot668)^2\ RV = 7\cdot12RV$. If K is put equal to 1·1547, K^2 becomes $\frac{4}{3}$ and $f = \frac{3}{4}\frac{V^2}{R}$ and $c = 16\cdot04557c'^{1/3}$ and $S = \cdot0003727f^{3/2}R^{-1/2}$ or $\cdot000391\frac{f^{5/3}}{q^{1/3}}$ where $q = RV$, or $\cdot000542\frac{f^{5/3}}{Q^{1/6}}$.

REGIME EQUATIONS

Lacey

$$P = 2\cdot668Q^{1/2}$$
$$V = 1\cdot155f^{1/2}R^{1/2}$$
$$R = \cdot472\left(\frac{Q}{f}\right)^{1/3}$$
$$S = \cdot000542\frac{f^{5/3}}{Q^{1/6}}$$

Punjab Research Institute

$$P = 2\cdot800Q^{1/2}$$
$$V = 1\cdot120R^{1/2} = \cdot767Q^{1/6}$$
$$R = \cdot470Q^{1/2}$$
$$S = \cdot00209\frac{m^{\cdot86}}{Q^{\cdot21}}$$ (m-diameter of silt particle in mm.)

The two slope equations show that the silt factor and silt grade take the place of a rugosity coefficient and are interrelated; if the power of m is taken to be ·833 it would make the silt factor vary as the square root of the mean diameter of the silt particle.

Crump found on analysis that in stable silt transporting canals the critical velocity ratio is an inverse function of the Kutter's rugosity coefficient. Any rugosity coefficient depends on the grade of bed silt. Lacey on plotting the values of f and m from the Punjab data finds that any correlation between m and f must be of an inverse character.

In perfect regime channels with wetted perimeter consisting of incoherent silt, grade of bed silt can be correlated with turbulence as measured by $\frac{V^2}{R}$ and under such circumstances, turbulence is also a true silt factor. In non-regime channels or channels approaching regime but not free from shock and the Crump effect, the grade of bed silt is a function of gross turbulence in the channel; the gross turbulence, the result of mean forward velocity, agitation of water brought about by shock, and destruction of shock energy, is also measured by $\frac{V^2}{R'}$ where R' is the altered value of the H.M.D. due to the existence of shock at the section. $\frac{V^2}{R'}$

the measure of gross turbulence is a true silt factor, R′ being greater than R where positive shock is encountered and less than R under exceptional circumstances when there may be negative shock due to irregularities in the channel taking the form of smooth portions of stiff fine clay banks and also possibly smooth rigid patches of the bed; in the latter case with the bed silt fine almost coherent there is no limit to the value assumed by $\frac{V^2}{R'}$; such a channel would have rigid boundaries as a limit and would fall beyond the class of channels under discussion.

Lacey suggests that the silt factor in a channel, free from shock, varies as the square root of the bed silt grade and that f_r will be equal to $km_r^{1/2}$ for silts of equal coherence, suffix r indicating regime conditions. When there is shock the measured values of m and f determine shock and the products $m_r^{1/2}f_r$, $m^{1/2}f$, $m'^{1/2}f'$ are all equal; the silt factor far from varying directly as the square root of the bed silt diameter, varies inversely as the square root. In the Punjab data, shock is so important a factor that variations in silt grade are often traceable to this source. $f_r = m^{1/2}f$, and $f_r = km_r^{1/}$ yield $m^{5/6} = \left(\frac{f_r}{f}\right)^{5/3}\left(\frac{f_r}{k}\right)^{5/3}$.

The 'Bose-Malhotra' slope equation $S = \cdot 00209 \frac{m^{\cdot 86}}{Q^{\cdot 21}}$ being an empirical relation partially compensates for shock. Shock in such channels transporting silt, perfectly incoherent or of constant coherence, will be indicated by a departure from regime slope and a corresponding departure from normal bed silt. Lacey modifies this relation to $S_b' \propto \frac{m^{5/6}}{q^{1/3}}$ and finds from the Punjab data, that $S_b' = \cdot 0010002 \frac{m^{5/6}}{q^{1/3}}$ which can be written as $\frac{\cdot 0010002}{k^{5/3}} f_r^{5/3} \frac{\left(\frac{f_r}{f}\right)^{5/3}}{q^{1/3}}$ where k should be equal to $1 \cdot 1775$ to suit the Punjab data. S then becomes $\cdot 000385 f_r^{5/3} \frac{\left(\frac{f_r}{f}\right)^{5/3}}{q^{1/3}}$. When $k = 1 \cdot 760$ S becomes $\cdot 000391\ f_r^{5/3} \frac{\left(\frac{f_r}{f}\right)^{5/3}}{q^{1/3}}$ and this becomes identical with Lacey's slope equation $S = \cdot 000391 \frac{f^{5/3}}{q^{1/3}}$ when there is no shock.

Lacey finds that the equation fits the Punjab data well and concludes that it is applicable to regimé channels transporting sandy silt of standard coherence, thus introducing a coherence factor for the majority of the Punjab observations as unity. For silts of the same degree of coherence $f_r = k'm_r^{1/2}$ where $\frac{k'}{1 \cdot 76}$ is the coherence factor for the silt and the modified equation of Bose is written as $S_b' = \cdot 0010002 \left(\frac{k'}{k}\right)^{5/3} \frac{m^{5/6}}{q^{1/3}}$ where $\frac{k'}{k}$ is a coherence factor and $S = \cdot 000391\,(k')^{5/3} \frac{m^{5/6}}{q^{1/3}}$ when k is taken equal to $1 \cdot 760$.

In the Punjab data there are five discordant channels of small discharge, for these channels it is found from the tabulated values that $\cdot 001311$ replaces $\cdot 0010002$ thus making $(K')^{5/3}\ \cdot 000391$ equal to $\cdot 001311$ giving k' a value of $2 \cdot 07$, and the coherence factor a value $1 \cdot 175$; and in the case of the five large discordant channels k' becomes $1 \cdot 894$ and the coherence factor $1 \cdot 075$. In the case of the small channels the silt factor is relatively high and the bed silt grade low, but high slopes are required in spite of the silt being fine as a result of increased internal friction of fine silt due to its coherence. In the case of the five large channels assumption of a high silt charge increasing coherence renders them concordant.

Bose's modified equation $S = \cdot 0010002 \frac{m^{5/6}}{q^{1/3}}$ applies equally well whether shock is present or not; shock is implicit in the equation and silt is of uniform coherence with a silt factor constant $k = 1 \cdot 76$. When no shock is present Lacey's equation $S = \cdot 000391 \frac{f^{5/3}}{q^{1/3}}$ is applicable whether the coherence varies or not, coherence being implicit in this relation.

To eliminate the effects of variations of kinematic viscosity, Dr. Malhotra gets from Lacey's equations for silt factor, the relation

$V \propto \left(\frac{R}{m}\right)^{1/2} (gRS)^{1/2} S^{1/2}$, in this relation kinematic viscosity being implicit as $\frac{R}{m}$ is a function of the temperature of water. Lacey writes this in the form $\frac{V}{V^*} \propto \left(\frac{RS}{m}\right)^{1/2}$ (where $V^* \propto \sqrt{gRS}$) to express regime flow in incoherent alluvium.

Mr. Gerald Lacey's work is a valuable contribution to the understanding of regime flow in alluvium and is a stimulus to further research on the subject.

C. GOPALAKRISHNAN.

SOME PRACTICAL RESULTS OF SUGARCANE RESEARCH IN INDIA

THE IMPERIAL COUNCIL OF AGRICULTURAL RESEARCH represents perhaps the most important outcome from the recommendations of the Royal Commission on Agriculture in India (1926) and the renaissance of the Indian Sugar Industry is possibly the most tangible achievement of that Body. The sugarcane position in India at the time of the founding of the Imperial Council of Agricultural Research in 1929 was such as to enable that Council to recommend to Government certain very important steps both by way of tariff protection to the industry and the proper organisation of sugarcane research in India for rehabilitating it. The Council acted both quickly and effectively.

The result is seen in India passing from the position of a major sugar importing country to the present one of surplus production and consequent search for export facilities. Certain of the recent troubles from the sugarcane belt of North India reported in the Press and from the platform are attributable to this very rapid but somewhat ill-planned development of our sugar industry during the last decade. The renaissance of the Industry has shown, however, that Indian capital is by no means shy when suitable avenues are open to it.

In the field of cane research a chain of experimental stations covering all the important cane areas has come into being, financed wholly or partly from the Council's funds and we have before us a publication* of the Council summarising practical results from such work upto and inclusive of 1937–38. Though the results now available are almost three years old, a brief resume of the salient features is here attempted as likely to be of considerable general interest in view of the stress now being rightly laid on the industrial development of our country as a necessary precedent to full development in other directions, economical, social and even political. The publication before us is of such practical utility that the public will be entitled to look forward to similar periodical publications in the future.

The publication includes a bird's eye picture of the history of sugarcanes in our country with a brief description of the Indian indigenous canes which were once in cultivation over the bulk of sugarcane India (mainly sub-tropical). While a low acre yield appears to be their characteristic feature, a fair amount of resistance to the rather difficult conditions of sub-tropical India has been their saving quality. This latter quality would appear to have been partly incorporated in the new Coimbatore productions "Co. Canes" through a somewhat complicated scheme of hybridization.

Brief notes are given of the characteristics of the more important of the new canes. Though the bulk of such are Coimbatore productions which are apparently the most widely cultivated, a few seedling canes from Mysore and foreign countries are also included. The utility of importations from foreign countries like Barbados, Java and Mauritius, would appear to have been mainly in tropical India like Madras and Bombay and also parts of Bengal. A brief indication is also given of types which at the time were considered promising and we gather that certain of these are steadily gaining ground as anticipated.

The report opens with a picture of the recent change in the varietal position

* *Miscellaneous Bulletin* No. 34 of the I.C.A.R., Manager of Publications, 1940, pp. 41, price Rs 1-8-0 or 2*sh*. 3*d*.