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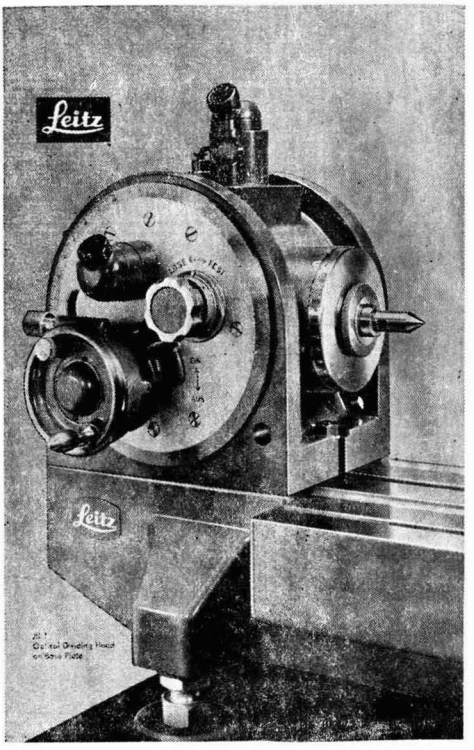

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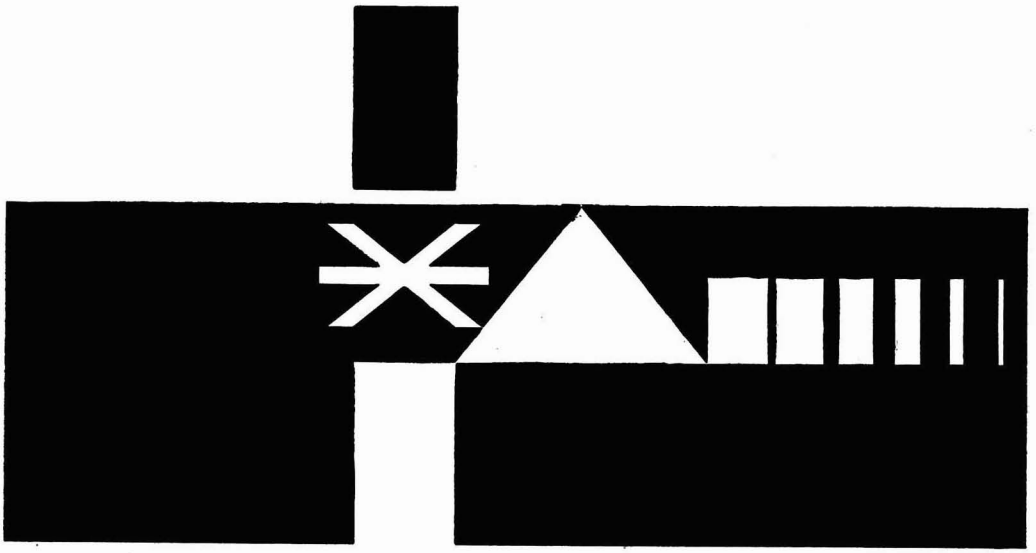

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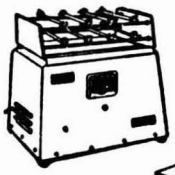

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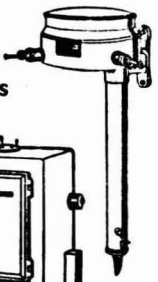

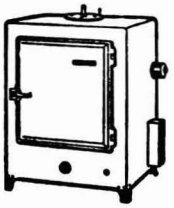

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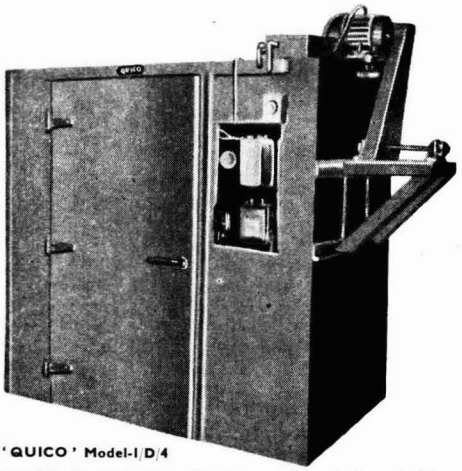

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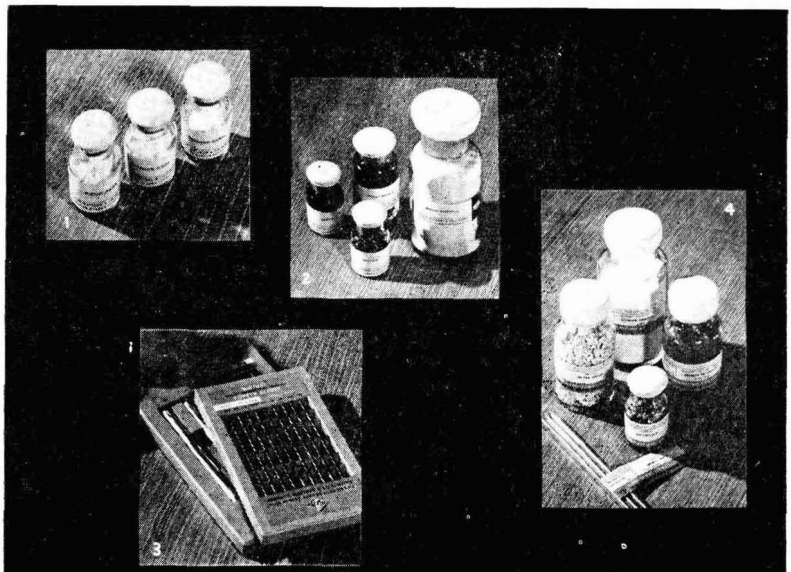

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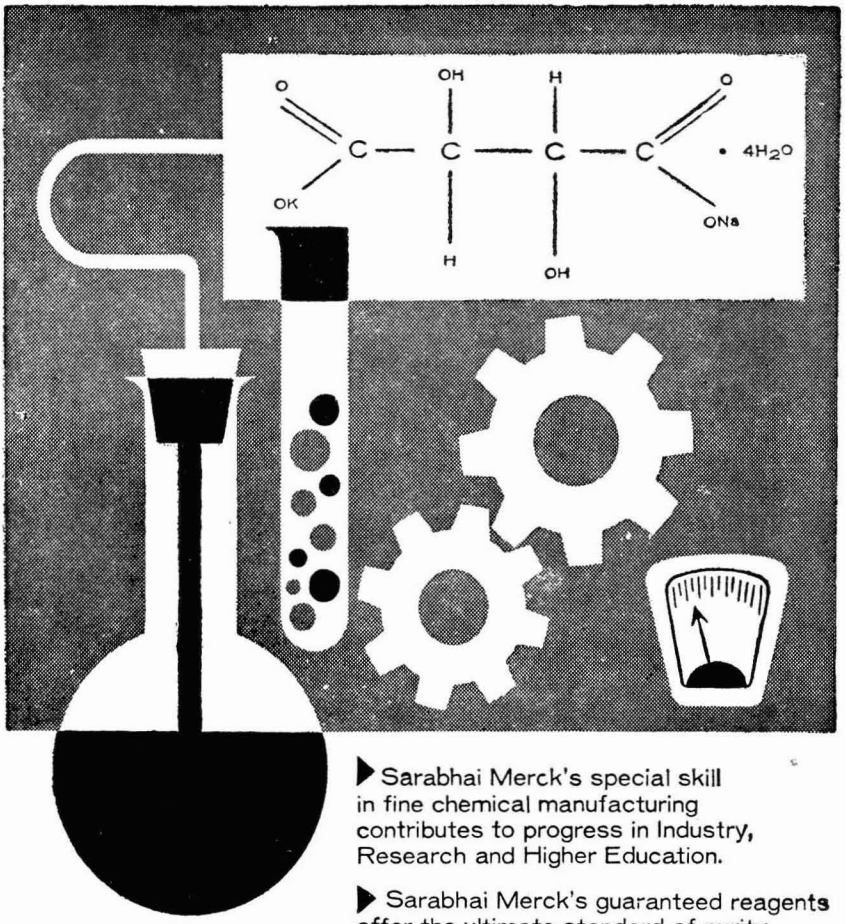

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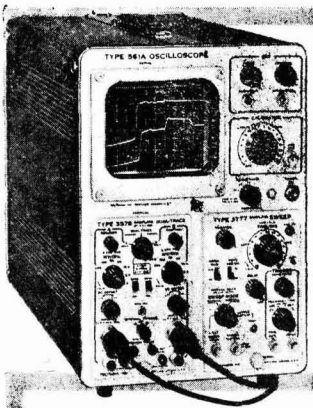

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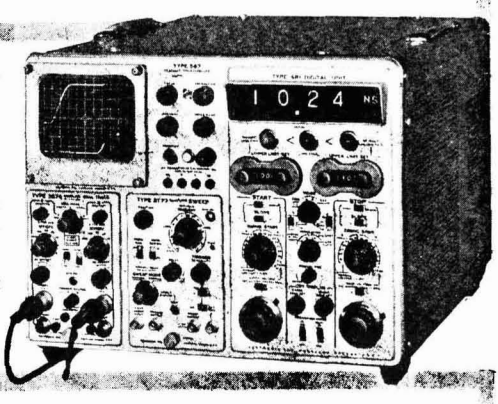

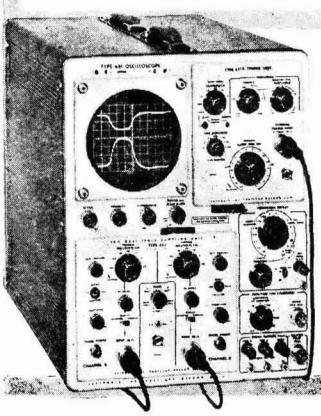

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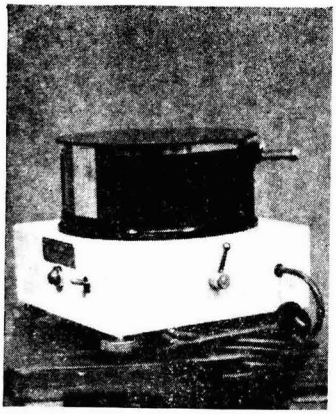

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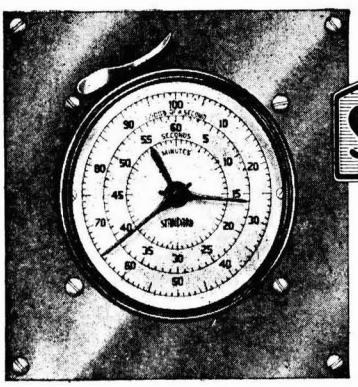

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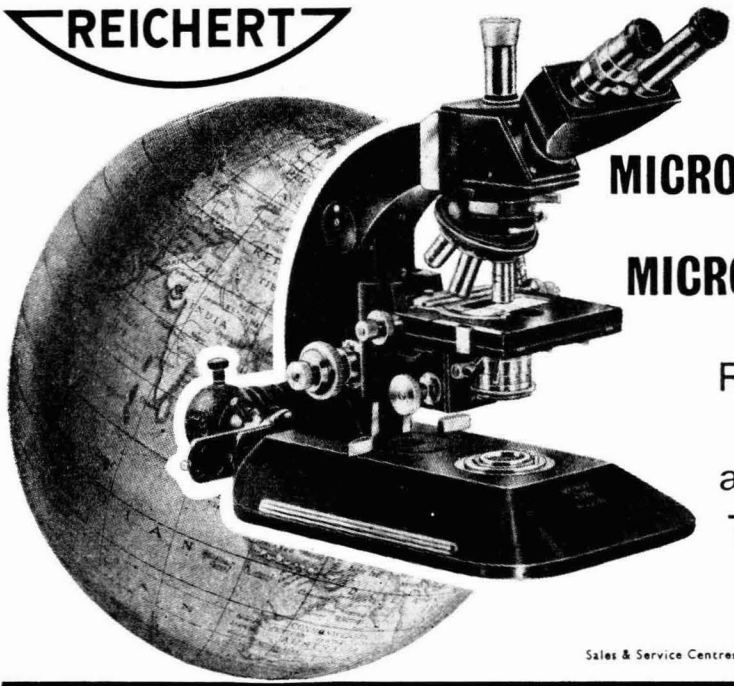

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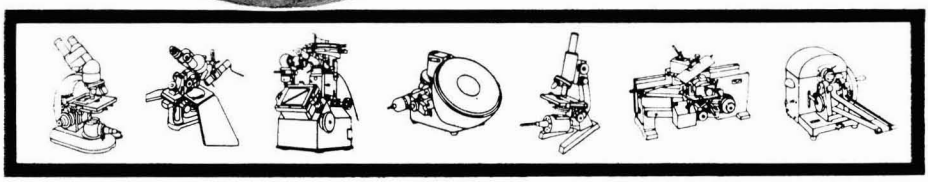

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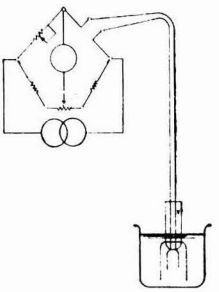

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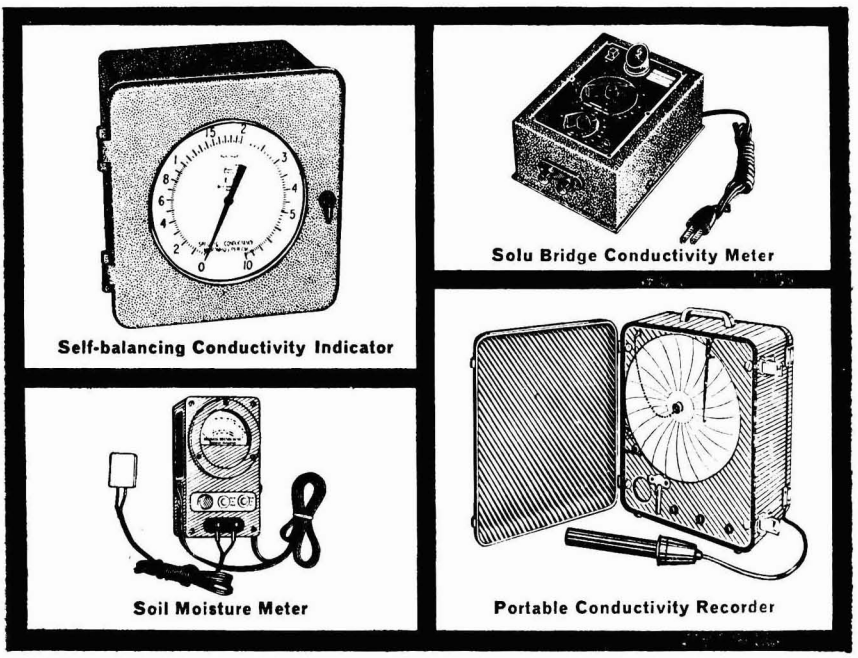

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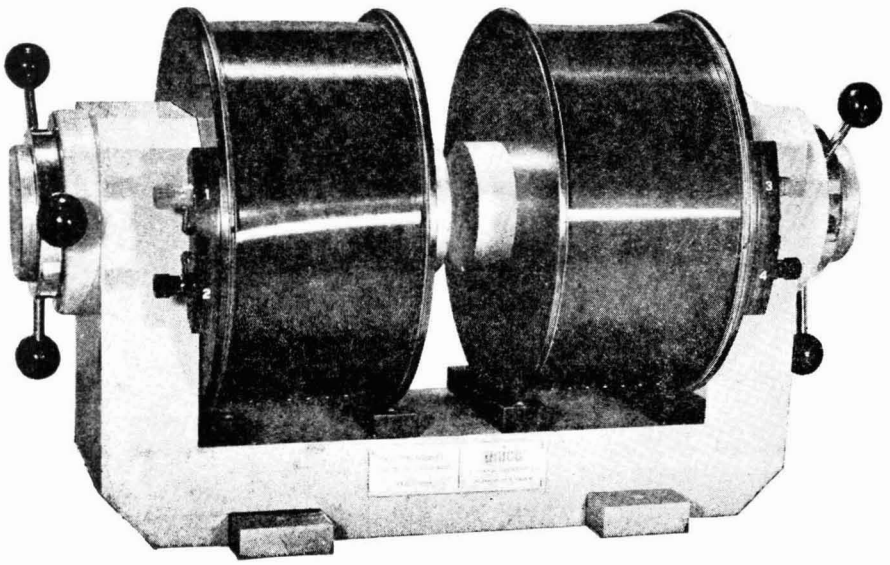

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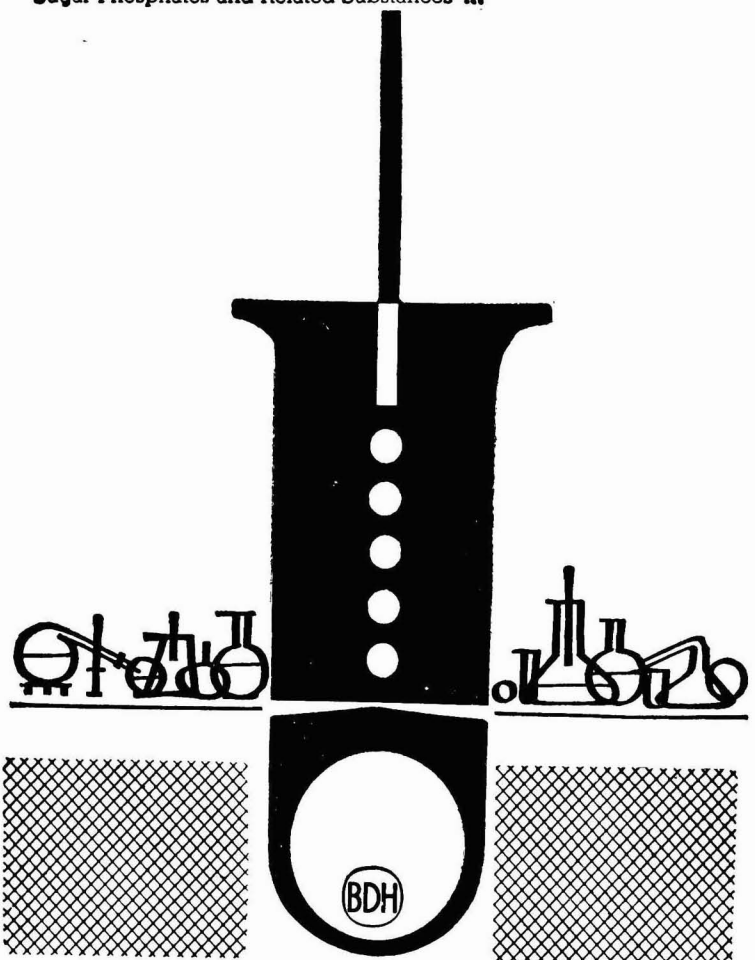

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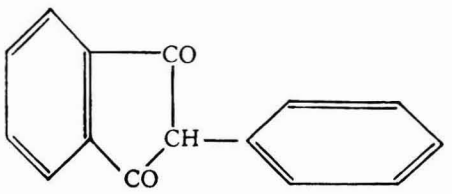

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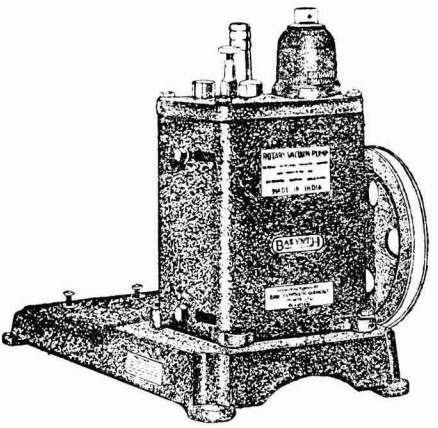

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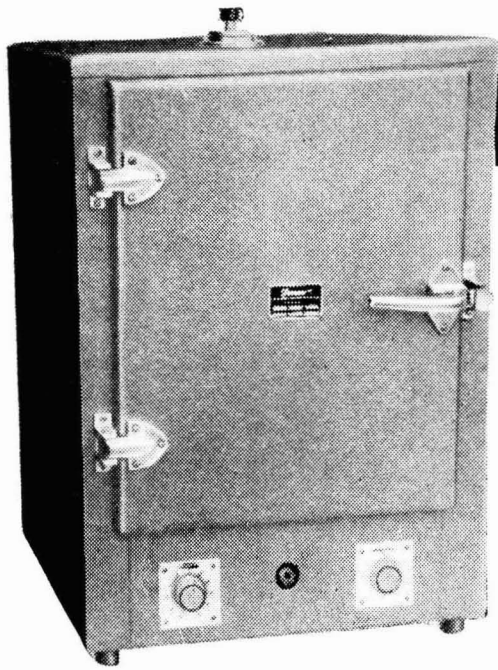

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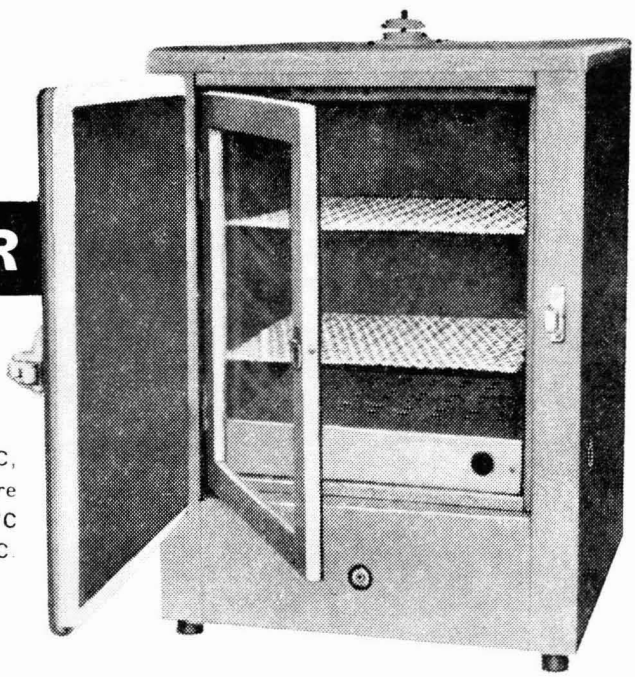

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Current Topics

Central Electrochemical Research Institute, Karaikudi

IN connection with its decennary celebrations, the Central Electrochemical Research Institute, Karaikudi, has brought out an informative brochure which records the achievements of the Institute during the period 1953-63. Established primarily with the object of undertaking applied research in electrochemistry, with particular reference to the utilization of Indian raw materials, the functions of the Institute have included setting up of pilot plants to prove the commercial feasibility of laboratory scale researches, maintenance of liaison with workers in allied fields of research and industry, evaluation and standardization of raw materials and finished products. Though emphasis is on applied research, the Institute's contribution in fundamental electrochemistry has been substantial.

The work of the Institute is carried out in its 12 divisions dealing with various branches of electrochemistry including chemical physics and instrumentation. A new Division of Electro-biochemistry is being set up. Technical aid to industry, and refresher courses in electroplating, corrosion prevention and storage battery technology are the other activities of the Institute which also acts as a patents inspection centre. The Institute is recognized as a centre for postgraduate research by a number of universities.

During the period under review, 254 original research papers have emanated from the Institute. Nineteen patents have been taken out and fourteen processes leased out to industry; nine more are ready for commercial exploitation. The Institute has also set up the following three pilot plants for the production of (i) lead dioxide electrodes (electrodeposited over carbon and graphite, (ii) potassium perchlorate using lead dioxide and platinum electrodes, and (iii) synthetic cryolite utilizing the by-product hydrofluosilicic acid from superphosphate industries.

Among the applied researches of the Institute, the notable ones are its studies in the field of electro-organic chemicals. Processes have been developed for the production of aminophenols, salicylaldehyde, calcium gluconate, dialdehyde starch, tolualdehyde, benzaldehyde and benzidines, and some of them handed over to industry for exploitation. In the field of electrothermics, processes have been worked out for the production of calcium carbide, calcium phosphatide and calcium silicide from indigenous raw materials. The possibility of producing calcium carbide from indigenous carbon sources (Bararee coke and Neyveli lignite) and crystalline limestone has been established. For the first time in India, sodium and magnesium have been successfully produced in pound lots using indigenous materials and equipment. Typical of the studies undertaken with the object of utilizing low-grade or waste materials and unconventional source materials are those relating to the production of ferromanganese, electrolytic manganese and various salts of manganese from low-grade manganese ores; electrolytic production of lead and zinc from chloride solutions from Zawar concentrates; recovery of copper in sheet form from oxidized copper ores from the residues obtained during the exploitation of barytes ores of Rajasthan; and recovery of antimony and lead from battery wastes. Electrodeposition studies cover a variety of alloys and metals. Metal powders have been produced by direct reduction of oxides, hydroxides, soluble and insoluble salts by keeping them in direct contact with the cathode in the presence of an alkaline electrolyte. The Inorganic Chemicals Division has established conditions for the production of more than a dozen industrial chemicals employing indigenous raw materials. An important contribution of the Battery Division is the preparation of batteries for performance at sub-zero temperatures.

The Institute has been an active research centre for fundamental and applied research on corrosion. Notable among its contributions in the field is a country-wide survey on the economics of corrosion control. Field stations have been established at Mandapam Camp for investigations under tropical marine conditions and exposure yards at Madras Port for studying the efficacy of protective treatments under industrial marine conditions. New vapour phase inhibitors, such as dyestuff intermediates (*m*-dinitrobenzene, β-naphthol, etc.), have been developed. Studies on cathodic protection have revealed that it can be effectively used not only in preventing stress corrosion of structures, but also in extending the life of paint coatings. Among the specific industrial problems tackled, mention may be made of prevention of corrosion of textile machinery, oil pipelines, and reinforcements in reinforced cement concrete and brick constructions; electrolytic derusting of engineering stores; prevention of staining of aluminium, etc.

Significant among the fundamental contributions made by the Institute is the development of a new electro-analytical technique based on redoxokinetic effect, which enables the carrying out of many reduction-titrations precisely. Another important contribution has been the discovery of phenomena leading to the concept of double layer slow relaxation which has great potentialities in interpreting biological phenomena such as muscle and nerve action. Studies on the effect of electrical double layer capacity have led to the development of a new technique — turbulent medium tensammetry — which

is likely to be of special value in understanding adsorption-desorption kinetics. Among the other fundamental investigations reported from the Institute, mention may be made of a new titration technique based on the change of impedance at the end point and a rigorous solution of the problem of mass transfer taking into account the migration in the double layer.

The contributions of the Institute, both in applied and fundamental electrochemistry, have demonstrated that the Institute is well equipped both in respect of facilities and personnel to tackle a variety of problems. It is for the electrochemical industry in the country to make increasing and effective use of the facilities available at the Institute.

Indian Current Science Bibliography

AS a first step towards the publication of Indian Science Abstracts, the Indian National Scientific Documentation Centre (Insdoc) has circulated a pilot fascicule of the new indexing periodical, 'Indian Current Science Bibliography', to scientists, documentalists, librarians and others to obtain a critical assessment of the pilot effort and improve upon it. The pilot fascicule has indexed about 850 original research papers from some 100 periodicals, including 95 papers published by Indian scientists in foreign periodicals, 10 dissertations, 15 reports and other ad hoc publications, 235 patents and 30 Indian standard specifications. Critical review articles and survey reports are also included. Author and subject index and a list of 340 Indian scientific periodicals to be scanned are also given.

During the past 15 years, there has been a tremendous spurt in scientific activity in the country which is reflected in the growing output of technical literature. The number of scientific and technical periodicals has steadily increased, and many universities and research establishments are recording the results of researches in non-periodical publications. Increasing number of scientific conferences and symposia are being held in the country contributing to the growing volume of scientific documents. It is estimated that scientific documents published add up to 15,000 per year. In spite of this rapidly increasing volume of publications, no concerted and adequate attempts have been made at bibliographical control of this enormous output of scientific literature, except for the pioneering effort of the National Institute of Sciences of India, which published the Indian Science Abstracts for the period 1935-39, and the publication of the *Bibliography of Scientific Publications of South and South East Asia* by Insdoc. It was mainly this lack of comprehensive bibliographical control that prompted the Conference of Information Scientists, held during May 1963 at Mysore, to recommend to Insdoc to take immediate steps to ensure bibliographic control of scientific documents in India. The pilot fascicule is the result of this recommendation.

A reference has been made earlier in these columns [**21** (1962), 369] about the necessity for a national abstracting service for India in the context of the preparation of the World Inventory of Abstracting Services by the Fédération Internationale de Documentation. It was suggested that the task is best undertaken by Insdoc which should be strengthened and expanded to tackle the job. Incidentally, a reference was made to the difficulties involved in undertaking such an abstracting service and ensuring reasonably exhaustive coverage of the published material.

An abstracting service to be useful must be exhaustive. However, in India, difficulties in collecting published scientific documents and documenting them are indeed many and often frustrating. So far no effective machinery has been set up to ensure that a reprint or copy of every scientific paper, dissertation, monograph and other scientific documents published is automatically made available or deposited at a centre which serves as a repository for them. Necessary steps have to be taken to establish such a centre and suitable machinery has to be devised so that the documents reach the centre with the minimum of delay. The *Journal of Scientific & Industrial Research* and other general science periodicals in the country have, for over two decades, made concerted efforts to secure and notice titles and abstracts of post-doctoral theses accepted by universities and research institutions, and the response has been disappointing. Of about 50 universities, less than a dozen have responded to requests for the material. Lack of cooperation in making available published documents on a voluntary basis by the concerned agencies will make the exhaustive coverage of documents an impossible task. This also applies to the large number of scientific reports put out by research establishments and research papers published by Indian scientists in foreign periodicals. There is a growing volume of scientific literature in Hindi and the regional languages, and this complicates the problem further. Yet another problem to contend with is, barring the periodicals brought out by CSIR and a few others, which not only provide abstracts for research papers but also for Short Communications (Letters to the Editor), many periodicals do not provide abstracts even for full papers. Short Communications and Letters to the Editor are topical and contain research results of importance, and many standard international periodicals are publishing abstracts of these. This lacuna must be immediately remedied, and editors of research periodicals must cooperate in this task, so that the work of those in charge of the abstracting service is facilitated.

The proposed National Science Library to be set up under the auspicies of CSIR must be made the repository of all scientific documents published in the country, and in this work research workers as well as the authorities in charge of scientific faculties in universities and heads of research institutions, including government research establishments, must whole-heartedly cooperate. It is only then that an exhaustive and complete bibliographic control of scientific documents published by Indian scientists can be possible.

Effect of Lattice Structure on Neutron Diffusion*

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IN a solid, the slowing down of neutrons near thermal equilibrium is essentially governed by lattice dynamics of the solid. For example, the main reason why the rate of slowing down of neutrons in graphite is very much smaller than what it would be in an almost isotropic solid of the same atomic weight (say, BeO whose average atomic weight is almost the same as that of C), is that graphite being a layer lattice, its frequency distribution function is very different from that of an isotropic solid.

Lattice structure, on the other hand, considerably influences the diffusion of neutrons in a solid. In this review are considered some cases where this influence is particularly marked.

Transport Mean Free Path

An important parameter in the theory of neutron diffusion is the average diffusion constant, $\bar{D}_0$, defined as[1]

$$\bar{D}_0 = \int \frac{v}{3n\sigma_{tr}(E)} M(E,T)dE \quad \ldots\ldots (1)$$

(for weak absorption of neutrons) where

$$M(E,T) = 2\left(\frac{E}{\pi k^3 T^3}\right)^{1/2} \exp(-E/kT) \quad \ldots (2)$$

is the Maxwellian energy distribution function at the temperature T, k is the Boltzmann constant, $\sigma_{tr}(E)$ is the transport cross-section for neutrons of energy E or velocity v $(=\sqrt{2E/m}$, m being the mass of the neutron), and n is the number of moderator atoms per unit volume. The transport cross-section $\sigma_{tr} = \sigma_s(1-\overline{\cos\theta})$ (σ_s is the scattering cross-section and $\overline{\cos\theta}$ is the average of the cosine of the scattering angle in the laboratory system) is a complicated function of energy and depends upon the structure of the solid. It has been calculated for beryllium[2,3], beryllium oxide[3,4] and graphite[3] and the results are shown in Figs. 1-3 respectively. We shall here consider the case of beryllium in some detail.

From Fig. 1 it will be observed that σ_{tr} is very small below neutron energy $E_1 = 60k$ which is the Bragg cut-off energy for this material. A number of consequences follow from this. The transport mean free path λ_{tr}, which is defined as $1/n\sigma_{tr}$, differs from scattering mean free path $\lambda_s = 1/n\sigma_s$ by the factor $(1-\overline{\cos\theta})^{-1}$, which is a measure of the forward scattering. If scattering is completely forward, then $\overline{\cos\theta} = 1$ and $\lambda_{tr} \to \infty$; if it is isotropic in the laboratory system, then $\lambda_{tr} = \lambda_s$.

For small values of energy, i.e. $E < E_1$, λ_{tr} is a large quantity of the order of 10 cm. in beryllium at room temperature. Further, it rapidly increases as the temperature of beryllium is reduced. However, what one measures is λ_{tr} averaged over an equilibrium flux distribution. Provided the moderator assembly is not too small, the equilibrium neutron energy distribution can safely be assumed to be Maxwellian at the temperature of the moderator, i.e.

$$\bar{\lambda}_{tr} = \frac{1}{n}\int_0^\infty \frac{E^{1/2}M(E,T)}{\sigma_{tr}(E)}dE \Big/ \int_0^\infty E^{1/2}M(E,T)dE \quad . (3)$$

For beryllium at room temperature, the contribution to the integral in the numerator of Eq. (3), from the energy region corresponding to $E < E_1$, is

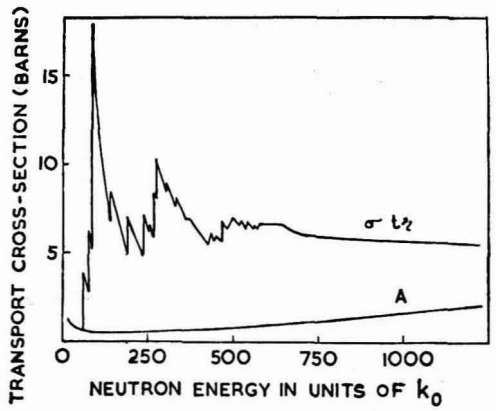

Fig. 1 — Plot of transport cross-section as a function of neutron energy for beryllium at 300°K. [Curve A represents inelastic scattering contribution]

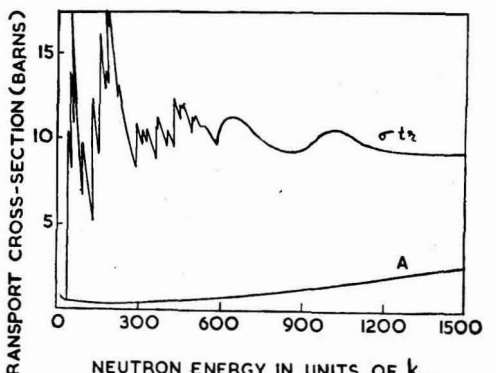

Fig. 2 — Plot of transport cross-section as a function of neutron energy for beryllium oxide at 300°K. [Curve A represents inelastic scattering contribution]

*Based on a paper presented to the Symposium on Lattice Defects and Lattice Dynamics, held at the National Physical Laboratory, New Delhi, in October 1962.

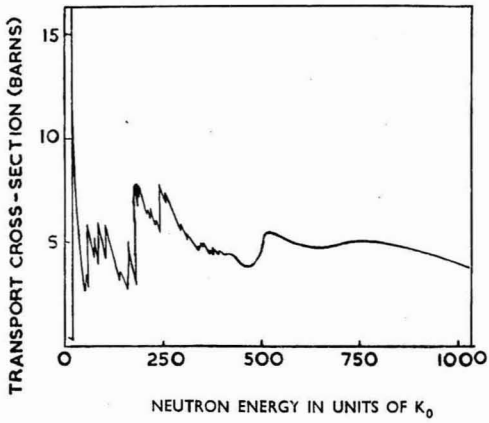

Fig. 3 — Plot of transport cross-section as a function of neutron energy for graphite at 300°K. [Contribution of inelastic scattering not considered]

small (about 15 per cent) in spite of $1/\sigma_{tr}$ being large. This is because the number of neutrons in the Maxwellian tail ($E < E_1$) is small. However, the situation changes entirely in the case of beryllium at lower temperatures. The peak of the Maxwellian distribution shifts to lower temperature so that the fraction of neutrons in the cold region increases and so does $1/\sigma_{tr}$ (for $E < E_1$). Both these factors together increase $\bar{\lambda}_{tr}$ with decreasing temperature, particularly below 200°K.[3]. This increase has actually been observed experimentally[5,6].

From Eqs. (1) and (3) we have

$$\bar{D}_0 = \tfrac{1}{3}\bar{v}\bar{\lambda}_{tr} \quad \ldots\ldots\ldots (4)$$

where $\bar{v}$ is the mean velocity. Below about 200°K., $\bar{\lambda}_{tr}$ increases far more rapidly than $\bar{v}$ decreases with decreasing temperature, so that on the whole $\bar{D}_0$ increases with decreasing temperature.

Similar results would also be observed for beryllium oxide and graphite though at much lower temperatures, since for both these the Bragg cut-off energy is lower than that for beryllium.

Diffusion of Neutrons

It is seen that the transport mean free path and hence the diffusion constant is very large for neutrons of energy $E < E_1$. This implies that the diffusion properties of the two groups of neutrons, (1) with $E < E_1$ and (2) with $E > E_1$, are very different. Dividing the whole energy range into these two groups (one group comprising the cold neutrons and the other the rest of them), Sanatani and Kothari[7] (see also errata[8]) have studied the diffusion of neutrons in a finite block of beryllium. Jain and Lawande[9] (see also errata[8]) have considered a semi-infinite medium. They found that at low moderator temperatures the equilibrium spectrum is never Maxwellian except for very large assemblies and very small absorption. This implies that if one wanted to calculate the average value of some parameter like the scattering cross-section or diffusion constant, then averaging it over a Maxwellian may not give the correct result.

For a slab geometry and in a source-free region, the time-independent diffusion equation for neutron flux $\Phi(x,E)$ is [here $D(E) = \frac{1}{3}\lambda_{tr}(E)$]

$$D(E)\frac{d^2\Phi(x,E)}{dx^2} - \Sigma_a(E)\Phi(x,E) - \Sigma_s(E)\Phi(x,E) + \int_0^\infty \Sigma_s(E'\to E)\Phi(x,E')dE' = 0 \quad \ldots\ldots (5)$$

where $\Sigma_a(E) = n\sigma_a(E)$ is the macroscopic absorption cross-section for neutrons of energy E and $\Sigma(E \to E') = n\sigma(E \to E')$ is the macroscopic scattering cross-section for neutrons of energy E being scattered into energy E'. Various models are available on which the microscopic scattering cross-section can be calculated[10].

To obtain the two group equations we first assume that $\Phi(x,E)$ can be written as a product $\Phi(x,E) = \varphi(x)M(E)$ where $\varphi(x)$ is a function of x only and $M(E)$ is the Maxwellian flux distribution function. Integrating Eq. (5) from 0 to E_1 and also from E_1 to ∞ leads to the following two equations:

$$\left(D^1\frac{d^2}{dx^2} - \Sigma_a^1 - g^{21}\right)\varphi^1(x) + g^{12}\varphi^2(x) = 0 \quad \ldots (6)$$

$$\left(D^2\frac{d^2}{dx^2} - \Sigma_a^2 - g^{12}\right)\varphi^2(x) + g^{21}\varphi^1(x) = 0 \quad \ldots (7)$$

where

$$\varphi^i = \int_{E_{i-1}}^{E_i} \varphi(x)M(E)dE;\ i = 1,2;\ E_0 = 0;\ E_2 \to \infty \quad \ldots (8)$$

$$D^i = \int_{E_{i-1}}^{E_i} D(E)Ee^{-E/kT}dE \Big/ \int_{E_{i-1}}^{E_i} Ee^{-E/kT}dE \quad \ldots (9)$$

$$\Sigma_a^i = \int_{E_{i-1}}^{E_i} \Sigma_a(E)Ee^{-E/kT}dE \Big/ \int_{E_{i-1}}^{E_i} Ee^{-E/kT}dE \quad \ldots (10)$$

and

$$g^{ij} = \int_{E_{i-1}}^{E_i} dE \int_{E_{j-1}}^{E_j} dE'\Sigma(E'\to E)E'e^{-E'/kT} \Big/ \int_{E_{i-1}}^{E_i} Ee^{-E/kT}dE \quad \ldots (11)$$

Once the parameters defined by Eqs. (8)-(11) are known, Eqs. (6) and (7) can be solved for $\varphi^1(x)$ and $\varphi^2(x)$ for any given source conditions. For a beryllium slab of 200 cm. thickness, using the one plus two-phonon cross-section for $\sigma(E \to E')$ and assuming a Maxwellian distribution of neutrons at the same temperature as that of the slab, to be incident on entire one face, Sanatani and Kothari[7] have found that for $T = 300$°K. the mean energy of the distribution does not change appreciably even at large distances from the source plane. This implies that around room temperature the effect of Bragg cut-off on the diffusion of neutrons is very small. However, the situation is very different at lower temperatures, say 100°K. At these temperatures the mean energy of distribution, away from

the source, is much lower than that of the incident Maxwellian distribution.

Jain and Lawande[9] (see also errata[8]) have studied neutron diffusion in a semi-infinite slab of beryllium at 100°K. and found the asymptotic value of the ratio $\varphi^1/\varphi^2 = 0{\cdot}68$ (instead of 0·14 for Maxwellian distribution at 100°K.). Jain has later made (Jain, R. D., unpublished data) 14 group calculations using first term of Placzek expansion[10] for $\sigma(E \to E')$, and obtained a value of 0·48 for the above ratio. Part of the difference in these two results may be due to the use of different scattering kernels.

Diffusion Cooling

In a small moderator assembly, because of preferential leakage of fast neutrons, the equilibrium spectrum is not Maxwellian. The measured value of the average diffusion constant, D_0 for such an assembly will be lower than the value one would obtain for a very large assembly $\bar{D}_0$. Further, the actual value will depend upon the size of the set-up. It is a fairly good approximation to write

$$D_0 = \bar{D}_0 - CB^2 \quad \ldots\ldots\ldots (12)$$

where C is the 'diffusion cooling constant' and $B^2 = 3\pi^2/a^2$ is the geometrical buckling, a being the side of the assembly, assumed cubic. (Actually a used in defining B^2 is slightly larger than the actual length of the side, but for the present purpose we may neglect the difference.)

The parameter C has been measured experimentally for a number of moderators by various workers[11,12]. It can also be calculated from theory[13,14]. Nelkin[13] first derived an expression for C assuming a smooth variation of λ_{tr} with energy. Generalizing his approach Singwi and Kothari[14] obtained

$$C = (\sqrt{\pi}\,\bar{D}_0^2/v_0 M_2)(A_1/A_0 - 3/2)^2 \quad \ldots\ldots (13)$$

where

$$M_2 = \frac{1}{k^2T^2}\int_0^\infty\int_0^\infty \Sigma(E\to E')(E-E')^2 M(E)\,dE\,dE' \Bigg\}$$
$$v_0 = (2kT/m)^{1/2} \qquad \ldots\ldots (14)$$

and

$$A_i = \frac{1}{(kT)^{i+2}}\int_0^\infty \lambda_{tr}(E)E^{i+1}e^{-E/kT}\,dE \quad \ldots (15)$$

If one assumes, as Nelkin[13] had done, that λ_{tr} varies with energy as E^α then one finds

$$C = (\sqrt{\pi}\,\bar{D}_0^2/v_0 M_2)(\alpha+\tfrac{1}{2})^2 \quad \ldots\ldots (16)$$

However, because of the complicated dependence of λ_{tr} on energy, the approximation made by Nelkin is not justified. A further complication arises from the fact that the ratio A_1/A_0 calculated by taking the more exact values of λ_{tr} comes out to be close to 3/2. This makes C depend sensitively on the values of A_i.

In the theories considered above it has been assumed that the neutron energy distribution remains Maxwellian throughout the slowing down process; only the temperature of the peak of the Maxwellian distribution decreases with time till it attains the equilibrium value. This assumption is not justified, and the equilibrium spectrum is certainly not Maxwellian. Since C depends sensitively on A_i's this assumption can lead to considerable error in C. One must, therefore, calculate more exactly the equilibrium neutron energy distribution inside the assembly, and this is discussed in the next section.

Another important point to be noted is the fact that the derivation of Eq. (16) or rather of the decay constant[14] λ, given by

$$\lambda = \Sigma_a v + \bar{D}_0 B^2 - CB^4 \quad \ldots\ldots (17)$$

is based on Rayleigh-Ritz variational principle with a very simple trial function. This only gives an upper bound for the lowest eigen value of λ, but it is then assumed that the upper limit is the same as the actual value. Recently, Corngold has shown (Corngold, N., unpublished notes of lectures delivered at Boyne Mountain, Michigan, 1962) that in certain cases the actual value of λ can differ from the upper bound by a large amount. He further proved the important result that

$$\lambda < |(\Sigma_a + \Sigma_s)v|_{\min.} \quad \ldots\ldots (18)$$

That is λ is always less than the minimum value of $(\Sigma_{\text{total}}.v)$.

Equilibrium Spectrum

When a fast neutron pulse is introduced in a finite solid moderator assembly, the neutrons tend towards an equilibrium energy distribution. Since the leakage of neutrons depends upon the transport mean free path λ_{tr} which is a complicated function of energy, the equilibrium spectrum is seldom Maxwellian, the departure from Maxwellian distribution being larger for smaller assemblies.

Jha[15] has calculated the equilibrium spectrum in a few beryllium assemblies. Starting from Boltzmann diffusion equation

$$\left[\frac{1}{nv}\frac{\partial}{\partial t} + \sigma_a(E) + \sigma_s(E) - \frac{D(E)}{n}\nabla^2\right]\Phi(E,\vec{r},t)$$
$$= \int_0^\infty \sigma(E'\to E)\Phi(E',\vec{r},t)\,dE' \quad \ldots\ldots (19)$$

and assuming that the different variables are separable, he writes

$$\Phi(E,\vec{r},t) = \chi(E)R(\vec{r})T(t) \quad \ldots\ldots (20)$$

This leads to the following relations:

$$\nabla^2 R + B^2 R = 0 \quad \ldots\ldots (21)$$

$$\frac{dT}{dt} + \lambda T = 0 \quad \ldots\ldots (22)$$

and

$$\left[-\frac{\lambda}{nv} + \sigma_a(E) + \sigma_s(E) + \frac{DB^2}{n}\right]\chi(E)$$
$$= \int_0^\infty \sigma(E'\to E)\chi(E')\,dE' \quad \ldots\ldots (23)$$

where B^2 is an appropriate buckling for the assembly and λ is the decay constant.

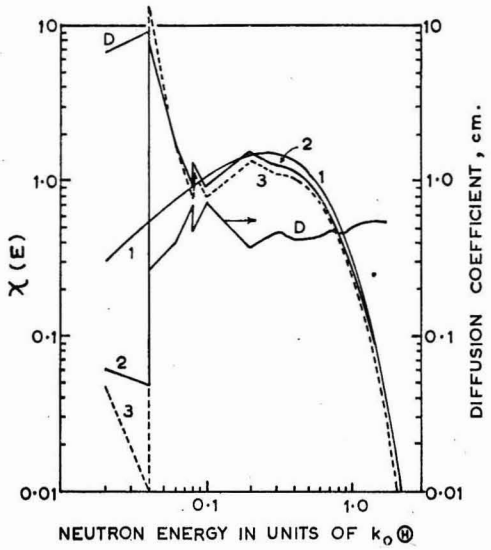

Fig. 4 — Equilibrium flux distribution for beryllium oxide [Curve 1, Maxwellian flux distribution; curves 2 and 3, equilibrium flux distributions for $B^2 = 3{\cdot}20\times10^{-2}$ and $4{\cdot}64\times10^{-2}$ cm.$^{-2}$ respectively; curve D gives the values of the diffusion coefficient $D = \lambda_{tr}/3$ (used in the calculations) as a function of neutron energy]

Instead of Eq. (23), Jha[15] considers a slightly modified equation

$$\left[-\frac{\lambda}{nv}+\sigma_a(E)+\sigma_s(E)+\frac{DB^2}{n}\right]\chi(E) = p\int_0^\infty \sigma(E'\to E)\chi(E')dE' \quad \ldots (24)$$

which is a homogeneous integral equation. Using an iteration procedure he determined that value of λ which gives $p = 1$. The corresponding values of $\chi(E)$ give the equilibrium neutron flux distribution. By plotting the calculated values of λ against B^2 and fitting a curve of the form given by Eq. (17) C can be determined. For beryllium a value of $C = 4\times10^5$ cm.^{4} sec.$^{-1}$ is obtained. Similar calculations have been made by Kothari and Khubchandani[16] for beryllium oxide. They reported a value for C of 5×10^5 cm.^{4} sec.$^{-1}$. The equilibrium flux distribution is shown Fig. 4.

The values of C obtained by this method and those obtained by the method discussed in section entitled 'Diffusion Cooling' do not agree. This only goes to show the very sensitive dependence of C on λ_{tr} and the equilibrium energy distribution.

Summary

Some cases where the influence of lattice structure on the diffusion of neutrons in a solid is particularly marked are considered. In particular, the variation of the transport mean free path with temperature, diffusion cooling constant and equilibrium energy distribution have been considered in some detail in the case of beryllium and beryllium oxide. The diffusion cooling constant is found to depend sensitively on the transport mean free path and the equilibrium energy distribution.

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References

1. Glasstone, S. & Edlund, M. C., *The elements of nuclear reactor theory* (Van Nostrand & Co., Princeton, New Jersey).
2. Bhandari, R. C., *J. nucl. Energ.*, **6** (1957), 104.
3. Singwi, K. S. & Kothari, L. S., *Proc. int. conf. peaceful uses of atomic energy*, Vol. 16 (United Nations, Geneva), 1958, 325.
4. Bhandari, R. C., Kothari, L. S. & Singwi, K. S., *J. nucl. Energ.*, **7** (1958), 45.
5. de Saussure, G. & Silver, E. G., *Nucl. Sci. Engng*, **6** (1960), 159.
6. Andrews, W. M., *Measurement of the temperature dependence of neutron diffusion properties in beryllium using pulsed neutron techniques*, Rep. UCRL-6083, 1960.
7. Sanatani, S. & Kothari, L. S., *Nucl. Sci. Engng*, **11** (1961), 211.
8. Sanatani, S., *Nucl. Sci. Engng*, **14** (1962), 318.
9. Jain, R. D. & Lawande, S. V., *Nucl. Sci. Engng*, **11** (1961), 228.
10. Kothari, L. S. & Singwi, K. S., *Solid State Phys.*, **8** (1958), 110.
11. Beckurts, K. H., *Nucl. Instrum. Methods*, **2** (1961), 144.
12. Poole, M. J., Nelkin, M. S. & Stone, R. S., *Progr. nucl. Energ. Sr.* 1, **2** (1958), 91.
13. Nelkin, M., *J. nucl. Energ.*, **8** (1958), 59.
14. Singwi, K. S. & Kothari, L. S., *J. nucl. Energ.*, **8** (1958), 59.
15. Jha, S. S., *J. nucl. Energ.*, **12A** (1960), 89.
16. Kothari, L. S. & Khubchandani, P. G., *Reactor Sci. Technol.*, **15** (1961), 30.

Some Aspects of Flow of Fluids & Heat Transfer Through Coiled Pipes: Non-Newtonian Fluids

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COILED pipes are used extensively in industry to handle corrosive liquids and slurries to be cooled in catalytic reactors. Therefore, the study of the fluid flow characteristics and heat transfer to non-Newtonian fluids in coiled pipes of variable and constant curvature ratios is of considerable importance.

For Newtonian fluids, direct proportionality between shear stress and rate of shear (Υ) is observed; whereas in the case of non-Newtonian fluids, the viscosity of a fluid is a function of many variables, such as the type of apparatus in which the fluid is contained, previous history of the liquid, rate of shear, temperature and pressure.

In this paper the work done so far on the time-independent non-Newtonian fluids has been reviewed. These fluids have been subdivided into: (i) Bingham plastic fluids, (ii) pseudoplastic fluids, and (iii) dilatant fluids.

Flow in Straight and Coiled Pipes

Bingham plastic fluids — For the flow of Bingham plastic fluids through straight pipes of circular cross-section, Hedström[1] has given a very convenient graphical equivalent for obtaining the pressure drop, viz.

$$c_f = \frac{D.\Delta P/4L}{u_m^2/2} = \phi\left(\frac{\rho u_m D}{\mu_p}, \frac{\tau_y \rho D^2}{\mu_p^2}\right)$$

According to the above correlation, friction factor is a function of Reynolds number, $\rho u_m D/\mu_p$ and Hedström group, $\tau_y \rho D^2/\mu_p^2$. Hedström plotted c_f against N_{Re}, taking plasticity number $\tau_y D/\mu_p u_m$ as one of the parameters and obtained the correlation

$$c_f = a\left(\frac{\rho u_m D}{\mu_p}\right)^b$$

where a and b are functions of Hedström number or plasticity number. The effect of curvature on pressure drop when a Newtonian fluid flows through coiled pipes has been discussed by the authors in an earlier communication[2], but no data are available for the flow of Bingham plastics through coiled pipes and data on pressure drop for Bingham plastics flowing through coiled pipes would provide interesting information.

The conventional equation used for estimating the friction factor for straight pipes has to be modified to include the curvature ratio term, to account for the effect of curvature. When a Newtonian fluid flows through a coiled pipe, the onset of turbulence is delayed. The analogous situation when a non-Newtonian fluid flows through coiled pipes has not yet been established. In the case of these liquids, the onset of turbulence may be offset or enhanced and it may or may not be a function of curvature ratio of the coil. The nature of the curvature ratio of the coil, i.e. whether it is variable or constant, is also important in deciding the criterion for the onset of turbulence. Correlations for laminar and turbulent flow have to be established including the curvature ratio in both types of flow. The relative index of curvature ratio should be capable of giving an insight into the contribution of centrifugal forces (curvature) in different types of flow. Therefore, for laminar flow, the following dimensionless equation is indicated:

$$c_f = \phi\left(\frac{\rho u_m D}{\mu_p}, \frac{\tau_y \rho D^2}{\mu_p^2}, \frac{D_i}{D_c}\right)$$

Pseudoplastic fluids — The flow equation for pseudoplastic fluids is

$$\tau = k\Upsilon^n$$

where k and n are constants, being the consistency index and the flow behaviour index respectively. The flow behaviour index is a measure of the degree of non-Newtonian behaviour and the greater the departure from unity the more pronounced are the non-Newtonian properties of the fluid.

Metzner and Reed[3] have taken the generalized Reynolds number given by

$$N_{Re'} = \frac{D^{n'} u_m^{2-n'} \rho}{k' 8^{n'-1}}$$

as the basis for calculation and plotted c_f versus $N_{Re'}$ on a log-log paper for about 18 non-Newtonian liquids. They obtained the following correlations:

Laminar flow: $c_f = 16/N_{Re'}$

Turbulent flow: $c_f = 0{\cdot}00140 + 0{\cdot}125/(N_{Re'})^{0{\cdot}32}$

Weltmann[4] proposed a correlation, defining Reynolds number by

$$N_{Re} = \frac{D u_m \rho}{\text{viscosity}}$$

where viscosity refers to Newtonian viscosity for Newtonian fluids; μ_p represents plastic viscosity for a Bingham plastic; and μ_a, the apparent viscosity for a pseudoplastic or dilatant fluid. The correlation obtained was

$$c_f = \frac{16}{N_{Re}}\left(\frac{3n+1}{4n}\right)$$

For turbulent flow, Dodge and Metzner[5] proposed the following correlation:

$$c_f = 0{\cdot}079/(n^5 N_{Re}^{\gamma})$$

where $\gamma = 2{\cdot}63/(10{\cdot}5)^n$ for the range $n = 0{\cdot}53$-$1{\cdot}0$. For $n = 1$, the correlation is $f = 0{\cdot}079/(N_{Re})^{1/4}$. Dodge and Metzner[5] found theoretically that for fluids of power law type

$$1/\sqrt{c_f} = A \log_{10}[N_{Re'} c_f^{(1-n')/2}] + B$$

where the coefficient A and constant B are functions of n' alone

$$N_{Re'} = \frac{D^{n'} u_m^{2-n'} \rho}{k' 8^{n'-1}}$$

where $A = 4{\cdot}0/(n')^{0{\cdot}75}$ and

$$B = \frac{1}{\sqrt{c_f}} - \frac{4{\cdot}0}{(n')^{0{\cdot}75}} \log_{10}[N_{Re'} c_f^{(1-n')/2}] - \frac{0{\cdot}4}{(n')^{1{\cdot}2}}$$

No data are available on the flow of non-Newtonian fluids through coiled pipes except those reported by Rajasekharan *et al.*[6] who conducted pressure drop measurements in an alkathene spiral, when a pseudoplastic fluid (0·2 per cent solution of sodium carboxymethyl cellulose) flows through it and arrived at the following conclusions: (1) Friction factors for the same generalized Reynolds number increase with increase in the variable curvature ratio; (2) friction factors for Newtonian fluids flowing in a spiral are greater than those for a non-Newtonian fluid flowing in the same spiral; (3) friction factors for a non-Newtonian fluid flowing through a spiral tube coil are greater than the friction factor for the same fluid flowing through a straight tube of the same diameter; and (4) the difference in the values of friction factors for non-Newtonian fluids flowing through straight and coiled pipes of variable curvature ratios are very sharp in higher ranges of generalized Reynolds number.

The above conclusions indicate that there is wide scope for further work in this field. The pressure drop data for non-Newtonian fluid flow in coiled pipes of constant and variable curvature ratios can be analysed as follows:

For coils of constant curvature ratios:

Laminar flow: $f = F(N_{Re'}, D_i/D_c)$

Turbulent flow: $f = F(N_{Re'}, D_i/D_c)$

For coils of variable curvature ratios:

$$\text{Laminar flow: } f = F\left[N_{Re'}, \Delta\left(\frac{D_i}{D_c}\right) \text{ or } \left(\frac{D_i}{D_c}\right)_{\text{av.}}\right]$$

$$\text{Turbulent flow: } f = F\left[N_{Re'}, \Delta\left(\frac{D_i}{D_c}\right) \text{ or } \left(\frac{D_i}{D_c}\right)_{\text{av.}}\right]$$

The curvature ratio term in the correlations for different types of flow will have different exponents depending upon the relative contribution of the effect of curvature on the pressure drop values.

Onset of Turbulence in Non-Newtonian Fluid Flow

When a Newtonian fluid flows through coiled pipes the onset of turbulence is delayed. Kubair and Varrier[7] derived an empirical correlation to serve as a criterion for the onset of turbulence in helical coils. Kubair and Kuloor[8] applied a similar approach to spiral coils (coils of variable curvature ratios) and found that the same criterion holds provided the average curvature ratio is considered. When a non-Newtonian fluid of Bingham plastic type flows through a straight pipe of circular cross-section, if

$$N_{Re} = \frac{\rho u_m D}{\mu_p}$$

then

$$(N_{Re})_{Cr} = f\left(\frac{\tau_y D^2 \rho}{\mu_p^2} \text{ or } N_{He}\right)$$

Therefore, the onset of turbulence when a non-Newtonian fluid flows in a straight pipe is delayed and there is no empirical method to estimate the magnitude of the delay.

When a non-Newtonian fluid of Bingham plastic type flows through a coiled pipe, the effect of curvature also comes into play along with the effect of Hedström number or plasticity number. Therefore, the criterion for the onset of turbulence in this case can be represented as

Helical coils: $(N_{Re})_{Cr} = F(D_i/D_c, N_{He} \text{ or } N_{Pl})$

Spiral coils: $(N_{Re})_{Cr} = F[(D_i/D_c)_{\text{av.}}, N_{He} \text{ or } N_{Pl}]$

For pseudoplastics it has been shown by Weltmann[4] that if

$$N_{Re'} = \frac{D^{n'} V^{2-n'} \rho}{k' 8^{n'-1}}$$

then $(N_{Re'})_{Cr} = F(n)$

According to Metzner and Reed[3], turbulence occurs when the value of friction factors falls below 0·008.

Dodge and Metzner[5] have shown that the value of $(N_{Re'})_{Cr}$ increases with fall in the value of n', but they could not arrive at a generalized criterion.

When a non-Newtonian fluid flows through a coiled pipe, the onset of turbulence is influenced by the combined effects of curvature and flow behaviour index (n'). Therefore, the criterion for the onset of turbulence for coiled pipes is

Helical coils: $(N_{Re'})_{Cr} = F(n', D_i/D_c)$

Spiral coils: $(N_{Re'})_{Cr} = F[n', (D_i/D_c)_{\text{av.}} \text{ or } \Delta(D_i/D_c)]$

Heat Transfer to Non-Newtonian Fluids in Straight and Coiled Pipes

There is little published information on heat transfer to non-Newtonian fluids flowing through straight pipes of circular cross-section, very little on straight pipes of non-circular cross-section, and none on heat transfer to non-Newtonian fluids in coiled pipes.

Laminar flow — For piston flow the approximate solution of the equation

$$u \frac{\partial \theta}{\partial z} = \alpha \left[\frac{\partial^2 \theta}{\partial r^2} + \frac{1}{r} \frac{\partial \theta}{\partial r}\right], \text{ where } \theta = \frac{T - T_0}{T_1 - T_0}$$

is given by

$$N_{Nu} = \frac{2}{\pi} \frac{WC_p}{KL} \left\{\frac{1-4S}{1+4S}\right\}$$

where S is the velocity of the slip.

For high values of Graetz number

$$\frac{h_{\text{av.}} D}{K} = \frac{8}{\pi} + \frac{4}{\pi} \left(\frac{WC_p}{KL}\right)^{1/2}$$

Pigford[9] extended Leveque's approximation of Newtonian systems and showed that

$$\frac{h_{\text{av.}} D}{K} = 1{\cdot}75 \left(\frac{3n'+1}{4n'}\right)^{1/3} \left(\frac{WC_p}{KL}\right)^{1/3}$$

In these equatins, the problem of heat transfer with constant wall temperature, corrections for

natural convection must be included. Metzner *et al.*[10] excluded natural convection effects and suggested that if $N_{Gz} > 20$, $n' > 0{\cdot}10$

$$\frac{h_a D}{K\delta^{1/3}}\left(\frac{\gamma_w}{\gamma}\right)^{0{\cdot}14} = 1{\cdot}75\left(\frac{WC_p}{KL}\right)^{1/3}$$

where

$$\delta = \frac{3n'+1}{4n'}$$

If $N_{Gz} < 20$ and $n' < 0{\cdot}10$, then

$$\frac{h_a D}{K\Delta^{1/3}}\left(\frac{\gamma_w}{\gamma}\right)^{0{\cdot}14} = \phi$$

where

$$\phi = \frac{h_a D}{K}\left(\frac{\gamma_w}{\gamma}\right)^{0{\cdot}14}$$

for Newtonian fluids at same Graetz number. Grigull and McAdams[11] gave a graphical presentation of ϕ, and Grigull, that of $\Delta^{1/3}$. Superposition of the effects of natural convection on heat transfer to non-Newtonian fluids was attempted by Metzner and Gluck[12] and they obtained the following correlation:

$$\frac{h_a D}{K\delta^{1/3}}\left[\frac{\gamma_w}{\gamma}\right]^{0{\cdot}14} = 1{\cdot}75\left[N_{Gz}+12{\cdot}6(N_{Pr_W}N_{Gr_W}D/L)^{0{\cdot}4}\right]^{1/3}$$

In the above correlation it is necessary to evaluate the viscosity and shear rate at wall temperatures since for most non-Newtonian systems, the viscosity is least at this temperature. The natural convection effect is important in laminar flow and if it is ignored, entirely different values of heat transfer coefficients are obtained. Even the correlation of Metzner and Gluck has to be verified with exhaustive experimental data. Under conditions of constant heat flux, very little data are available except those due to Schenk[13] and van Laar[14]. As a whole, very little work has been done so far on heat transfer to non-Newtonian fluids through straight pipes of circular cross-section.

There are no data for heat transfer to non-Newtonian fluids through coiled pipes. The approach applicable to straight pipes can be extended on the following lines to coiled pipes.

Coils of constant curvature ratios — In the case of these coils,

$$\frac{h_{av}D}{K} = F(N_{Gz},\ n',\ D_i/D_c)$$

In this correlation the effects of natural convection are ignored. However, if the effects of natural convection are considered, the following correlation is obtained:

$$N_{Nu} = F(N_{Gz},\ N_{Pr},\ N_{Gr},\ L/D,\ n',\ D_i/D_c)$$

Coils of variable curvature ratios — If the effects of natural convection are considered, then

$$\frac{h_{av}D}{K} = F[N_{Gz},\ N_{Gr},\ N_{Pr},\ \Delta(D_i/D_c)\ \text{ or }\ (D_i/D_c)_{av.},\ L/D,\ n']$$

If the effects of natural convection are excluded,

$$\frac{h_{av}D}{K} = F[N_{Gz},\ \Delta(D_i/D_c)\ \text{or}\ (D_i/D_c)_{av.},\ n']$$

Turbulent Flow Through Straight Pipes

Fluids exhibiting slight non-Newtonian behaviour — Winding *et al.*[15] and Orr and Dalla Valle[16] investigated the heat transfer characteristics of suspensions and derived the following correlation:

$$\frac{hD}{K} = 0{\cdot}023(N_{Re})^{0{\cdot}8},\ (N_{Pr})^{0{\cdot}33}\left(\frac{\mu}{\mu_w}\right)^{0{\cdot}14}$$

Fluids exhibiting pronounced non-Newtonian behaviour — Metzner *et al.*[10] suggested the equation

$$\frac{hD}{K} = 0{\cdot}023\left(\frac{D^{n'}u_m^{2-n'}\rho}{m}\right)^{0{\cdot}8}\left[\frac{mC_p}{K}\left(\frac{u_m}{D}\right)^{n'-1}\right]^{0{\cdot}4}\left(\frac{m}{m_w}\right)^{0{\cdot}14}$$

where

$$\mu_a = m\left(\frac{u_m}{D}\right)^{n'-1} \quad \text{and} \quad m = k'8^{n'-1}.$$

However, there are no experimental data to verify the validity of this correlation. Clapp[17] suggested for turbulent flow

$$N_{Nu} = 0{\cdot}023(9350)^{0{\cdot}8(1-n-n_1)}(N_{Re'})^{n'0{\cdot}8/n}(N_{Pr'})^{0{\cdot}4}$$

for $0{\cdot}698 < n < 0{\cdot}786$ and $5480 < (N_{Re'}) < 29{,}200$.

Based on similarity principle, Tomita[18] derived the following heat transfer correlation for pseudoplastic and dilatant fluids.

Pseudoplastic fluids:

Natural convection: $N_{Nu} = f_1(N_{Gr^*};\ N_{Pr_2^*})$

Forced convection: $N_{Nu} = f_2(N_{Re^*};\ N_{Pr_1^*})$

Bingham plastics:

Natural convection: $N_{Nu} = f_3(N_{Gr}, N_{Pr}, C_{N_{Gr}}, C_{N_{Pr}})$

Forced convection: $N_{Nu} = f_4(N_{Re}, N_{Pr}, C_{N_{Re}}, C_{N_{Pr}})$

where

$$N_{Re^*} = \frac{\rho u^{(2n-1)/n}\, l^{1/n}}{(\mu_{p_{su}})^{1/n}}$$

$$N_{Pr_1^*} = \frac{C \times \mu_{p_{su}}^{1/n}\, l^{(n-1)/n}}{\lambda u^{(n-1)/n}}$$

$$N_{Pr_2^*} = \frac{\rho^{(n-1)/n}\, l^{(2n-1)/n} \times \mu_{p_{su}}^{1/n}\, l^{(2n-2)/n}}{\lambda^{(2n-1)/n}}$$

Coiled pipes — Since no data are available for coiled pipes, the approach to straight pipes can be extended to coiled pipes. The following equations can be derived.

Coils of constant curvature ratios:

$$N_{Nu} = F(N_{Re^*},\ N_{Pr^*},\ D_i/D_c)$$

Coils of variable curvature ratios:

$$N_{Nu} = F[N_{Re^*},\ N_{Pr^*},\ \Delta(D_i/D_c)\ \text{or}\ (D_i/D_c)_{av.}]$$

Secondary Flows in Coiled Pipes

Kubair and Kuloor[19] have shown that diametrical pressure drop in Newtonian fluids flowing through helical coils is a measure of the intensity of secondary circulation and it depends on factors like length to diameter ratio and curvature ratio of helical coil. Analogous generalizations in the case of non-Newtonian fluids flowing through helical and spiral coils have yet to be arrived at. The effect of curvature on the secondary flows in coiled pipes is more pronounced in laminar flow.

Analogy Equations

The analogy between heat and momentum transfer in turbulent flow was extended to non-Newtonian systems by Metzner and Friend[20]. The following correlation was derived:

$$N_{St} = \frac{f/2}{1{\cdot}20+11{\cdot}8\sqrt{f/2}\,(N_{Pr_w}-1)\,N_{Pr_w}} - 0{\cdot}33$$

where

$$\frac{N_{Pr'}}{N_{Pr_w}} = \left[\frac{16}{(N_{Re'})f}\right]^{(n'-1)/n'} - \left(\frac{3n'+1}{4n'}\right)$$

For coiled pipes the analogy equations have to be modified incorporating the effect of secondary flows due to centrifugal action.

Summary

The correlations available for calculating the pressure drop during the flow of non-Newtonian fluids through straight pipes have been critically reviewed and an attempt has been made to apply the correlations to coiled pipes with suitable modifications. Data on pressure drop, when carboxymethyl cellulose solution flows through alkathene spiral, have been analysed and the effect of curvature on pressure drop values during the flow of a non-Newtonian fluid through coiled pipes has been discussed. The scope for further work has been indicated with suitable and similar approaches applicable to straight pipes. Correlations for heat transfer in straight pipes have also been reviewed and scop fore further work has been indicated.

Nomenclature

f or c_f	= friction factor from $\Delta H = \frac{2c_f L V^2}{g_c D_i}$
V	= velocity
L	= length
D_i	= diameter of the tube
ΔH	= head loss
D_c	= diameter of the coil
D_i/D_c	= curvature ratio of the coil
(D_i/D_c)av.	= average curvature ratio of the spiral coil
$\Delta(D_i/D_c)$	= change in curvature ratio
τ	= shear stress
τ_w	= shear stress at the wall
n	= flow behaviour index
k	= consistency index
μ_a	= apparent viscosity
μ_p	= viscosity of a Bingham plastic
ρ	= density of the fluid
n'	= exponent in $\left[\frac{d\ln(8u_m/D)}{d\ln(D\Delta P/L)}\right]$
k'	= coefficient in the equation $\tau_w = k'(8u_m/D)^{n'}$
S	= velocity of the slip
u_m	= mean velocity
ha	= heat transfer coefficient based on arithmetic mean temperature difference
β	= volumetric coefficient of thermal expansion
δ	= ratio of non-Newtonian to Newtonian wall shear rates at a given flow rate
$\Delta^{1/3}$	= ratio of non-Newtonian to Newtonian heat transfer coefficients
μ_w	= viscosity at wall conditions of shear rate and temperature
γ_w	= fluid consistency at wall temperature
$N_{Re'}$	= generalized Reynolds number
N_{He}	= Hedström number
N_{Pl}	= plasticity number
N_{Gr}	= Grashof number
N_{Pr}	= Prandtl number
N_{Gz}	= Graetz number
L	= heated length of the tube
W	= mass flow rate
K	= thermal conductivity
$C_{N_{Re}}$	= $l\tau_y/\mu_B.\mu$
$C_{N_{Pr}}$	= $l^2\tau_y c\rho/\lambda\mu_B$
$C_{N_{Gr}}$	= $\rho g\beta l\Delta T/\tau_y$
C_p or C	= specific heat at constant pressure
g	= acceleration due to gravity
l	= representative length
n	= rheological constant
ΔT	= temperature difference
u	= representative velocity
λ	= thermal conductivity
μ_{su}	= pseudoplastic viscosity of fluid
τ_y	= yield value of shearing stress
μ_B	= viscosity of Bingham fluid
θ	= dimensionless temperature

References

1. Hedström, B. O. A., *Industr. Engng Chem.*, **44** (1952), 651.
2. Kubair, V. & Kuloor, N. R., *J. sci. industr. Res.*, **22** (1963), 499.
3. Metzner, A. B. & Reed, J. C., *Amer. Inst. chem. Engrs J.*, **1** (1955), 434.
4. Weltmann, R. N., *Industr. Engng Chem.*, **48** (1956), 386.
5. Dodge, D. W. & Metzner, A. B., *Amer. Inst. chem. Engrs J.*, **5** (1959), 181.
6. Rajasekharan, S., Kubair, V. & Kuloor, N. R., *Indian J. Technol.*, **2** (1964), in press.
7. Kubair, V. & Varrier, C. B. S., *Trans. Indian Inst. chem. Engrs*, **14** (1961-62), 93.
8. Kubair, V. & Kuloor, N. R., *Indian J. Technol.*, **1** (1963), 336.
9. Pigford, R. L., *Chem. Engng Progr. Symp. Serv.* No. 17, **51** (1955), 79.
10. Metzner, A. B., Vaughn, R. D. & Houghton, G. L., *Amer. Inst. chem. Engrs J.*, **3** (1957), 92.
11. Grigull, U. & McAdams, W. H., cited in Metzner, A. B., Vaughn, R. D. & Houghton, G. L., *Amer. Inst. chem. Engrs J.*, **3** (1957), 92.
12. Metzner, A. B. & Gluck, D. F., *Chem. Engng Sci.*, **12** (1960), 185.
13. Schenk, J., cited in Metzner, A. B. & Gluck, D. F., *Chem. Engng Sci.*, **12** (1960), 185.
14. van Laar, J., cited in Metzner, A. B. & Gluck, D. F., *Chem. Engng Sci.*, **12** (1960), 185.
15. Winding, C. C., Dittmann, F. W. & Kranich, W. L., *Annu. Rep. Cornell Univ.*, 1944.
16. Orr, C. & Dalla Valle, J. M., *Chem. Engng Symp. Serv.* No. 9, **50** (1954), 29.
17. Clapp, R. M., *International developments in heat transfer*, Part III, ASME Publication, 1961, 652.
18. Tomita, Y., *Kagaku Kogaku*, **23** (1959), 66.
19. Kubair, V. & Kuloor, N. R., *Indian J. Technol.*, **1** (1963), 333.
20. Metzner, A. B. & Friend, P. S., *Industr. Engng Chem.*, **51** (1959), 879.

Capparis moonii Wt.: A Reinvestigation of Its Identity & Value as a Drug

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CAPPARIS MOONII Wt. (Pl. I), practically unknown earlier for its medicinal value, has now attained some prominence as a drug useful in the treatment of tuberculosis and puerperal sepsis. Krishnamurthy[1] reported, for the first time, on the curative properties of these fruits in the treatment of tuberculosis, and in a recent symposium Sheth and Krishnamurthy[2] provided additional clinical data in support of their claim. As against this, the efficacy of *Capparis moonii* was doubted by many workers[3-5] (Bhatnagar, S. S., personal communication) besides Mukerji and Gupta[6] who carried out *in vitro* tests against *Mycobacterium tuberculosis* and *in vivo* tests involving experimentally induced tuberculosis in guinea-pigs. Prof. Pershin[4], Chemopharmaceutical Scientific Research Institute, USSR, has reported that these fruits failed to show any chemotherapeutic action in experimentally induced tuberculosis in mice. At the K.G. Medical College, Lucknow, the drug was administered to 10 patients involving both treated and untreated cases of chronic pulmonary tuberculosis. A preliminary report[5] on the treatment reveals that the drug has little effect on the natural course of pathology of tuberculosis; in fact, one of the patients developed symptoms of hypersensitive reaction, namely itching, mental irritation and insomnia, after five days of treatment. Negative results were obtained by the Hamdard Waqf Laboratories, Delhi, working with fruits obtained from Khandala (personal communication). In spite of all this evidence, tablets prepared from powdered immature fruits of *C. moonii* are being sold in the market under the trade name 'Rudanil' and 'Capyna'.

Often research workers working on the therapeutic value of indigenous drugs are not sufficiently aware of the importance of initially determining the correct botanical identity of the plants taken up for investigation. Sheth and Krishnamurthy[7] claimed that there are two varieties of *C. moonii* involved, namely a 'Khandala' variety occurring in Maharashtra and another 'Konkan' variety growing in Mysore. The 'Konkan' variety was reported by these workers to be therapeutically more active than the 'Khandala' variety and that there were a few morphological differences between the leaves and the fruits of these varieties. Blatter[8] has recorded, besides *C. moonii*, a new variety *C. moonii* var. *tomentosa* Blatt. & Hallb., as occurring in Khandala. According to Shah and Sukkawala[9], the 'Konkan' variety is only *C. horrida* Linn. f. and the medicinal properties hitherto attributed to the 'Konkan' plants are really due to *C. horrida* only. Further, Krishnamurthy has coined the Sanskrit name *Rudanti* for *C. moonii*, not quite realizing the inappropriateness of selecting a new name when another medicinal plant is already known under the same Sanskrit name. *Cressa cretica* Linn. (Convolvulaceae), a plant quite unrelated to *Capparis moonii*, is known as *Hrudanti* or *Rudanti* (one that sheds tears) in various Ayurvedic works. Thus, quite apart from the therapeutic value of the fruits, the Sanskrit name has created certain confusion regarding the botanical identity of this plant.

The term 'Konkan' as used by Krishnamurthy is rather unfortunate. Shri R. S. Vats, one of the suppliers of crude drugs, states that his collections of *Capparis* fruits had not only been obtained from Khandala but also from Nagothane, Ramraj and other neighbouring areas in Kolaba district (Konkan), and that Konkan actually starts from just below the old reversing station at Khandala. This implies that the geographical range of the 'Konkan' and 'Khandala' varieties actually overlaps, and when collections are made in such a mixed condition from localities between Nagothane and Khandala, there is a possibility that the fruits of the same group have been analysed under two different names as no morphological distinction in the fruits of these two 'varieties' is possible. Later, Krishnamurthy (personal communication) indicated that by the term 'Konkan' variety* he had actually meant plants collected from the coastal regions of North Kanara (Kumpta, Shirali, Bhatkal, etc.) in Mysore State.

Present Studies

The present investigation was undertaken covering three aspects of the problem. The primary object was to clarify the botanical identity of the plant involved and determine whether a mixture of two or more species of *Capparis* was involved in the samples used for clinical trials. Secondly, samples of fruits of the 'Konkan' variety were obtained from various individuals who worked on them and from those who were directly or indirectly connected with the clinical investigations, to ascertain whether the material investigated was identical with the fruits collected by the authors from the forest areas. Field trips were undertaken to various localities in North Kanara to study *C. moonii* and the related species in their natural habitat. Finally, fresh fruits of *C. moonii* ('Konkan' variety of Krishnamurthy) were collected from the very

*The term 'variety' as applied in the paper is not used in the botanical sense but in the same meaning as used by Krishnamurthy. Again, the term 'Konkan' variety is used exclusively to denote collections from North Kanara in Mysore State; all the other collections of *C. moonii* from Khandala and neighbouring areas are referred to as 'Khandala' variety only. This has been adopted for easy explanation without introducing any new regional name as 'North Kanara'. It may, however, be emphasized that the fruits collected from North Kanara and Krishnamurthy's so-called 'Konkan' variety are one and the same.

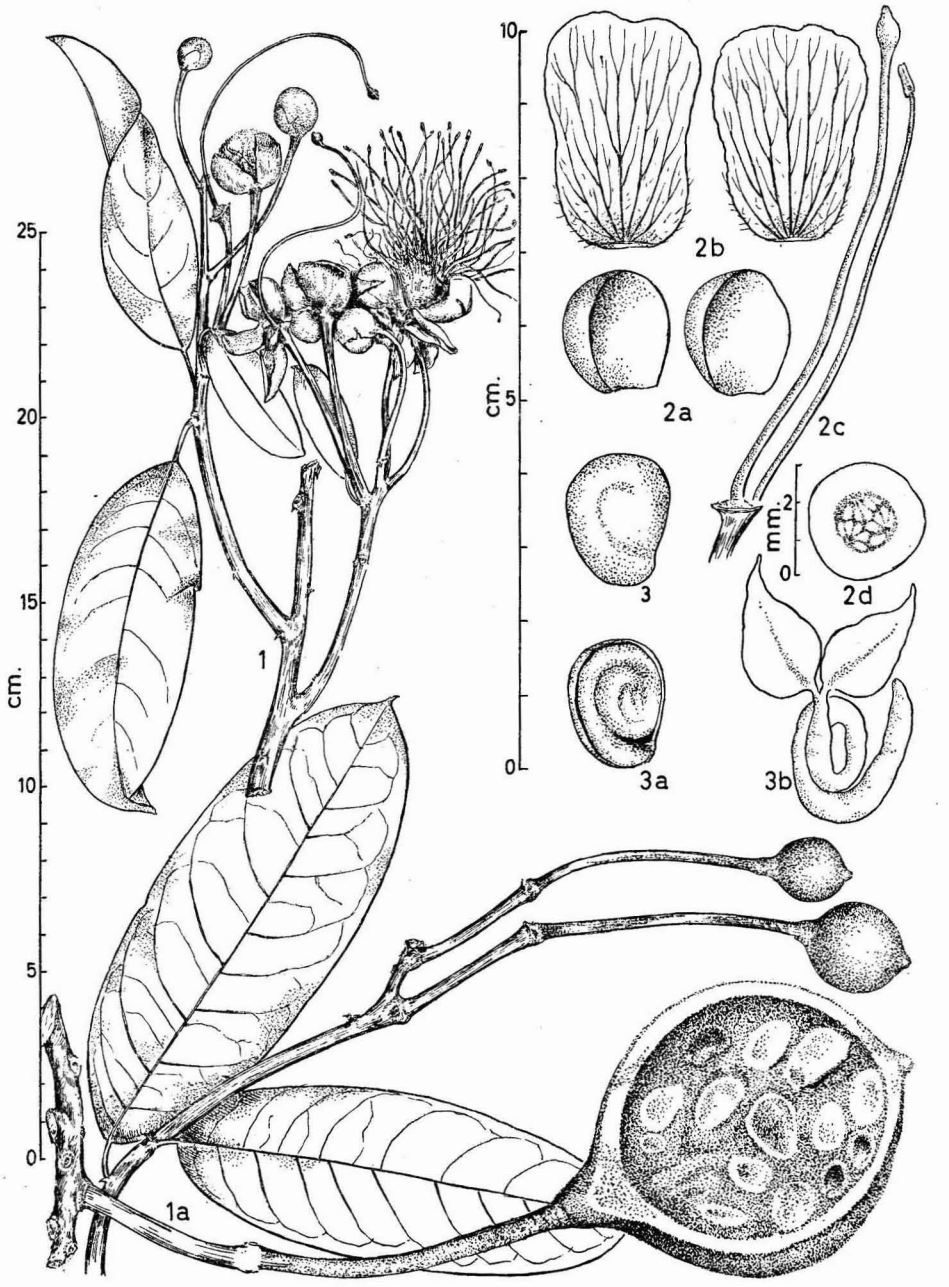

PLATE I — *Capparis moonii* Wt. [Fig. 1: A flowering twig. Fig. 1a: A fruiting twig with two immature fruits and another with the fruit cut exposing the seeds. Fig. 2a: An outer and an inner sepal. Fig. 2b: An outer and an inner petal. Fig. 2c: A stamen and ovary with gynophore. Fig. 2d: C.s. of ovary. Fig. 3: Seeds. Fig. 3a: Seed with seed coat partly removed exposing coiled embryo. Fig. 3b: Mature embryo]

localities in North Kanara involving the same group of plants and from the samples for which Krishnamurthy reported tuberculostatic activity. All the samples were sent without any delay for trials to different institutions for a re-examination of their therapeutic value.

As a result of the above studies, it can now be definitely concluded that all the samples of the drug supplied by Shri A. V. Modi, Unichem Laboratories, Bombay (' Konkan ' variety), and Shri R. S. Vats (' Khandala ' variety) to Haffkine Institute, Bombay, National Chemical Laboratory, Poona, and the Central Drug Research Institute, Lucknow, are referable to only *C. moonii* Wt. Much of the present confusion is due to the loose application of the term ' variety '. A scrutiny of Mahdihassan's[10] description and figures of *Capparis moonii* collected from North Kanara (Pl. I) clearly points out to the correctness of his identity. In fact, the specimens originally collected by Krishnamurthy from Bhatkal in North Kanara were identified in 1955 both by Dr Santapau (at present Director, Botanical Survey of India, Calcutta) and Sir Edward Salisbury (then Director, Royal Botanic Gardens, Kew, England) as *C. moonii* Wt. only. A careful examination of the specimens sent to us by the Director, Haffkine Institute, Bombay, Messrs Anu Pharma Ltd, Bombay, Dr Krishnamurthy (Balabhai Nanavati Hospital, Bombay), Range Forest Officer, Kumpta (North Kanara), and Shri Bajpai from Sirsi (North Kanara) under the label ' Konkan ' variety confirms that only *C. moonii* Wt. has figured in all the clinical investigations. It appears that Shah and Sukkawala[9] have based their observations on immature young fruits of *C. moonii* and in all probability confused these with mature fruits of *C. zeylanica* Linn. (syn. *C. horrida* Linn. f.). After failing to get samples from Shah, Shri A. V. Modi, who had supplied fruits to Shah, was approached for similar samples and from a detailed study of the young twigs and fruits obtained from Shri Modi it was evident that the fruits belonged to *C. moonii* only.

Botanical Identity of the Drug Samples

The validity of the above observations is borne out by extensive field data gathered at Khandala and in North Kanara areas where this species occurs wild. In North Kanara (Shirali, Kumpta, Bhatkal and Chitrapuri) these plants, locally known as ' Luthikai ', grow at an altitude of 150 m. on exposed hillocks in laterite soil, nearly 8-25 km. away from the seashore, in close association with *C. zeylanica* Linn. (syn. *C. horrida* Linn. f.) and *C. heyneana* Wall. The local plant collectors and contractors who supply the fruits of these plants to the Bombay market are very clear as to the identity of these plants and can readily identify them in their natural habitat even in the vegetative condition. This fact, as also a careful study of the large quantities of fruits (Fig. 1) gathered by the local forest department at Kumpta for supply to Bombay drug firms, convinced us that there was no question of mixture of two or more species of *Capparis* involved at any time. Mature fruits of *C. moonii* (Fig. 1) are quite distinct and can never be confused with any other closely related species.

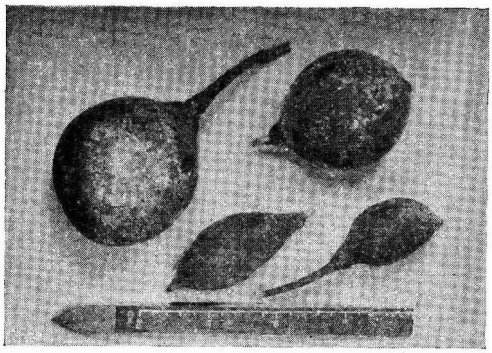

Fig. 1 — Young and mature fruits of *Capparis moonii* Wt. showing variations in shape

In order to clarify the botanical variations, if any, between ' Khandala ' and ' Konkan ' varieties of *C. moonii*, a critical study of both the living and the herbarium specimens was made. The plants growing in North Kanara do show some minor variations when compared to the Khandala plants, but these fall within the normal range of variation expected of a species growing in different habitats. The North Kanara plants exhibit more bushy and luxuriant growth, leaves are slightly larger, shoots somewhat pubescent and the fruits range from subglobose or globose types with rounded apex to occasional ellipsoid forms tapering at both ends. The Khandala plants are scandent shrubs ascending up to 8-10 m. wherever there is good support, leaves less robust, young shoots slightly pubescent or even glabrous and late flowering. In both areas, the plants assume a bushy habit whenever they grow on exposed rocky areas and in one and the same plant young shoots are practically unarmed whereas the older shoots are densely spiny. The degree of pubescence in the young shoots is highly variable and is not always reflected in the herbarium specimens. A study of the plants growing at Khandala shows that most of the plants are only slightly puberulous or even glabrous, but those growing in open areas develop a slightly more hairy nature. It is evidently based on this one character that Blatter[8] has described a new variety *Capparis moonii* var. *tomentosa* Blatt. & Hallb., which is only a slightly more tomentose form of *C. moonii*. Also, Santapau[11] has not indicated any such variety in this species. Further, the early flowering nature of the North Kanara plants is probably due to the low altitude, close proximity to the sea and higher day temperature. On the basis of the evidence gathered from field data and a critical study of all the herbarium specimens from the Central National Herbarium, Calcutta, Blatter Herbarium, Bombay, and the Regional Herbaria of the Botanical Survey of India at Poona and Coimbatore, it is clear enough that the various varieties of *C. moonii* are untenable from the botanical viewpoint.

While working on *Capparis moonii* two other allied species of *Capparis* normally confused with *C. moonii* have been worked out and a detailed botanical note clarifying the botanical identity of all the three species is being published elsewhere.

Tuberculostatic Activity of the Drug Samples: *In vitro* and Animal Experiments

Fruits of *C. moonii* (Fig. 1) in all stages of development were collected from Kumpta and Shirali in North Kanara, dried as whole fruits in shade, pulverized and sent without any delay to the Haffkine Institute, Bombay, Central Drug Research Institute, Lucknow, and Sarabhai Research Institute, Ahmedabad, for clinical trials. In view of Krishnamurthy's contention that the 'Konkan' fruits are more efficacious than the 'Khandala' samples and the possibility that all the earlier investigations were carried out with a mixture of material from 'Konkan' and 'Khandala', in the present study only the 'Konkan' fruit material was used. Also, as Bundeally and Bellare[12] had reported that the 'Konkan' variety exhibited some tuberculostatic activity, fresh fruits of the 'Konkan' variety were supplied to all the investigators.

Trials were carried out at the Central Drug Research Institute, Lucknow, with guinea-pigs which were infected intramuscularly with 0·1 mg. (moist weight) of *Mycobacterium tuberculosis* var. *hominis* strain $H_{37}Rv$ and immediately put on *Capparis moonii* (by the 'drug-diet' method) at levels of 888, 444 and 222 mg./kg. body weight for 90 days. Average necropsy scores in different groups were 8·16, 9·41 and 9·42 as compared to 7·28 for the infected untreated control group of animals. These results show that *C. moonii* has no effect in experimental tuberculosis of guinea-pigs (Director, Central Drug Research Institute, Lucknow, personal communication). A recent report[13] published by the Haffkine Institute, Bombay, also shows that feeding of dried whole fruits to guinea-pigs experimentally infected with tuberculosis failed to show any curative action and that all organs of the animals treated with *Capparis* fruits showed signs of progressive tuberculosis similar to infected untreated controls.

Aqueous extracts of the whole fruit and of the fruit kept in powdered form were also examined at the Haffkine Institute, Bombay, for their *in vitro* tuberculostatic activity. The extract of the whole fruit inhibited the growth of tubercle bacilli between the dilution range 1:10 and 1:50, whereas the extract of powdered fruit exhibited inhibitory activity only below 1:10 dilution. These results confirmed the earlier findings[12] that aqueous extracts of the fruit possess antitubercular activity of a very low order (Director, Haffkine Institute, Bombay, personal communication). Experiments carried out at the laboratories of Squibb Institute for Medical Research, New Brunswick, New Jersey, with authentic samples of 'Khandala' fruits of *C. moonii* have indicated that the fruits have a very low tuberculostatic effect *in vitro*, but trials with animals yielded negative results (Dr Varadarajan, Sarabhai Research Institute, Ahmedabad, personal communication). According to Dr Varadarajan, similar results were obtained with the 'Konkan' fruits also, and hence the plant is not of any pharmaceutical interest.

The above reports conclusively prove that both the 'Khandala' and 'Konkan' varieties of *C. moonii* fruits have a very low tuberculostatic activity *in vitro* and have no effect on experimentally induced tuberculosis in animals. Even this low activity exhibited in *in vitro* experiments was completely lost on storage either as whole fruits or in powdered form, and fruits stored for one year or more had no inhibiting effect even at the highest concentration.

In view of the report of Shah and Sukkawala[9] that the 'Konkan' variety of *C. monii* is referable to *C. zeylanica* Linn. (syn. *C. horrida* Linn. f.) fruits of *C. zeylanica* were also collected from Poona (Maharashtra) and Gajanoor (Shimoga District, Mysore State). Three samples of fruits, representing young and mature fruits collected from Poona and a mixed collection of fruits (in all stages of maturity) collected from Gajanoor, were powdered separately and sent to the Central Drug Research Institute, Lucknow, for trials. *In vitro* tests against *M. tuberculosis* $H_{37}Rv$ at 37°C. for 4 weeks showed that the drug has poor activity; the activity of young and mixed fruits ranged between 200 and 2000 μg./mg. and the mature fruit was inactive (Director, Central Drug Research Institute, Lucknow, personal communication). These trials clearly prove that the fruits of *C. zeylanica* do not possess any antitubercular properties and that *C. zeylanica* never comes into the picture both from the botanical and medicinal points of view.

Summary

The present study was undertaken with a view to determining the exact botanical identity of the medicinal plant *Rudanti* ('Konkan' variety of *Capparis moonii* Wt.) reported to be efficacious in the treatment of tuberculosis and to reinvestigate the various botanical and medicinal aspects of the fruits of this plant. From the extensive field data gathered, supplemented by a critical study of the herbarium specimens, as also samples of fruits investigated by the earlier workers, it can be stated that the fruits of both the 'Khandala' and 'Konkan' varieties of *Rudanti* belong to only *C. moonii* Wt. The observations of Shah and Sukkawala[9] that the 'Konkan' variety of *C. moonii* is *C. zeylanica* Linn. (syn. *C. horrida* Linn. f.) appears to be based on a study of the immature fruits of *C. moonii* only, and, therefore, the question of a mixture of two or more different species of *Capparis* reported does not arise. A review of the clinical trials involving freshly collected fruits of the so-called 'Konkan' variety from North Kanara (Mysore State) confirms that the drug has very low tuberculostatic activity *in vitro* but has no effect in experimentally induced tuberculosis and that whatever little potency it has is lost on storage either in the powdered form or as whole fruits. It has also been established that the fruits of

C. zeylanica Linn. do not possess any antitubercular properties as revealed by *in vitro* experiments against tubercle bacilli.

Acknowledgement

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References

1. KRISHNAMURTHY, G., *Curr. med. Pract., India,* **2** (1958), 117.
2. SHETH, S. C. & KRISHNAMURTHY, G., *Symposium on chemotherapy* (Council of Scientific & Industrial Research, New Delhi), 1958, 111.
3. BHATNAGAR, S. S., *Symposium on chemotherapy* (Council of Scientific & Industrial Research, New Delhi), 1958, 112.
4. PERSHIN, G. N., cited from Kanthamani, S., Narayanan, C. R. & Venkataraman, K., *J. sci. industr. Res.*, **19B** (1960), 409.
5. TANDON, R. N., KHANNA, B. K., BAJPAI, R. P. & ZAIDI, S. H., *J. Indian med. Ass.*, **36** (1961), 143.
6. MUKERJI, B. & GUPTA, S. K., *Symposium on chemotherapy* (Council of Scientific & Industrial Research, New Delhi), 1958, 90.
7. SHETH, S. C. & KRISHNAMURTHY, G., *Curr. med. Pract., India,* **3** (1959), 179.
8. BLATTER, E., *J. Bombay nat. Hist. Soc.*, **31** (1927), 905.
9. SHAH, C. S. & SUKKAWALA, V. M., *J. sci. industr. Res.*, **20C** (1961), 100.
10. MAHDIHASSAN, S., *Indian For.*, **81** (1955), 576.
11. SANTAPAU, H., *Rec. bot. Surv. India,* **16** (1960), 9.
12. BUNDEALLY, A. E. & BELLARE, R. A., *J. sci. industr. Res.*, **19C** (1960), 128.
13. BUNDEALLY, A. E., SHAH, M. H., BELLARE, R. A & DELIWALA, C. V., *J. sci. industr. Res.*, **21C** (1962), 305.

Enzymes as Antigens

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THE specificity of serological reactions has been employed by biologists for over seven decades in the identification and the establishment of the homogeneity or heterogeneity of proteins[1]. The use of precise quantitative methods has shown that the precipitin reaction between a soluble antigen and its serum antibody is primarily the result of a protein-protein interaction[2]. That the property of eliciting antibodies in animals is not confined to proteins became evident from studies on the polysaccharides of *Pneumococcus* and other bacteria[3]. It was, however, the work on human blood group substances that brought to light the far-reaching clinical implication of the finding that antigenicity is a property shared by polysaccharides and proteins alike[4]. Immunochemical studies on bacterial and blood group antigens have led to the general conclusion that it is the surface polysaccharide antigens that confer on them their type specificity, whereas virulence and toxicity in the case of pathogens is associated with the cytoplasmic protein antigens.

Our earlier knowledge on the role of chemical structure in determining immunological specificity stemmed from studies on the effect of introducing into proteins known chemical groupings or ' haptens '. The classical studies of Obermayer and Pick[5], and Landsteiner[1] and subsequently those of Pauling *et al.*[6] indicated that the tagging of antigens with iodo, nitro and diazo groups resulted in new specificity directed against these groups. Judicious application of the concept of haptens and the availability of proteins of high purity, together with the technique of equilibrium dialysis, has in the last few years transformed serological reactions into invaluable investigational tools in the hands of structural chemists.

Ouchterlony's[7] discovery of the gel diffusion technique for visualizing precipitin reactions and the extremely ingenious combination of gel diffusion with electrophoresis introduced first by Grabar and Buntin[8] and known as the immunoelectrophoresis technique have greatly extended the scope of immunochemical analysis. By these comparatively simple and quick methods, it is now possible to gain insight into the bewildering complexity of the antigenic mosaic of a cell. The recent discovery of the hitherto undetected existence of several natural antibodies in blood to streptococcal factors is an example that would bear out the limitless potentiality of the immunoelectrophoretic technique[9].

The practical importance for diagnostic purposes of haemagglutination, precipitin and related serological reactions is only too obvious to need any special stress. Immunoanalysis, however, assumes a special significance when the antigens used for eliciting antibodies possess some biological property like, for example, an enzymic or hormonal activity. While a precipitin reaction between a simple protein antigen and its homologous antibody belongs to the class of two-component interactions, a three-component system results when the antigen used is an enzyme and properties of precipitation as well as enzyme activity inhibition are looked for in the antibody. Anti-enzymes have been used from the thirties of this century ever since Sumner employed rabbit sera immunized with crystalline Jack bean urease for enzyme inhibition studies[10,11]. The list of enzymes which have been investigated likewise runs presently to over 40 and degrees of inhibition from 0 to 100 per cent have been registered with different systems depending upon the molecular weight of the substrate on which the enzyme acts. In general, with enzymes acting on small molecular weight substrates, the degree of inhibition recorded is low, whereas with enzymes acting on complex polymer substrates, the degree of inhibition is high.

Analysis of three-component systems, consisting of a protein with its antigenic site reacting with an antibody and enzymic site reacting with its antibody in the presence of the substrate, could provide valuable data for elucidating the mechanism of protein-protein interaction, the active site of enzymes and the function of secondary and tertiary structures in the expression of biological activity. In view of the current interest in molecular mechanisms of protein biosynthesis and the availability of several excellent methods of fractionation of polymer constituents, immunochemical studies on enzymes could be very fruitful indeed. In the light of this, the proceedings of the symposium on 'Antibody to enzymes — A three-component system' organized by the New York Academy of Sciences should be most welcome to molecular biologists[12]. The symposium covered the following broad facets of enzyme immunochemistry: (1) Aspects of two-component immunology dealing with the nature and specificity of antibody and the forces which act between antigen and antibody; (2) Reaction mechanisms of the interaction of enzymes, antibody and substrate; (3) The effect of antibodies on various enzymes; (4) Interaction of enzyme, coenzyme and substrate with antibody; (5) Use of antibodies in the discrimination of multiple forms of enzymes; and (6) Antibodies as tools in the study of biosynthesis of proteins. It would be futile to attempt even a connected summary of the forty-three papers presented at the symposium which run into 661 pages of closely printed matter. In an introductory paper Cinader, who has over two decades of dedicated work in this field to his credit, has outlined the scope of the symposium and critically reviewed the currents and lacunae of knowledge in this fast-developing subject. We shall, therefore, content ourselves in this brief review by focusing attention on some of the highlights of experimental work presented to indicate the extreme versatility of the immunochemical approach to molecular biology.

Site of Antibody Action

Many different antigenic sites, mostly on the surface, are situated in a protein molecule. In contrast, the active site of an enzyme is now known to reside in a small fragment of the peptide sequence of the primary structure. With the available information, it would be rather difficult to predict whether an antibody directed against an enzyme molecule as a whole would bind the active enzyme site as well. Within each antigen site, there are many groupings which, on account of complementary configurations, interact with antibody. Protein chemists have modified reactive amino, carboxy or tyrosyl groups by a variety of techniques to study the resultant effect on antibody binding. Some of the techniques employed are acetylation, succinilation, esterification, iodination, diazotization, guanidation, reduction, partial enzymic hydrolysis, deamination, polyglycination or photo-oxidation[13]. Chemical modification of the antigen molecule may change the property of giving rise to precipitin with antibody without affecting the degree of combination with it.

No single method of chemical modification can yield unequivocal results regarding the nature of antigenic site. Thus tyrosine is known to enhance the antigenicity of some proteins, but it is not *per se* essential for eliciting antibodies. With ribonuclease, for example, non-polar groups may be as essential as the polar ones for antigenicity. Consequent on a study of modified antigenic sites followed by titration with homologous antiserum, three amino residues have been suggested as part of the active site. Physical alterations of the antigen have been attempted on phage lysozyme in relation to genetic changes. The tryptophan synthetase of *Neurospora* can be degraded by trypsin to give rise to fragments possessing differing antigenic character.

Nature of the Antibody

The combining sites of antibody molecules are apparently formed by the folding of portions of the polypeptide chains of γ-globulin molecule so that a complementariness is effected in relation to the antigenic site attacked. This configuration helps in making a close fit with the antigenic region. It is the presence of a specific sequence of amino acid residues on γ-globulin that contributes to its dipolar interaction, hydrogen bond formation and the forging of non-polar bonds by the close approximation of the latter to van der Waal's interaction.

Since γ-globulin is exclusively the carrier of antibody activity, purified γ-globulins from several mammalian species have been subjected to intensive chemical investigation. The crucial data on the active site of antibody action in γ-globulin have stemmed from Porter's well-known work on the fractionation of γ-globulin by enzymic degradation[14]. Out of the three fragments obtained by papain digestion of γ-globulin, two retain antibody activity.

Further degradation of the antibody containing fragments leads to loss in activity from which it would appear that a minimum critical size is indispensable for antibody action.

There is ample evidence at the moment to believe that antibody action is closely akin, if not similar, to enzyme action. The comparison of antibody action to enzyme induction is based on the evidence provided by labelling studies on antibodies in the presence of haptens. The concept of 'active site' determined by a given sequence of amino acids is common to enzymes and antibodies. The active sites of only a few hydrolytic enzymes are known with precision up till now. The task of accomplishing the mapping of the active site of antibody has just begun and the evidence obtained by using RNAse fragment with known active centres encourages one to believe that serine and histidine together might determine activity by their juxtaposition in space. There is also need to apply rigorous statistical laws as originally devised by Goldberg[15] to put the antigen-antibody reaction on a sound operational basis as has been possible for enzyme-substrate action based on the collision theory.

Mechanism of Enzyme Inhibition by Antibody

A unified concept on the mechanism of inhibition of enzymes by their antibodies has yet to be propounded. The use of an enzyme like RNAse, which can attack either a polymer substrate RNA or a simple molecule like cyclic cytidylic acid or can dimerize two cytidylic molecules, has been of great help in elucidating the mechanism of steric hindrance offered by antibody. One has also to distinguish between antibodies which are inhibitory to enzyme and those which are non-inhibitory but which cause precipitin reaction. The lack of complete inhibition observed with many anti-enzymes is due to the heterogeneity of antibodies. Specific antibody against the V-antigen of influenza viruses is capable of inhibiting their neuraminidase activity by a non-competitive and steric mechanism.

Direct evidence of inhibition of enzymatic activity without the involvement of the catalytic site of the substrate has been obtained with phosphoglucomutase. With several preparations of xanthine oxidase, neither the substrate nor the competitive inhibitor, 4-amino-6-hydroxypyrazolo-(3, 4*d*)-pyrimidine prevented antigen-antibody reaction. The retention of considerable enzymic activity by the enzyme-antibody precipitate indicated that steric blockade of active centre by proximal binding of the antibodies was complete.

Action of Antibody on Enzymes

Action of antibody has been used as a method for distinguishing proenzymes like pepsinogen, chymotrypsinogen, trypsinogen, plasminogen, etc., from their derivatives, the active enzyme molecules. The limited hydrolysis of peptide bonds necessary for the activation of proenzymes to enzymes points to the possible existence of differing antigenic sites. The sites on the pepsinogen molecule that contribute to the antigenic activity are different from those responsible for the enzymic activity of pepsin. Phage lysozyme loses its ability to form a precipitate with antibody in concentrations of urea sufficient to unfold the molecule but which do not prevent the precipitation of other protein antigens. Carboxymethyl RNAse obtained by iodoacetate treatment of RNAse shows a pattern of precipitin reaction different from that of the original enzyme. The use of homologous antibody has been investigated successfully to separate by precipitation of the antigen-antibody complex ribosome containing a specific enzyme. Siekivitz has, however, expressed skepticism about the utility of this technique in unravelling the singularity of protein synthesis by one ribosome particle[16]. Immuno studies on aspergillin O, a proteolytic agent of fungal origin and a prototype of bacterial and fungal proteases, show the presence of natural inhibitors in serum of this activity; the technique is of use in evaluating potentially thrombolytic agents. Exploration of the intricate mechanism of complement action has been attempted by the use of specific antibodies directed against different components of the complement system.

The presence of a number of protein fractions from different tissues possessing the same enzymic activity has been revealed by gel electrophoresis and these enzymes, designated as isoenzymes, particularly the isoenzymes of lactic dehydrogenase, have been studied extensively in recent times in relation to tissue and organ[17] specificity. A close relationship of antigenic properties of these enzymes with their catalytic property is suggested from antibody analysis. Both the immunological and enzymatic activities appear to be dependent on secondary and tertiary structures. In a multiple enzyme system dependent on a coenzyme, the latter could stabilize the enzyme against the inactivating action of the antibody as evident from studies on the effect of β-mercaptoethanol in reversing the neutralizing action of antibody on triosephosphate dehydrogenase.

The presence of substrate is known to protect enzymes against inhibitors in many instances and a hypothesis based on conformation change has been proposed to account for this substrate mediated protection. In the new conformation induced by substrate complexing on an enzyme, the sites are widely separated. Although optical rotation changes ensuing from conformational alteration are small, they appear to be significant as evident from studies on the myosin-antimyosin reaction. Using glucose-6-phosphate dehydrogenase as a marker, tolerance to antigens foreign to recipient animals has been studied. In a detailed analysis of the complexes between human erythrocyte glucose-6-phosphate dehydrogenase and its antiserum, both the concentration of the enzyme and triphosphopyridine nucleotide (NADP) affect the extent of inhibition.

Immunoelectrophoresis has been successfully used in characterizing peroxidase, catalases, carboxylic esterases, ceruloplasmin and proteases in a complex mixture of proteins. To the group of isoenzymes differentiated by immunochemical methods belong

alkaline phosphatases, penicillinases and amylases. As an extension of this one could include studies on morphogenesis where enzymes associated with growth of specific organs could be used as tools for analysis of metabolic phases of growth.

Antibody as a Tool for the Study of Protein Biosynthesis

The close similarity of enzyme to antibody has already been referred to. This behavioural similarity is the basis of the use of the antibody system in elucidating the mechanism of protein biosynthesis. The enzyme antigens used in this connection with some encouraging result are the β-galactosidase of *Esch. coli*, penicillinase of *B. cereus* and tryptophan synthetase of *Esch. coli*. The immunological study of genetically altered products of the Z-gene has helped in the understanding of the structure of β-galactosidase and, by eliminating genetic artifacts, in a better approach to the study of the formation of active enzyme sites and the regulation of enzyme synthesis. The analysis of the tryptophan synthetase system has been useful in distinguishing the effects on the level of a specific protein formed from the effects on its activity. Immunochemical studies on trysosine-α-ketoglutarate system suggest that an increase in the amount of microsomal enzymes of the tryptophane pyrrolase group elicited by drugs or cortisone is accompanied by a stimulation of liver protein and RNA turnover.

The explosive interest currently evinced by molecular biologists in unravelling the coding mechanism of information transfer to ribosomal RNA mediated by messenger RNA has overshadowed the significance of other related studies in the field of protein biosynthesis. The complementariness of the base sequence of sRNA to ribosomal RNA accounts for the primary structure of proteins. The folding of the polypeptide helices or pleats to give rise to the several biologically active globular proteins seems to occur by mechanisms which have defied experimental approaches so far. And yet it is this folding which gives the protein its secondary and tertiary structure to which, in turn, it owes its biological specificity and morphological integrity. Immunochemical analysis, apart from helping in the elucidation of the differences in the active site of enzyme action and active site of antigen action, has also revealed the vastness of the uncharted area in the domain of protein synthesis. This lacuna remains as a challenge to the ingenuity of investigators.

References

1. Landsteiner, K., *The specificity of serological reactions* (Harvard University Press, Cambridge, Mass.), 1945, 19.
2. Kabat, E. A. & Mayer, M. M., *Experimental immunochemistry* (Charles C. Thomas, Springfield, Ill., USA), 1961, 250.
3. Heidelberger, M., *Bact. Rev.*, **3** (1939), 49.
4. Boyd, W. C., *Fundamentals of immunology* (Interscience Publishers Inc., New York), 1947, 617.
5. Obermayer, F. & Pick, E. P., *Wien klin. Wschr.*, **19** (1906), 327.
6. Pauling, L., Pressman, D., Campbell, D. H., Ikedar, C. & Ikawa, M., *J. Amer. chem. Soc.*, **66** (1944), 330.
7. Ouchterlony, O., *Ark. Kemi*, **26B** (1949), 14.
8. Grabar, P. & Buntin, P., *Immunoelectrophoresis analysis* (Masson & Cie, Paris), 1960.
9. Hanson, L. A., *Arch. Allergy, App-Immunol.*, **14** (1959), 279.
10. Krik, J. S. & Sumner, J. B., *J. biol. Chem.*, **94** (1931), 21.
11. Cinader, B., *Annu. Rev. Microbiol.*, **11** (1957), 371.
12. Cinader, B., *Ann. N.Y. Acad. Sci.*, **103** (1963), 493.
13. Sri Ram, J., Bier, M. & Maurer, P. H., *Advanc. Enzymol.*, **24** (1962).
14. Porter, R. R. & Press, E. M., *Annu. Rev. Biochem.*, **31** (1962), 625.
15. Goldberg, R. J., *J. Amer. chem. Soc.*, **75** (1963), 3127.
16. Siekivitz, P. & Palade, G. E., *Fed. Proc.*, **21** (1962), 413.
17. Versell, E. S., *Ann. N.Y. Acad. Sci.*, **94** (1961), 877.

REVIEWS

MOLECULAR VIB-ROTORS: THE THEORY AND INTERPRETATION OF HIGH RESOLUTION INFRARED SPECTRA by Harry C. Allen (Jr) & Paul C. Cross (*John Wiley & Sons Inc., New York*), 1963. Pp. vii+324. Price $ 13.50

The book is a welcome addition to the growing field of molecular spectroscopy. Comprehensive and authentic treatises on the theory and applications of this branch of spectroscopy are few and published at unduly long intervals. After the publication of the excellent volumes by Herzberg in 1945, the book *Molecular vibrations* by Wilson, Decius and Cross — the last-named being the coauthor of the book under review — and a few articles which are in fact book-sized, like the ones by H. A. Nielsens article and Lecompte's paper in *Handbuch der Physik*, are some of the important publications in the branch of vibrational and vibrational-rotational spectroscopy.

A consistent exposition of the theory of the rigid rotor, asymmetric rotors, perturbations of their energy levels is given in the first four chapters. Energy levels, frequency of transition and the selection rules are dealt with at some length. At one or two places relatively simpler aspects of the theory are presented in great details. For instance, the derivation of the matrix elements of the angular momentum operator in Chapter 2 could have been given in lesser detail without impairing the clarity of the subject. The inclusion of Wang symmetry parameter adds to the utility of the book.

Line strength — transition intensity — which is as important or even more than the frequency of transitions is discussed in Chapter 5. Symmetry properties of the vibrations of the vibrational-rotational states and the nuclear spin degeneracies contribute to the understanding of the intensities of spectra.

The bonds between the atoms are not rigid; therefore, the interatomic distances vary with the speed of rotation and this results in centrifugal distortion. The theory of centrifugal distortion mainly based on Kivelson and Wilsons's theory has added to the value of the book. Kivelson-Wilson's theory is reproduced in the appendix.

In the last three chapters of the book, analyses of the vibrational-rotational bands of linear, symmetric and asymmetric rotors are presented. The selection rules for rigid rotators are observed with great rigidity, whereas in the case of asymmetric rotors, a fair amount of relaxation in the selection rules is required to interpret the spectra. In the analysis of such spectra usually stochastic methods are employed. But in this book, under one cover, probably for the first time, methods have been presented which require lesser use of guesswork, and quantitative results based more on theoretical rigour are given.

Nine appendices at the end of the book will be found very useful for research workers engaged not only in this field but in the allied fields as well.

P. G. PURANIK

ELECTRONIC PROCESSES IN MATERIALS by L. V. Azaroff & J. J. Brophy (*McGraw-Hill Book Co. Inc., New York*), 1963. Pp. xv+462. Price $ 10.75

This book is designed primarily as a text for B.Sc. (Hons) and M.Sc. first year level and as a reference book for those working engineers and scientists who want a general introduction to electronic processes in solids.

The book is divided into 14 chapters, the first two of which discuss crystal structure and X-ray diffraction. The next four chapters cover the fundamentals of quantum mechanics, atomic bonding, statistical mechanics and zone theory. The material in these chapters is well presented and the reader also finds here a nice connecting link from chapter to chapter.

The next three chapters covering about 100 pages are devoted to theory of semiconductors, semiconductor materials and semiconductor devices. The presentation of the material here again is good but lacks in completeness. There is not very much in these chapters which cannot be found in another similar books of early 1950. It is a pity that a book of 1963 mentions only three ways of making p-n junctions (one of which, i.e. grown junction, is already obsolete) for semiconductor devices. It does not mention epitaxial junctions which are known since the middle of 1961. Besides, under the subtitle ' transistor types ' there is no mention of some later types of transistors such as mesa, planar passivated and thin film types.

The last four chapters of the book cover widely separated areas of solid state physics, i.e. electron emission, dielectric processes, magnetic processes and optical processes.

The treatment of the subject in the book seems rather sketchy at places. Nevertheless, the wide coverage of topics provides a broad view of the field of electronic materials for students, engineers and physicists who are looking for an introductory text to solid state physics.

For consistency, the authors have used MKS units throughout the text. In practice, however, the system of mixed units is still in use. For example, the MKS units of mobility (meter^2/volt-sec.) is quite confusing to a working scientist in semiconductors.

On the whole, the book is well written and, in spite of some minor criticisms, it can be profitably read by a large class of readers.

K. S. BALAIN

THE FRACTURE OF METALS by J. R. Low (Jr), Vol. 12, No. 1, PROGRESS IN MATERIALS SCIENCE edited by Bruce Chalmers (*Pergamon Press Ltd, Oxford*), 1963. Pp. iii+96. Price 30*s*.

Students, researchers and teachers of metal physics have gratefully looked forward since 1950 to the volumes of *Progress in metal physics* published annually by Pergamon Press Ltd under Prof. Bruce

Chalmers' editorship and containing up-to-date, critical reviews by authorities on different aspects of this rapidly growing field of research. Following the recent trend to look upon the science of metals as part of the science of materials, the editor and publisher have decided to broaden the subject matter of their annual volume to include the whole field of materials science and also to publish each review separately to ensure the quickest and maximum possible availability. The book under review is the first article of the 1963 volume of *Progress in materials science.*

This review is timely as nearly ten years have elapsed since the appearance of Petch's review on this subject in Vol. 5 of *Progress in metal physics* and considerable progress has been made in recent years on the study of the nucleation and propagation of fracture in materials on a microscopic as well as submicroscopic scale. The information contained in over 200 papers has been condensed here under four sections, viz. Low temperature brittle fracture; Fatigue fracture; Creep fracture; and Ductile fracture. Experimental observations are described first in each section followed by a discussion of the hypotheses put forward to explain the observed behaviour or to permit a quantitative description of the influence of various structural and physical factors on the resistance to fracture. Over 70 illustrations add to the value of this excellent and comprehensive review.

T. R. ANANTHARAMAN

FRACTURE OF SOLIDS — Proceedings of an International Conference, Washington, 21-24 August 1962, edited by D. C. Drucker & J. J. Gilman (Interscience Publishers Inc., New York), 1963. Pp. x+708. Price $ 28.00

This publication contains the proceedings of an international conference sponsored by the Institute of Metals Division and American Institute of Mining, Metallurgical & Petroleum Engineers. The publication is edited by Messrs D. C. Drucker and J. J. Gilman and is dedicated to the memory of Mr A. N. Stroh. It contains technical contributions chiefly from distinguished authors on the subject from USA, UK and Japan.

The subject of 'Fracture of solids' is a field of study presenting today an unlimited scope. An engineer and a metallurgist would have examined at one time or the other a fracture and failure of a component during its service life as also a fracture in the laboratory under predefined conditions of stress and environments. Such fractures vary from brittle to ductile, progressive types to pure fatigue failures and, in each case, the fracture is brought about by the onset of certain now precisely defined conditions, such as triaxiality of stress, presence of fatigue nuclei, stress concentration, and yet the element of mystery can hardly be ruled out altogether. It is the scientific investigation and systematic research on important factors which cause an ultimate fracture in a solid, on which the scientists have rigorously applied themselves based on purely theoretical studies to fundamentally applied or wholly empirical. Despite the wealth of knowledge thus acquired, fractures in solids still take place. It was perhaps the sudden fractures and failures of welded hulls of liberty ships during World War II and which probably caused greater losses of men and materials than through enemy submarine action that the study of fracture of solids came into limelight. Since then, the subject has received the dedicated scientific study of metallurgists, engineers and scientists alike on a scale often unparalleled.

The publication is divided into different parts, such as relating to continuous mechanics based on plasticity of the growth of cracks, plastic energy dissipation, role of stress concentration; microstructural phenomena containing a full metallurgical treatment of the subject covering cleavage fracture, nucleation and growth of fatigue cracks, potential relationship of microstructural features with fatigue cracking and ultimate failure; atomistic mechanism covering such phenomena as twinning and fracture, fracture of single crystals and plastic deformation progressing at the tip of a moving crack; the last part covers one of the most important factors, viz. environmental effects including effects of residual absorbed gases such as hydrogen, in promoting embrittlement.

The publication is an authoritative treatise on the subject, and deals with a variety of metals and solids and highlights an array of scientifically aligned features related to fracture of solids. To a practical metallurgist, the subject, fracture in metals, eludes wholly satisfactory and plausible explanation since, despite the notable advances on the subject, the conjoint interplay of service stress fluctuations and reversals, service conditions responsible for corrosion and high temperature creep, fretting corrosion and the inevitable stress concentration, does bring about service failures often causing loss of men and materials. In the case of failure, for example, of aircraft, these studies are dedicated, apart from their academic professional merit, to possible elimination of factors responsible for the disasters. Each research paper and technical contribution unfolds some unknown and somewhat less appreciated features, such as the statistical basis of fracture studies.

The publication is an excellent addition to texts on the subject and deserves the sincere appreciation of all engaged in one way or the other in the study of the complex subject of solid fracture. With an almost flawless presentation of the subject, the publication would undoubtedly be universally accepted as a book of reference on the subject.

B. R. NIJHAWAN

INTERNATIONAL SERIES OF MONOGRAPHS ON NUCLEAR ENERGY: Vol. 8 — SYSTEMATICS OF BETA DECAY ENERGIES by B. S. Dzhelepov & G. F. Dranitsyana; translated from the Russian by J. B. Sykes (Pergamon Press Ltd, Oxford), 1963. Pp. vii+63. Price 25s. net

The monograph under review forms a very recent account of the systematics of beta decay energies superseding the early works on the same subject. This work presents an account of semi-empirical mass formulae as deduced by different authors in which various features, such as the effects of a nuclear surface, nuclear shells, the weak and heavy

charges, are taken into account. These formulae are not only discussed at length but also their contents are exhibited in extensive diagrams.

The authors have taken pains in collecting all the data and presenting them in tables for over 600 beta decay transitions with the corresponding predictions from semi-empirical mass formula of Cameron and Levy. Another important feature of this work is Table 5 giving 19 cases where there is a large discrepancy between theory and experiment regarding beta disintegration energy which requires further investigation.

Thus this book contains a large amount of data in a small compass. The authors are to be congratulated for bringing out such a useful work on the systematics of beta decay energies.

SWAMI JNANANANDA

INTERNATIONAL SERIES OF MONOGRAPHS ON NUCLEAR ENERGY: Vol. 11 — ISOBARIC NUCLEI WITH THE MASS NUMBER A = 73 by Ye. P. Grigor'ev, Pp. viii+48, Price 25*s.*; Vol. 6 — ISOBARIC NUCLEI WITH THE MASS NUMBER A = 74 by B. S. Dzhelepov, Pp. viii+58, Price 25*s.*; Vol. 9 — ISOBARIC NUCLEI WITH THE MASS NUMBER A = 110 by B. S. Dzhelepov & N. N. Zhukovskii, Pp. ix+90, Price 35*s.*; Vol. 10 — ISOBARIC NUCLEI WITH THE MASS NUMBER A = 140 by B. S. Dzhelepov, V. P. Prikhodtseva & Yu. V. KhoL'nov, Pp. xiv+128, Price 35*s.*; translated from the Russian by P. Basu (Pergamon Press Ltd, Oxford), 1963

The four monographs on nuclear energy under review entitled *Isobaric nuclei with the mass numbers, A = 73, 74, 110 and 140*, the works of the workers from the Radium Institute, Academy of Sciences of the USSR, are essentially devoted to the study of the properties of atomic nuclei bringing together extensive data on these isobars. These works deal with the specific and generic characteristics of the mentioned isobaric nuclei, the lifetimes of the isobaric nuclei, their methods of determination, the ground and excited states of the above nuclei, their spectra and many other data relating to them. These volumes encompass all the available data important from the point of view of the study of the systematics of nuclei. The other possible isotopes with these mass numbers and open as well as disputed problems for further investigation are suggested.

The authors of these useful and important works are to be congratulated for undertaking such a stupendous task. These works will be assets to all the research workers in this field and, therefore, will be important requisites in every research laboratory.

SWAMI JNANANANDA

OPERATOR TECHNIQUES IN ATOMIC SPECTROSCOPY by Brian R. Judd (McGraw-Hill Book Co. Inc., New York), 1963. Pp. ix+242. Price $ 9.95

The methods usually employed to find expressions for the energies of the terms of a complex atom make use of the rules formulated by Slater in 1929 combined with the classical techniques described by Condon and Shortley in their book *The theory of atomic spectra*. The calculations, however, become extremely involved and cumbersome when applied to atoms possessing several electrons outside closed shells, atoms, for example, of the rare earth or actinide series.

During the years 1942-49 Racah published a series of four papers under the general title *Theory of complex spectra* dealing with the application of tensor operators and theory of continuous groups for finding the term energies of configurations of equivalent f-electrons. Since then the theory has been further developed by others like Jahn, Flowers, Elliott, etc.

For the first time the methods developed by Racah and others are put into a systematic form and presented in this book. In the first chapter, the author presents the basic outline of the methods of Condon and Shortley. The second chapter deals with a brief but necessary exposition of the crystal field theories and the group theory. In the last chapter are described certain applications of the methods described in the intermediate chapters, to the theory of configurations of more than two equivalent f-electrons.

Although the text is, of necessity, highly mathematical, emphasis is laid on physical applications. All the techniques are illustrated by examples drawn from the work of the last few years. A number of problems are set forth at the end of each chapter.

The book will be of special interest to physicists engaged on any one of the diverse topics like emission, absorption and fluorescence spectra of atoms and ions in crystals as well as in the free state, atomic beams, paramagnetic resonance, masers, classical atomic spectroscopy, etc., in fact, wherever a knowledge of atomic spectroscopy is necessary.

D. PREMASWARUP

APPLIED THERMODYNAMICS by A. E. J. Hayes (Pergamon Press Ltd, Oxford, and Macmillan & Co., New York), 1963. Pp. ix+270. Price £1 1*s.* net

A large number of text-books with titles like 'Applied thermodynamics', 'Engineering thermodynamics', 'Thermodynamics for engineers', etc., have appeared in the past three years. Indeed, to convert lecture notes and numericals done during the course into a text-book seems to become a fashion amongst the teachers of the subject. In departing from the old standard books, which gave importance to the rigour of logical development of the laws of thermodynamics and their conclusions, the new crop of books sometimes swing to the other extreme. They devote little space, if any, for the consideration of basic principles and concepts, and plunge directly into applications, numerical illustrations and problems. The book under review is a typical example of the latter class of books.

The author of the book prefaces it with the statement: "The attention given to topics such as entropy and the laws of thermodynamics has been restricted to that which has direct bearing on the applications to engineering. Only a brief text is given to each topic, the main purpose being to guide the student through typical calculations." The book bears this statement out fully. The basic

concepts of thermodynamics like equilibrium, reversibility, etc., and the limitations they set on the application of the subject are not clearly defined; the statement of the First and Second Laws is inadequate; the 'III Law' receives no mention (because it has no "direct bearing on the applications to engineering"). Excepting for one chapter on combustion (Chapter 11), the entire book seems to be devoted to the solution of problems connected with mechanical operations. The chapters on flow in nozzles (Chapter 10), turbines (Chapter 12) and compressors (Chapter 13) and the last two chapters are very well illustrated.

The examples have been selected with some care to give the student confidence in finding solutions for similar situations in practice. A large number of problems has been worked out in the body of text and the solutions are remarkably free from errors. Illustrative graphs, figures and charts are clearly printed, and the general get-up is extremely satisfactory. Exercises taken from the examinations of various institutions of engineers have been added at the end of each chapter. They will be useful to students who intend to take these diploma or certificate examinations.

The units used throughout the book are British units and are likely to cause conversion difficulties to students in this country. For teachers, who are well versed in the principles of thermodynamics and want to illustrate their lectures with examples, this book is likely to be of immense help.

V. RAMAKRISHNA

INTRODUCTION TO MICROWAVE SPECTROSCOPY by Terence L. Squires (George Newnes Ltd, London), 1963. Pp. 140. Price 30s.

The technique of electron spin resonance (ESR) discovered in 1945 by Zavoisky is today one of the powerful tools for the study of molecules and free radicals with an unpaired electron and radiation damage and crystal field effects. On account of its high sensitivity, and the consequent possibility of studying the interaction of the unpaired electrons with their surroundings, the concentration of free radicals and their role in chemical reactions and transient phenomena, ESR is likely to play an increasingly important part in applied research, particularly in the biological and medical sciences. However, ready-made ESR instruments, involving microwave techniques are quite expensive and research workers in our country with limited budget may like to build their own ESR spectrometers. The present book will be found most useful by such workers and others interested in the experimental techniques of ESR and the problems associated with the instrumentation.

The author has explained in detail the features of a 'straight' spectrometer as well as the more modern ESR spectrometer based on superheterodyne principle. In all the chapters the emphasis is on the constructional details and practical difficulties and the methods of overcoming them. The principles of operation of klystron and the propagation of electromagnetic waves in waveguides have been clearly explained with clear sketches. Factors which have to be taken into account in constructing a magnet for ESR work and the methods of ensuring a good homogeneity of field have also been given. The sensitivity, noise and bandwidth of the spectrometers have been considered.

In the chapter on ESR circuitry, the best arrangements of the head amplifier, LF and HF amplifiers and the phase sensitive detector have been indicated. The book contains also a chapter on measurements with microwave spectrometers and in this the details for setting up klystron, achieving frequency stability, preparing small samples, a microbalance improvised from a moving coil milliammeter, and checking input noise and noise factor have also been given.

The book will serve as a useful guide to beginners in microwave spectroscopy and to research workers engaged in constructing or servicing ESR spectrometers. Very few references have been given to original papers and treatises on ESR or microwave techniques and if the author had indicated these also they would have been helpful to those who desire to follow up further the subject and learn the theory. The price of the book seems to be slightly on the higher side.

R. S. KRISHNAN

CLAYS AND CLAY MINERALS — Proceedings of the Eleventh National Conference on Clays and Clay Minerals, Ottawa, 13-17 August 1962 (Pergamon Press Ltd, Oxford), 1963. Pp. 220. Price £ 5 5s.

The Proceedings of the Eleventh National Conference on Clays and Clay Minerals has a wealth of information to offer through its 25 papers, 3 abstracts, 3 extended abstracts and the account of the field study trip organized in the course of the conference. The proceedings are reported under two broad sections: (1) Symposium on clay mineral transformations and (2) General session. From the reader's point of view there appears to be a random distribution of papers under these heads. A more systematic and subjectwise subgrouping of the papers would have been more helpful.

The dominant subjects during the conference appear to have been the field and laboratory studies on the formation of clay minerals and their diagenesis. Interest has been centred around the formation of interlayer minerals and quite many papers deal with mica $\rightleftharpoons$ illite $\rightleftharpoons$ vermiculite $\rightleftharpoons$ montmorillonite transformations. Jackson's fascinating account of 'fringed edge' type weathering by mica with potassium release later leading to interstratification and the mechanism of attachment of gibbsite interlayers leading to swelling montmorillonite-chlorite intergrades are some of the interesting concepts worth further examination. Similar views have been suggested by Pawluk also. Grant's is the only paper dealing with the transformation of granite. Formation of kaolinite, allophane and gibbsite is attributed to processes that may at least partly be due to solution and reconstitution reactions. A number of papers deal with the formation of bentonites from volcanic rocks and these support the view emphasized by Schultz that not all bentonites are composed of montmorillonite minerals. Many are found to contain kaolinites and mixed layer minerals. Heystack has traced the

transformation beidellite-hydro mica → beidellite-vermiculite → beidellite → kaolinite from some rhyolites. Huff's investigations reveal the alteration of some volcanic beds first to montmorillonite which due to later adsorption of potassium alter to mixed layer minerals of montmorillonite randomly interstratified with illite. The effect of defect structures as in Stenensite's conversion to minerals like talc is illustrated by De Rudder and Beck.

Among the laboratory and theoretical studies on the weathering processes, the investigations of Cook and Rich on artificial weathering of mica and of Addison and Sharp on oxidation and reduction of hydroxylated iron silicates are of interest. Wayman's treatment of solid-gas interface weathering reaction explains the stability of gibbsite during bauxite dehydration.

Excellent reviews on clays, clay minerals and their diagenesis have been furnished by Mackenzie and Keller. The former rightly criticizes the outdated equations still employed in geological texts to explain feldspar weathering such as

$$2KAlSi_3O_8+2H_2O+CO_2 \rightarrow Al_2Si_2O_5(OH)_4+K_2CO_3+4SiO_2$$

Keller's account of the mineralogical revolution following the 'dethroning of King Kaolin', his explanation and suggested two-stage mechanisms of the transformation of montmorillonite to illite, makes that paper the most readable and important for anyone interested in clay diagenesis.

Of special interest to the civil engineer and sedimentary geologist are Van Olphen's account of the compaction of clay sediments, Kondner and Vendral's stress-strain response of soils in direct shear, Yong *et al.*'s experiments on swelling pressure of Na montmorillonite at depressed temperature and Mungam and Jessen's proposed 'hinged structure' for aqueous montmorillonite gels.

To the X-ray crystallographer, Radoslovich's new approach to layer lattice silicate structure suggesting a di-trigonal rather than a hexagonal arrangement of surface oxygen as also the studies of Kodama and Oinuma on infrared absorption method employing the 3698 ± 2 cm.$^{-1}$ band for the identification of kaolin minerals in the presence of chlorites, offer material that needs a more critical examination. Hinckley's studies also shed light on the variability of crystallinity among kaolin. A method for quantitative evaluation of the crystallinity index is suggested.

The paper by James and Harward on ammonia absorption by montmorillonite and kaolinites should be of interest to agricultural soil chemists.

Data of value to the oil industry are presented by Brunton and others on montmorillonite-polyalcohol complexes. The other paper touching petroleum industry by Vivaldi gives the occurrence, mineralogy and the industrial use of the bentonites in south-east Spain and north Morocco.

The publishers, Pergamon Press, have maintained their usual high standard which always accompanies the Proceedings of the National Conferences on Clays and Clay Minerals. The volume is a very useful addition to the shelves of those concerned with the study and research of diverse fields in which clay mineralogy has a part to play.

N. R. SRINIVASAN

ORGANIC SYNTHESES — Collective Volume IV (A Revised Edition of the Annual Volumes 30-39), edited by Norman Rabjohn (John Wiley & Sons Inc., New York), 1963. Pp. xiv+1036. Price $ 16.50

Organic syntheses has an established reputation as the most reliable and authoritative guide in the domain of preparative organic chemistry, and the publication of each new volume in this series is eagerly awaited by organic chemists. The collective volumes, of which three issues have already been published, each including the contents of ten annual volumes, are not a mere collection of the material covered in separate numbers. Their importance lies in the fact that they incorporate improvements or modifications in procedures, safety precautions and additional material regarding 'Methods and preparation' section published subsequent to the appearance of individual volumes, besides presenting the material in a more handy form in one cover.

The present collective Vol. IV includes the material contained in annual volumes 30-39 and gives a good idea of the extensive coverage of the separate volumes. It gives details of apparatus for specialized synthetic reactions, with illustrations wherever necessary, which should prove invaluable to those working in the field of synthetic organic chemistry. Even a glance through its pages will hold the attention of the reader and can be a useful and enjoyable pastime to those interested in the subject. This volume gives new procedures for the preparation of 2,3-diphenylsuccinonitrile, ethyl azodicarboxyllate and mucobromic acid. A new feature of this volume is the inclusion of an author index.

This volume maintains the excellent standards of its predecessors in regard to the quality of printing and editing, and would be a welcome addition to any organic chemistry library.

NITYA ANAND

ADVANCES IN ELECTROCHEMISTRY AND ELECTROCHEMICAL ENGINEERING: Vol. 3 — ELECTROCHEMISTRY edited by P. Delahay (Interscience Publishers, a Division of John Wiley & Sons Inc., New York), 1963. Pp. 397. Price $ 15.00

This volume is the third in the series which has been planned to bridge the gulf between electrochemistry and electrochemical engineering. The topics discussed are: (1) the interface between aqueous electrolyte solutions and the gas phase, (2) thermogalvanic cells, (3) metal deposition and electro-crystallization, (4) anodic films, and (5) hydrogen overvoltage and adsorption phenomena. Each chapter has been written by a specialist in the field, and the last one by Frumkin is a continuation from Vol. 1.

The modern concepts in electrochemistry have been put forth very well, keeping in view the mathematical approach which is so essential for a proper understanding of physico-chemical problems. Each chapter begins with a convenient list of contents: there are tables and figures and up-to-date references. There is a general index as well as a cumulative

index for the three volumes. The editorial board and the publishers have to be congratulated for bringing out this concise monograph which will no doubt serve as an extremely useful reference book in the field of modern electrochemistry.

T. L. RAMACHAR

PROBLEMS OF PRODUCT DESIGN AND DEVELOPMENT by C. Hearn Buck (Pergamon Press Ltd, Oxford), 1963. Pp. viii+168. Price 12*s*. 6*d*. net

The book deals with the mechanics of producing and selling a product with the greatest advantage. Very lucidly written, the book can be used alike by the technical man and the management. Few new ideas are put forward and as the author has himself pointed out " However obvious the principles of good design may be, many manufacturers appear not to bother, and while that situation lasts I shall continue to state the obvious ". The ' obvious ' has been stated with remarkable clarity and a continuity of thought that is not only instructive but eminently readable.

The book is divided into several chapters dealing with such topics as initiation of a new product, design for production, distribution, design for maintenance and coordination of design. Other chapters include research, drawing office and legal protection of designs. A significant feature of the book is a concise summary at the end of each chapter.

Pointing out that there are five areas of design thinking, viz. need, function and use, production, sales and maintenance, the author develops his ideas in a rational manner, and in this process gives a clear exposition of the various factors involved in the introduction of new products (such as company policy, diversification of range and reduction of variety). He then proceeds to explain the development of a new idea, the patent and sales backing necessary for the profitable realization of the idea, and restyling of the idea to ensure a continuing future for the product.

To design a product cheaply is, of course, very important, and the author discusses the various economic factors involved in the production of designs with the minimum cost. Often expensive or complicated products must be designed, and in these cases the designs must be such that the products can be easily maintained. Maintenance facilities including the supply of spares and instructions are necessary for all except the simplest products. The author then summarizes the organization of design and presents an organization chart to explain his views.

While every effort has been made by the author to present his ideas clearly and objectively, one cannot fail to notice the absence of a quantitative approach in his treatment. The value of the book would have been considerably enhanced had the author given a case history of the development of a product at the end of the book, so that the ideas presented by him could be far better appreciated.

In the final analysis the book is doubtless extraordinarily well written, and should be welcomed by those engaged in the development of new products.

L. K. DORAISWAMY

FURNACES by J. D. Gilchrist (Pergamon Press Ltd, Oxford), 1963. Pp. 156. Price 15*s*. net

This comprehensive book is a companion of *Fuels and refractories*. The basic concepts of evolution of heat, combustion of fuel, conversion of electrical energy to heat transfer, thermal efficiency, furnace dynamics, furnace construction, classification of furnaces, laboratory furnaces and pyrometry and control are briefly discussed in its various chapters. Furnaces are essential for the production, fabrication and heat treatment of metals and alloys. The efficiency of a furnace depends on the optimum transformation of chemical or electrical energy and heat transfer. The thermal efficiency is a very important criterion in the design and operation of any furnace. The flow of gases in a furnace largely affects its performance. The construction of a furnace has been explained on the basis of these considerations. The furnaces have been broadly classified as crucible, hearth and shaft furnaces, and their application in metallurgical industries has been described. Retorts, converters, sintering strands and other miscellaneous furnaces have been described. This is followed by laboratory furnaces for research. An unseparable part of furnace operation is control and measurement of temperature, and pyrometry has been briefly presented.

The whole treatment and presentation are extremely lucid and interesting. The illustrations are clear and help to understand the topic.

Summing up, the book will be immensely useful to students pursuing a course in metallurgy.

A. B. CHATTERJEA

DESIGN OF EQUILIBRIUM STAGE PROCESSES by B. D. Smith (McGraw-Hill Book Co. Inc., New York), 1963. Pp. xi+647. Price $ 17.50

This book is a new addition to the famous McGraw-Hill series in chemical engineering. The text deals with the application of equilibrium stage concept to the various chemical engineering separation processes like distillation, absorption, extraction, etc.

The book is divided into sixteen chapters. The first two chapters deal with the thermodynamic and correlation methods for ideal and non-ideal vapour-liquid and liquid-liquid equilibrium mixtures. The next eleven chapters are devoted to a review of methods for the calculation of the number of stages required in the equilibrium stage process. The last three chapters which are perhaps the best in this book deal with application of equilibrium stage concept to actual industrial plant.

No basic unified approach to stagewise processes is presented anywhere in the book. What is really attempted is to relate stagewise concept to the distillation operation. Distillation is described as the basic general case and other processes are treated as related to it. This is not altogether a satisfactory approach and has resulted in confusion inasmuch as distillation is not an ideal stagewise operation because of several restrictions.

There are several incorrect statements and confused concepts because of which the book may not

become a student text unless drastically revised. However, it is of value to design engineers.

N. R. KULOOR

TECHNOLOGY OF SCANDIUM, YTTRIUM AND THE RARE EARTH METALS by Eugene V. Kleber & B. Love (Pergamon Press Ltd, Oxford), 1963. Pp. ix+205. Price 50s. net

The book is based on the survey report prepared for the US Air Force in 1960. As the title of the book suggests, it deals primarily with the physical and mechanical properties of the pure metals and of their many alloys. It contains four major chapters, the first dealing with the chemistry of these elements, their electronic structure, chemical and nuclear properties and methods employed for their purification and analysis. The remaining three chapters deal with their technology — metallography of the pure metals, their mechanical properties and their fabrication and forming, binary and ternary constitutional diagrams and their alloying behaviour, and misch metal and its alloys with other metals.

The publication of this book is most welcome since it has only recently been possible to obtain these individual metals in quantities and in a state of high purity for a systematic and accurate study to be made of their physical and mechanical properties and of the alloy systems. For the first time a large number of binary and ternary constitutional diagrams involving these elements have been brought together in a book form. The book contains over nine hundred references to original papers. These will be of great assistance to the chemist and the metallurgist in further study to extend their large-scale uses, on which the economics of rare metal technology depends.

JAGDISH SHANKAR

CHEMISTRY IN NUCLEAR TECHNOLOGY by Sigfred Peterson & Raymond G. Wymer (Addison-Wesley Publishing Co. Inc., Reading, Massachusetts, USA), 1963. Pp. x+374. Price $ 12.50

The book begins with a review of those fundamentals of chemistry with which a student of nuclear technology should be familiar for an understanding of various processes of interest. These include the relationship of structural chemistry and periodic classification, solubility, chemical equilibrium, complex formation, oxidation-reduction, solvent extraction, etc. This is followed by a brief elementary account of radioactivity, passage of radiation through matter, nuclear reactions (including fission), radiochemical techniques of separation and detection and measurement of radioactivity. Four chapters are devoted to the chemistry of thorium, protactinium, uranium and the transuranium elements. The next four chapters deal with technological aspects, such as extraction of uranium and thorium from ores, dissolution of spent fuel elements, recovery of plutonium and fission products, etc. The authors also deal with the problems involved in shielding of radiochemical plants, control of criticality and disposal of radioactive waste. The book also has a chapter on isotope separation by gaseous and thermal diffusion, chemical exchange, and electromagnetic separation techniques.

The authors of the book have had many years of experience in the field and can, therefore, write about the subject with authority. The book is well written and illustrated with numerous diagrams. Problems and references are given at the end of each chapter and an index at the end. The book will be useful both to students of chemistry and chemical engineering and particularly to nuclear technologists.

JAGDISH SHANKAR

REACTIONS OF ORGANIC COMPOUNDS — A Text-book for the Advanced Student, by Reynold C. Fuson (John Wiley & Sons Inc., New York), 1962. Pp. viii+765. Price $ 12.95

This book on organic reactions is, according to the author, designed to give " a mastery of the fundamentals of the subject to students who have had a first course in organic chemistry ". Its primary purpose is not to serve the truly advanced student. It starts off rather in an unsatisfactory way with an introductory chapter giving a brief survey of the fundamental theoretical aspects. Considering the intended users, this chapter is inadequate. The section where the terms acid, base, electrophile, and nucleophile are introduced and explained would leave the neophyte confused and dissatisfied. It would have been best to present the definitions of Bronsted and Lewis for acids and bases with illustrations. The student is told that all acids are electrophiles and all bases nucleophiles. The necessity for the two pairs of terms is not explained. Changes in π-electron density arising from resonance and inductive effects in aromatic compounds are treated in a section on ' electron transfer '. The fact that ' electron transfer ' has a different meaning in current usage is overlooked. The statement that " if a reaction occurs in the gas phase and is catalysed by the input of energy, the free radical mechanism is suggested " is confusing. A concise and adequate survey of the fundamentals necessary for the material presented in the book would not have taken very much more space.

Apart from the introductory chapter, the main body of the book furnishes a clear and readable account of most of the common organic reactions, which are discussed in the light of simple electronic theory. The references to original literature for factual information are numerous, and those to ' organic synthesis ' are particularly helpful; almost all references involving theoretical aspects are made not to the original literature but to the brief digests available in other monographs. Quite often the reader's curiosity is aroused by drawing his attention to experimental facts that are not readily rationalized in terms of elementary theory.

Although the general organization of the book is satisfactory, it is quite disconcerting to find the dehydration of amides to nitriles by reagents like P_2O_5, PCl_5 and $SOCl_2$ treated as a nucleophilic displacement reaction (p. 345). This is a serious error considering the nature of the reactions which is not gone into at all. The formation of alkyl halides from alcohols and halogen acids (or acid halides) is classed along with that of reaction of

PCl_5 on carbonyl compound to give dichloro derivatives under electrophilic displacement reactions of unsaturated aliphatic compounds. The former reaction is not an electrophilic displacement and the substrate is not unsaturated. It is doubtful if the latter can be called an electrophilic displacement. The likely stages through which this transformation takes place could have been given and the opportunity taken to tell the student that classifications are dependent on the nature of the rate-determining step. Esterification of alcohols by inorganic acids is also included under the same heading. These misplaced discussions involve serious misrepresentations. One also finds that whereas the conversion of carboxylic acids to the corresponding acid chlorides by the action of PCl_5, $POCl_3$ or $SOCl_2$ is considered as nucleophilic displacement, the similar conversion of alcohols to alkyl halides by the same or similar reagents are treated as electrophilic reactions. On pages 44 and 50, the term ' radical ' is employed to refer to groups.

The book is almost totally devoid of any discussion of the relation between molecular geometry and reactivity. Topics like neighbouring group participation are not even touched upon. The book would have been of far greater value pedagogically if some of the enormous wealth of detail presented in it is replaced by brief discussions of topics of this kind.

The book is not completely free of errors of oversight. On page 64 (para 4), ' 9,10-dibromophenanthrene ' should be replaced by phenanthrene-9,10-dibromide. The Favorski rearrangement of only 1,1,3-tribromo-3-methyl-2-butanone can lead to α-bromo-β-methylcrotonic acid (p. 266) and not that of 1,1,3-tribromo-2-butanone. Page 269 (bottom) has errors in formulae.

Despite the drawbacks of the book, it will be of considerable help to advanced students as a ready reference volume. Those who have had only an introductory course in organic chemistry have to acquire a background of electronic theory before they can benefit by reading this book.

P. M. NAIR

PROCEEDINGS OF THE FIRST INTERNATIONAL PHARMACOLOGICAL MEETING: MODE OF ACTION OF DRUGS, Vol. 2 — EFFECT OF DRUGS ON SYNTHESIS AND MOBILIZATION OF LIPIDS edited by E. C. Horning & P.. Lindgren (Pergamon Press Ltd, Oxford), 1963. Pp. xii+214. Price 60s.

Studies on ' Lipid metabolism ' have of late attracted the attention of investigators of various disciplines including nutritionalists, biochemists, pharmacologists and clinicians. The intimate relationship existing between atherosclerosis and cholesterol metabolism, the regulatory mechanism involved in the synthesis, storage and release of lipids in the body, the role of catechol amines and sympathetic system in general on the release of the lipid components from the liver and adipose tissue and the chemotherapeutic approach for the control of hyperlipidaemia are some of the facets of study presented in this volume.

Bile acids are important constituents in the excretory pathways of cholesterol. An analysis of the factors that influence the formation and excretion of bile acids has revealed that these bile acids can vary very much with changing dietary and hormonal conditions thus reflecting the nutritional impact on lipid metabolism.

The discussions on the ' role of the catechol amines and sympathetic nervous system ' and ' their interrelationship with the adrenal cortical hormones ' in the regulatory mechanisms involved in the release of free fatty acids from the adipose tissue and of the triglycerides from the liver are interesting contributions to the maintenance of homeostatic mechanisms of the body.

Other aspects of research studies presented in this volume are: cholesterol turnover in man; mechanism of actions of cholesterol synthesis inhibitors; the biological activity of the intermediate compounds accumulating as a result of inhibition of cholesterol synthesis; hormonal control of lipid transport; influence of sex hormones and hormones of the thyroid on lipid metabolism and the associated topics like ' the nature of the lipaemia clearing factor ' and ' lysolecithin in biological material '.

M. SIRSI

PHYSIOLOGICAL MEASUREMENTS OF METABOLIC FUNCTIONS IN MAN by C. Frank Consolazio, Robert E. Johnson & Lovis J. Pecora (McGraw-Hill Book Co. Inc., New York), 1963. Pp. ix+505. Price $ 14.50

Human bioenergetics is a new discipline in medical research. Although the work is very basic and reaches the border lines of pure science, but still its results are easily and widely applied to the day-to-day clinical knowledge. Comparatively few authentic publications are available regarding this branch of speciality.

Of the various books available on human bioenergetics, *Physiological measurements of metabolic functions in man* is one of the most reliable, authentic and comprehensive. The authors have been very meticulous and have spared no effort to make the book a rich source of information.

The book has been carefully divided into various chapters, dealing separately with different aspects of the subject, such as Gaseous metabolism in the lungs and their turnover in the blood, Metabolic balances, Physical fitness, Meteorological measurements, Human metabolism in heat and cold, as well as Physiological variations in young men. Methods used in these studies have been given in precise and clear manner, easy to be adopted by those who want to take up this type of work.

The work is adequately illustrated by large number of charts, suitable illustrations and actual photographs wherever they are needed. The data have been carefully analysed statistically, and references to the original monographs and literature have been given at the end of every chapter.

The book will be of great interest even to those who are engaged in purely applied aspects of various medical disciplines, particularly the chapters dealing with pulmonary gaseous exchange and blood O_2-CO_2 turnover which are of immense value to the advanced thoracic surgeons and the chapter on

cardiorespiratory function tests which may find ready application in modern anaesthesia.

Indian readers may profitably utilize the data given regarding the standards of physical fitness as we have only scanty data of our own, and such comparative study will be of great benefit to us.

The chapter on methodology and data pertaining to human metabolism in heat and cold as well as the chapter on meteorological measurements are of special significance to us at this juncture because most of this work was done on the American soldiers in collaboration with United States Medical Research Division. The results, in principle, can be applied to the Indian soldier after a comparative study.

The publication of this book is very opportune and it should find a place in the libraries of all biological and medical institutions.

R. B. ARORA

REPAIR OF GENETIC RADIATION DAMAGE AND DIFFERENTIAL RADIOSENSITIVITY IN GERM CELLS edited by F. H. Sobels (Pergamon Press Ltd, Oxford), 1963. Pp. x+454

This book is a collection of papers presented at an international symposium organized at the University of Leiden, The Netherlands, during August 1962. The 24 invited papers which are included in this volume summarize studies conducted at different laboratories from all over the world on the important problem of repair of radiation damage and differential stage radiosensitivity. This aspect of radiobiology has both fundamental and applied bearings, as it is important to know in this atomic age, as to how radiation acts to injure the living systems, how the living systems try to recover from the radiation damage, and why some of induced damages are difficult to recover from. Some aspects of these questions are answered by the papers presented during this symposium, concerning recovery process in diverse organisms such as: Drosophila (12 papers), bacteria (3), yeast (1), Habrobracon (1), silkworm (1), paramecium (1), mice (2), and barley (1).

Apart from the above papers there are two papers of general interest dealing with basic radiobiological problems (one by Wolff and the other by Evans) and one concluding paper by Kimball as a synthesis of all the papers presented. Wolff deals with kinetics of two-hit aberrations (chromosome exchanges) in the irradiated cells and utilizing earlier chromosome breakage data in diverse organisms, he has shown that the two-hit aberration frequency follows a 3/2 power rule rather than square law, when sparsely ionizing radiations are used. This paper clearly brings out that this 3/2 rule applies very well in certain cases, but as evidenced from the discussion, this rule requires a rigorous testing under different conditions of irradiation and in different organisms before being accepted universally. The following paper by Parker presents additional support to Wolff's hypothesis in the form of data on detachment of attacked X-chromosomes in Drosophila. The paper by Evans tries to elucidate the probable reasons for variation in chromosome radiosensitivity during mitotic and meiotic cell cycles. Chromosome duplication, oxidative metabolism and change in levels of —SH groups, i.e. radioprotectors, are considered as possible causes for the differential sensitivity.

Several papers deal with the recovery process and differential radiosensitivity of the germ cells in *Drosophila.* Since this symposium was dominated by Drosophila workers, the papers under this group are very interesting and present the latest progress in this field. Oster's paper deals with the spectrum of mutation following X-irradiation under different atmosphere (oxygen or nitrogen), indicating that a high rate of mosaics is produced when irradiation is done under anoxia. The genotype of the X-chromosome on the radiosensitivity of the sperm has been studied by Lindsley and his associates. Wurgler and his group have standardized techniques to transfer eggs to different treatments within such a short time as 2-3 min. following laying, to study the sensitivity changes in freshly laid eggs. The changes in the radiosensitivity, depending on the time of irradiation after egg laying, are shown to correlate with mitotic and meiotic stages of division during cleavage. Similar stage sensitivity studies as measured by different events which ultimately lead to killing have been dealt with in detail in *Habrobracon* by von Borstel and his group: Repair in developing germ cells of male Drosophila and differential radiosensitivity of various stages of spermatogenesis has been presented by Sobels, who has used various pre- and post-treatments along with irradiation, by interfering with nucleic acid synthesis and protein synthesis. Further data on stage sensitivity of Drosophila, under aerobic and anoxic conditions, have been presented by Mossige and Savaghan. A cytological evaluation of this stage sensitivity problem in Drosophila is made by Kaufmann and Gay with elegant electron microphotographs. Kimball and Magni report similar situations of stage sensitivity paramecium and yeast respectively.

There is a set of interesting papers on the intensity effect in radiation response of various organisms. This problem is very important, since in the event of an atomic explosion human population will be exposed to radiation with low intensity for long periods of time, and such a dose received by slow accumulation will be more or less harmful than a dose received acutely in a very short period. The three different systems studied, namely mice (Russel), Drosophila (Purdom and Muller) and silkworm (Tazima), indicate that the response to dose rate is a complex phenomenon, and it varies with the organism, the stage in which they are irradiated and the relative efficiency of the repair mechanism. In Drosophila, no intensity effect is demonstrated, while in silkworm and mice there is a complex intensity effect. Muller's paper in this symposium is a classic as, apart from the extensive data presented there, it shows in short ' how to conduct critical experiments in Drosophila '. The other set of papers (Harm, Witkin and Doudney) on microorganisms deal with the fundamental aspects of mutation induction, stabilization and expression following ultraviolet irradiation. These papers are similar in nature to those presented by

these authors in an earlier symposium in 1961 [Oakridge Symposium, *J. cell. comp. Physiol.*, **58** (1961) Suppl. 1]. The only paper on repair process in plant seeds (Natarajan and Narayanan) deals with the important aspect of post-irradiation metabolic changes, in the expression of chromosome breakage and mutations. This study has demonstrated that there is no fundamental difference between neutron and X-ray induced breaks and they interact freely, if appropriate conditions are provided for this interaction.

The concluding paper by Kimball clearly synthesizes the highlights of the symposium, which provided a lot of information on the universality of the phenomenon of germ cell sensitivity to diverse organisms, and as pointed by him "if the gaps are filled up, we can emerge an overall conceptional framework of mutation induction".

The impressive aspect of this symposium volume is its editing. Extreme care has been taken to record the lively discussion which followed each paper. The volume has been published in record time following the symposium. It is very well printed and has very few printing mistakes. This volume will definitely find a place in all the libraries engaged in biological research, and it will prove very useful to all the radiobiologists engaged in this field of research, as this volume brings out the 'current thoughts' of the leaders in this field of research. Prof. Sobels is to be congratulated for his efforts in organizing such an important symposium and editing this valuable volume in the present form.

A. T. NATARAJAN

THE GERMINATION OF SEEDS by A. M. Meyer & A. Poljakoff-Mayber (Pergamon Press Ltd, Oxford), 1963. Pp. vii+236. Price 35*s*.

The topic is highly fascinating to the plant physiologist; it is of immense importance to the agronomist and equally so to the food technologist; and the biologist is eager to know the mechanism of dormancy in plants and plant parts, as also of diapause in insects and hibernation in animals. Thus the present title, third in the series in the Plant Physiology Division, released by Pergamon Press, will be helpful to workers in this field of study.

The authors have been investigating in detail, for over a decade, different aspects of seed germination, particularly the mechanism of dormancy. Beginning with a preliminary account of the structure of seeds and seedlings in the first chapter, the authors deal next with the 'Chemical composition of seeds', wherein compiled data on gross analyses of seeds of some crop plants and weeds, as well as detailed analyses of lettuce and soya bean seeds are included. 'Factors influencing germination' (Chapter 3) is again brief and gives the usual information contained in the latest editions of standard text-books on plant physiology, except that the portion relating to 'light' is enlarged and that recent references are included. The authors apparently felt more at home in the following three chapters: 'Dormancy, germination, inhibition and stimulation', 'Metabolism of germinating seeds', and 'Germination inhibitors and stimulators', especially with the last topic wherein they summarize the researches carried out by their school of workers. The last two chapters, 'Ecology of germination' and 'Dormancy in other organisms', give a brief account of the scope of the subject.

The fifth chapter, 'Metabolism of germinating seeds', gives a detailed account of the changes occurring in the cotyledons or storage organs and the growing embryos of starchy and fatty seeds from recent literature, and is well illustrated by data and suitable graphs. Activities of the different enzymes involved in the metabolism of germinating seeds and respiration are critically examined. The fourth chapter, 'Dormancy, germination, inhibition and stimulation', and the sixth on 'Germination inhibitors and stimulators' could have been suitably combined to avoid some inevitable repetition and to maintain continuity of the topic. The authors, however, justify the separation in order to develop at some length their views on inhibitors and stimulators of germination and on the mechanism of dormancy in lettuce seeds. It is interesting to note that release of inorganic phosphorus from stored phytin and its conversion to ATP may indicate the end of dormancy, as shown in lettuce seeds with coumarin, light and thiourea. The role of other germination inhibitors and stimulators is still not clear.

The book is useful to students of plant physiology, especially to research workers studying seed germination. Literature citation relates mostly to the last decade and is well distributed. The indices at the end — 'plant', 'author' and 'subject' — are helpful. The editors and the Pergamon Press should be congratulated on the neatly arranged and clearly printed figures and tables. The cost, however, is beyond the means of the students and scholars in India.

I. M. RAO

A DICTIONARY OF SCIENTIFIC UNITS (INCLUDING DIMENSIONLESS NUMBERS AND SCALES) by H. G. Jerrad & D. B. McNeill (Chapman & Hall Ltd, London), 1963. Pp. 197. Price 21*s*.

Of late, there have been several dictionaries for specialist fields like: (1) *The encyclopaedic dictionary of physics*, now being issued in eight volumes, intended to cover every branch of pure and applied physics; (2) *Mathematics dictionary*; (3) *Electronics and nucleonics dictionary*; (4) *A new dictionary of chemistry*, etc. Added to such dictionaries is the volume under review: *A dictionary of scientific units*. This is a welcome addition, as the names of units proposed or under active consideration by the international standardizing bodies, with newer technologies and sciences, are growing in number. Therefore, often a scientist or a technologist has to refer to a 'Dictionary of units' to get a correct idea, history or the definition of a 'unit'. This dictionary has covered 400 units, though some of them are mere proposals and not universally adopted. The units are listed alphabetically for easy reference. There are five appendices and a 20-page supplement containing some 500 references. Apart from an 'Introduction' on the necessity for four

fundamental units for physical quantities, there is also a 5-page article on 'System of units'. The book is fairly up to date. It has given the latest definition of the international 'metre' in terms of the wavelength of a selected line of the krypton-86 emission spectra, as decided upon at the Eleventh General Conference of Weights and Measures, held in Paris during October 1960.

The book under review has not given the 'International system of units' (SI), based on Resolution 12 of the Eleventh General Conference of Weights and Measures. This system is rapidly coming into vogue displacing all other system of units. Hence, there is need to devote even a special appendix to the 'International system of units' and define all its units (basic, supplementary and derived) together with their symbols. Also in the article 'System of units', the notable omissions are the Gaussian system and the MIE (German) system.

On page 39 under 'Decibel (dB)' the last line runs as follows: "The 'decilit' was a product of the Bell Telephone Laboratories." This is incorrect. This name was suggested by the reviewer, then working in Madras (India) and was never associated with the Bell Telephone Laboratories of USA. The paper suggesting the name 'Decilit: A new name for the logarithmic unit of relative magnitudes' was published in the *Journal of the Acoustic Society of America*, Vol. 27 (1955), 376 (vide item 8, under 'D' on p. 182 of the book under review).

The following two important publications are found missing in the 'References' section: (1) *A guide to the metric system* (containing over 70 conversion tables from FPS and CGS systems to the MKS and RMKSA systems) published in 1961 by Messrs Asia Publishing House, Bombay and London — under 'Units' and (2) *The decibel notation and its applications to radio engineering and acoustics*, published in 1946 by the Chemical Publishing Co., Brooklyn, New York, under 'D' in the 'References'.

However, the present book, in Appendix 4, gives about 22 conversion tables, and in Appendix 5 the conversion factors of mechanical and electrical quantities from CGS to MKS systems.

Appendix 1 gives the best experimental values of 26 fundamental physical constants. Appendix 2 gives a summary of 8 standardization committees and conferences. This is incomplete and needs to be expanded, as there are at least 8 international organizations and 9 national standardizing laboratories dealing with 'Units' in the world of today. Appendix 3 gives the tables of 'Weights and measures'.

It is hoped that in the next edition, the few omissions referred to above will be covered and the 'References' also brought up to date and the conversion tables of Appendix 4 considerably enlarged to make it exhaustive and comprehensive.

The get-up is good and considering the present-day costs, the price is not too high for a 200-page book printed on nice paper and bound well — the usual high standards of the publishers. The book should find a place on the reference shelves of all scientific and engineering libraries and laboratories.

V. V. L. RAO

BRITISH MINIATURE AND MICROMINIATURE DATA ANNUAL 1963-64 edited by G. W. A. Dummer & J. Mackenzie Robertson (Pergamon Press Ltd, Oxford), 1963. Pp. xii+335. Price 105s.

The use of miniature and microminiature assemblies in the fields of computer technology, defence electronics and space technology is becoming increasingly popular. More and more industries are getting interested in this particular field and their activity has resulted in a new approach to the problem. Modules are developed to fulfil generalized electronic circuit functions. It may not be too long before a custom built functional module could be chosen for a particular circuit function desired.

The book presents technical information and practical application data on miniature and microminiature assemblies introduced by the British firms. Assemblies refer mainly to digital circuit elements, transistorized packages of amplifiers (audio and wideband) and semiconductor networks and integrated circuits involving multiple transistors. It can be divided into four main categories: (i) Microcircuits based on evaporated thin films; (ii) Semiconductor networks and integrated circuits; (iii) Transistorized packaged assemblies using microminiature components and printed circuits; and (iv) General information on printed circuits, chemical etching and milling, plating processes, laminates, encapsulation materials, wrapped joints, soldering instruments and solder products and other construction methods.

Bringing together details regarding these assemblies introduced by different manufacturing firms is a task of considerable proportion. It is just as well that this book is introduced as a volume by itself and separate from the one on general components. The comprehensive information on these integrated and packaged components is of considerable importance to the circuit designer. It is expected that with the addition of further data on new modules introduced and by expanding the information on applications the usefulness of the volume can be further enhanced. It would facilitate easy reference if an index of the circuit modules is included.

CHEMICAL PLANT TAXONOMY edited by T. Swain (Academic Press Inc., London), 1963. Pp. ix+543. Price 110s.

Correct classification is essential for the spread of knowledge and also for its consolidation. In the field of botany, the basis has been for a long time the study of morphological features. This was natural since it was more easy to depend on visible characters, either visible to the naked eye or visible with the help of the microscope. An alternative is to test for what are inside as chemical components, but classification based on this is more difficult. However, even in the first quarter of the present century, chemical tests were widely applied to the field of lichens and their importance was appreciated in the study of microorganisms. As time passed on, chemical taxonomy slowly grew into greater importance. It has solved satisfactorily cases of doubt. In post-war years, the possibility of using chemical methods for taxonomy has enormously increased because of the

wealth of information obtained and the ease and efficiency of methods that are employed.

A considerably large number of compounds are present in any plant. Many of these are so common that they have small taxonomic value, but others, notably the so-called secondary plant products, are often restricted in their occurrence and are of help to distinguish one group of plants from another. The vast increase in the exploration of the distribution of natural products over the last 10 years is in part due to the growing interest on the part of botanists in the chemistry and biochemistry of plants. As already mentioned, a more important factor is the development of new analytical techniques in organic chemistry such as chromatography and ultraviolet, infrared, nuclear magnetic resonance and mass spectroscopy. With the help of such methods a large number of individual compounds present in anyone plant can be identified unambiguously in a very short space of time.

This book is the first comprehensive attempt to survey the scope and usefulness of chemical plant taxonomy. Its form was determined by a symposium held in Paris in October 1962 supported by the North Atlantic Treaty Organization. The authors of the different chapters are persons who have made distinctive contributions to special aspects of this subject. The book contains sixteen chapters. The first two chapters deal with methods and concepts of plant taxonomy. These are followed by chapters concerning the history, characteristics and development of chemical taxonomy and its usefulness as illustrated by flavonoid constituents. Further, two chapters deal with factors affecting the production of natural products and biosynthetic pathways. The later nine chapters which cover the major part of the book discuss the distribution of special components of plants such as acetylenic compounds, plant lipids, anthocyanins, alkaloids, sulphur compounds and their taxonomic significance. At the end of the book there is a list of plant families and comprehensive indexes of authors, plant genera and species and also of chemical compounds. The book is an authoritative treatise on chemical plant taxonomy and is highly useful to both botanists as well as chemists working in the field of natural products.

T. R. SESHADRI

RADIATION EFFECTS ON ORGANIC MATERIALS edited by Robert O. Bolt & James G. Carroll (Academic Press Inc., New York), 1963. Pp. xv+576. Price $ 13.50

Although it has been known for some time that radiations bring about profound changes in organic materials of different types, the mass of available information has been put together for the first time in a book form in the publication under review.

The book includes a short chapter on interaction of radiation with matter and another on mechanism of the chemical effects of ionizing radiations and briefly deals with radiation chemistry of pure compounds. Separate chapters are devoted to the effects of radiation (reactor radiation, including neutrons) on physical properties such as optical, thermal and electrical properties, and on the chemical behaviour of polymers, plastics, elastomers, lubricants, adhesives, textiles as well as of reactor fuels, shielding materials, reactor coolants, etc. The book has obviously been written primarily for the nuclear reactor technologist but will be found useful to a wider group of scientists and technologists. The authors have done well to use 'rad' as the basic radiation unit throughout.

At the end of each chapter, the authors have given a very comprehensive bibliography which should prove immensely useful to the research workers in the field. It has in addition both a subject and an author index. It is well printed and illustrated. The book should find a place in all science libraries.

JAGDISH SHANKAR

THE CONDITION OF SCIENCE IN AUSTRALIAN UNIVERSITIES (A STATISTICAL SURVEY, 1939-60) by Joseph Gani (Pergamon Press Ltd, Oxford), 1963. Pp. x+131. Price 21s.

This book is a statistical study of the pure sciences in Australian universities, a brief historical document about the development of university education in science. The two oldest Australian universities were founded at Sydney and Melbourne in the middle of the nineteenth century, and by 1911 six universities were set up. Two more universities and one university college were established by 1939. After the end of the war three more universities and one more university college were founded. Thus, there are 11 universities and 2 university colleges in the country.

Before 1939, the study of science was relatively unimportant in Australian universities. Staff was not numerous and included only a few distinguished scientists; the range of courses available for study was incomplete. Most science students took pass degrees, but a few continued with Honours and Masters degrees; the Ph.D. degree had not been established, and exceptional graduates interested in further research sought advanced training overseas, almost exclusively in Britain.

After 1939, on account of the important role which science played in the conduct of the World War II, and the increasing industrialization and scientific development of Australia, the situation at the universities improved intermittently, particularly during the last decade. The range of courses available for study was widened and in 1960 several Australian universities offered a large number of science subjects. Advanced postgraduate training lagged behind until the 40's when Ph.D. degree was introduced at all the universities; the establishment of postgraduate schools, since then, at many universities has helped raise postgraduate training and research to a new level in the country.

Between 1939 and 1960, the total university student population in Australia increased nearly four-fold, twice as fast as in UK. Student enrolments in 1960 numbered 5230 per million of population in Australia, compared to 2290 in the United Kingdom. During the same period, science students increased by a factor of 4·9 as against 3·2 in UK; science enrolments per million of population in 1960 were 661 in Australia (76 of them

postgraduate), while there were 473 in UK (with 91 postgraduate students). It may, however, be pointed out that in view of the higher rate of failures in Australia than in UK, the final number of degrees awarded per million of population was smaller. Nevertheless, there has been since 1939 a steady increase in science graduates and this trend shows every sign of continuing. The increase has been largely due to the overall increase in student enrolments, since the proportion of students in science in Australia has shown only a moderate increase from 9·8 per cent in 1939 to 12·6 per cent in 1960; in Britain there has been a more marked increase in the proportion of enrolments in science which has risen from 12·1 per cent in 1939 to 20·6 per cent in 1960.

The increase in science staff between 1939 and 1960 was approximately four-fold, but the student-staff ratio, considered inadequate, stood at 10·9 in 1960 (or 17·3 if estimated medical and engineering students in science courses are included), much the same as in 1939. The demand for scientific staff has been extremely high in Australia during the last ten years. Recruits from abroad have filled about one-third of the posts, including many retiring Australians. In order to meet the rising demand, appointment of inadequately trained staff has become inevitable. Emigration of some of the most talented staff to more active scientific centres abroad has accentuated the problem of shortage of staff.

As regards the quality of scientific research, the Australian standards are not first rate by international standards, even though they are comparable to the smaller provincial universities of the UK. Money for research comes mostly from government sources, but this is not adequate and lags behind the UK and USA on population basis.

The author concludes by saying that whatever be the theoretical objectives of higher education in science — the thrill of new discoveries, the challenge of scientific problems to the human intellect or the pleasure of understanding natural processes more deeply — in practice the overwhelming argument in its favour is essentially economic.

The author has taken pains to estimate figures of total enrolment, science enrolment and staff position for the period (1961-70), and thus serves the useful purpose of showing the dimensions of the problem. Indeed the problems discussed are not peculiar to Australia. They are essentially a world phenomena. If a relatively prosperous country like Australia with a small population is baffled by the immensity of the problem, how much more should it be for India may be better imagined than expressed !

I. C. MENON

PUBLICATIONS RECEIVED

CRYOGENICS: RESEARCH AND APPLICATIONS by Marshall Sittig (D. Van Nostrand Co. Inc., New York), 1963. Pp. ix+221. Price $ 6.75

MOTION AND TIME STUDY DESIGN AND MEASUREMENT OF WORK by Ralph M. Barnes (John Wiley & Sons Inc., New York), 1963. Pp. 739. Price $ 8.95

THE MANAGEMENT PROBLEMS OF DIVERSIFICATION: A PILOT STUDY OF THE CORPORATION DIVERSIFYING FROM AN ESTABLISHED BASE by Stanley S. Miller (John Wiley & Sons Inc., New York), 1963. Pp. xi+189. Price $ 4.50

ADMINISTRATION OF THE CHEMICAL ENTERPRISE edited by Courad Berenson (Interscience Publishers, a Division of John Wiley & Sons Inc., New York), 1963. Pp. x+414. Price $ 11.50

ANALYTICAL CHEMISTRY edited by Carl E. Crouthamel (Pergamon Press Ltd, Oxford), 1963. Pp. vii+163+265. Price 30s. net

THEORETICAL PHYSICS (Lectures presented at a Seminar, Trieste, 16 July 25 to August 1962) edited by A. Salam (International Atomic Energy Agency, Vienna), 1963. Pp. 637. Price $ 12.00 or Sch. 252 or 72s. stg

NUCLEAR ELECTRONIC INSTRUMENTS IN TROPICAL COUNTRIES (Technical Specifications for the Ordering by the IAEA of Nuclear Electronic Instruments to be used in Tropical Countries), Technical Reports Series No. 13 (International Atomic Energy Agency, Vienna), 1963. Pp. 29. Price $ 1.00 or Sch. 21 or 6s. stg

ADVANCES IN AUTOMOBILE ENGINEERING (Proceedings of a Symposium on Vehicle Ride, held at the Advanced School of Automobile Engineers, Cranfield, July 1962) edited by G. H. Tidbury (Pergamon Press Ltd, Oxford), 1963. Pp. viii+188. Price 35s. net

ELECTROMAGNETIC FIELDS by Sergei A. Schelkunoff (Blaisdell Publishing Co., New York), 1963. Pp. xiv+413

THE WORLD OF ELEMENTARY PARTICLES by Kenneth W. Ford (Blaisdell Publishing Co., New York), 1963. Pp. ix+246. Price $ 2.95 paper bound; $ 4.50 cloth bound

THE THEORY OF SUPERCONDUCTIVITY edited by N. N. Bogoliubov (Gordon & Breach Science Publishers Inc., New York), 1963. Pp. xii+357. Price $ 4.95

AUTO-PRIMER IN COMPUTER PROGRAMMING by Doris R. Entwisle (Blaisdell Publishing Co., New York), 1963. Pp. x+345. Price $ 6.50

AMERICAN SUBMINIATURE ELECTRONIC COMPONENT PARTS: DATA ANNUAL — 1963-64, edited by G. W. A. Dummer & J. Mackenzie Robertson (Pergamon Press Ltd, Oxford), 1963. Pp. xiii+679. Price £ 7

EFFECT OF IONIZING RADIATION ON HIGH POLYMERS edited by T. S. Nikitina, E. V. Zhuravskaya & A. S. Kuzminsky (Gordon & Breach Science Publishers Inc., New York), 1963. Pp. vi+90. Price $ 4.95

QUANTUM MECHANICS by John L. Powell & Bernd Grasemann (Addison-Wesley Publishing Co. Inc., Reading, Massachusetts), 1963. Pp. x+495. Price Rs 15 net

FOOD DEHYDRATION: Vol. I — PRINCIPLES by W. B. Van Arsdel (AVI Publishing Co. Inc., Westport, Connecticut), 1963. Pp. xi+185. Price $ 11.00

TRACTORS AND THEIR POWER UNITS by E. L. Barger, T. B. Lilzedahl, W. M. Carleton & E. G. Mckibben (John Wiley & Sons Inc., New York), 1963. Pp. xvii+524

THE EVOLUTION OF THE METAZOA by Jovan Hadzi (Pergamon Press Ltd, Oxford), 1963. Pp. xii+499. Price £ 5 net

ADVANCES IN ENZYME REGULATION: Vol. I, edited by George Weber; technical editor Catherine E. Forrest Weber (Pergamon Press Ltd, Oxford), 1963. Pp. xiv+420. Price £ 5 net

STATIC ELECTROMAGNETIC FREQUENCY CHANGES by L. L. Rozhanskii (Pergamon Press Ltd, Oxford), 1963. Pp. xii+110. Price 35*s*. net

THE ROLE OF SURFACE PHENOMENA IN METALLURGY edited by V. N. Eremenko (Consultants Bureau Enterprises Inc., New York), 1963. Pp. 141. Price $ 27.50

HISTOCHEMISTRY AND CYTOCHEMISTRY (Proceedings of the First International Congress, Paris, 1960) edited by R. Wegmann (Pergamon Press Ltd, Oxford), 1963. Pp. xviii+481. Price £ 5 5*s*. net

MECHANISMS CONCERNED WITH CONCEPTION (Proceedings of a Symposium held under the auspices of the Population Council and the Planned Parenthood Federation of America) edited by Carl G. Hartman (Pergamon Press Ltd, Oxford), 1963. Pp. xviii+526. Price £ 6 net

A COURSE OF MATHEMATICAL ANALYSIS: Part I, by A. F. Bermant (Pergamon Press Ltd, Oxford), 1963. Pp. xiv+493. Price 80*s*. net

FIFTY YEARS OF SCIENCE IN INDIA (PROGRESS IN MATHEMATICS) by B. R. Seth (Indian Science Congress Association, Calcutta), 1963. Pp. 44. Price Rs 1.50

FIFTY YEARS OF SCIENCE IN INDIA (PROGRESS OF STATISTICS) by P. K. Bose (Indian Science Congress Association, Calcutta), 1963. Pp. 50. Price Rs 1.75

FOUNDATION OF GENERAL TOPOLOGY by Á. Császár (Pergamon Press Ltd, Oxford), 1963. Pp. xix+380. Price £ 5 5*s*. net

HUMAN VIBRATION RESEARCH (A collection of articles sponsored by the Human Factors Society) by S. Lippert (Pergamon Press Ltd, Oxford), 1963. Pp. viii+111. Price 35*s*.

EXPLOSIVE WORKING OF METALS by John S. Rinhart & John Pearson (Pergamon Press Ltd, Oxford), 1963. Pp. viii+351. Price £ 5 net

SOLUBILITIES OF INORGANIC AND ORGANIC COMPOUNDS: Vol. I, Part II — BINARY SYSTEMS by H. Stephen & T. Stephen (Pergamon Press Ltd, Oxford), 1963. Pp. 961+1933. Price £ 12 10*s*. net

PSYCHO-PHARMACOLOGICAL METHODS (Proceedings of a Symposium on the Effects of Psychotropic Drugs on Higher Nervous Activity held in Prague from 30 October to 2 November 1961 under the auspices of the Society for the Study of Higher Nervous Activity) by Zdĕnek Votava Milan Horvàth Oldřich Vinar (Pergamon Press Ltd, Oxford), 1963. Pp. 360. Price £ 5 net

BASIC MATRIX ALGEBRA TRANSISTOR CIRCUITS by G. Zelinger (Pergamon Press Ltd, Oxford), 1963. Pp. xv+116. Price 42*s*. net

BIOGENESIS OF NATURAL COMPOUNDS edited by Peter Bernfeld (Pergamon Press Ltd, Oxford), 1963. Pp. xiii+930. Price £ 10 net

HIGH TEMPERATURE HEAT CARRIERS by A. V. Chechetkin (Pergamon Press Ltd, Oxford), 1963. Pp. xii+307. Price 60*s*. net

LIGHTING PROBLEMS IN HIGHWAY TRAFFIC edited by Erik Ingelstam (Pergamon Press Ltd, Oxford), 1963. Pp. 151. Price 70*s*. net

ANALYSIS AND COMPUTATION OF ELECTRIC AND MAGNETIC FIELD PROBLEMS by K. J. Binns & P. J. Lawrenson (Pergamon Press Ltd, Oxford), 1963. Pp. xiv+333. Price 84*s*. net

PAPER AND BOARD IN PACKAGING edited by J. H. Young, G. A. Gordon & D. J. Hine (Pergamon Press Ltd, Oxford), 1963. Pp. vii+199. Price 70*s*. net

THE TECHNOLOGY OF POLYESTER FIBRES by B. V. Petukhov (Pergamon Press Ltd, Oxford), 1963. Pp. xiv+89. Price 30*s*. net

CONTROLLED DELAY DEVICES by S. A. Doganovskii & V. A. Iranov (Pergamon Press Ltd, Oxford), 1963. Pp. ix+67. Price 30*s*. net

APPLICATIONS OF NEUTRON DIFFRACTION IN CHEMISTRY by G. E. Bacon (Pergamon Press Ltd, Oxford), 1963. Pp. xi+141. Price 42*s*. net

COSMETIC SCIENCE (Proceedings of the Second Congress of International Federation of Societies of Cosmetic Chemists, London, 1962) edited by A. W. Middleton (Pergamon Press Ltd, Oxford), 1963. Pp. xv+270. Price 84*s*. net

RADIATION EFFECTS IN PHYSICS, CHEMISTRY AND BIOLOGY (Proceedings of the Second International Congress of Radiation Research, Herrogate, Great Britain, 5-11 August 1962) edited by M. Ebert & A. Howard (North Holland Publishing Co., Amsterdam), 1963. Pp. xiv+510. Price 100*s*.

ADVANCED PROPULSION CONCEPTS (Proceedings of the Third Symposium held at Sheraton, Cincinnati, Ohio, 2-4 October 1962): Vol. I (Gordon & Breach Science Publishers Inc., New York), 1963. Pp. xii+432. Price $ 29.50

FOOD PROCESSING OPERATIONS: THEIR MANAGEMENT, MACHINES, MATERIALS AND METHODS: Vol. 2, by J. L. Heid & Maynard A. Joslyn (AVI Publishing Co. Inc., Westport, Connecticut), 1963. Pp. xi+594

COMBUSTION AND PROPULSION — Fifth AGARD Colloquium, Braunschweig, 9-13 April 1962: HIGH TEMPERATURE PHENOMENA edited by R. P. Hagerty, A. L. Jaumotte, O. Lutz & S. S. Penner (Pergamon Press Ltd, Oxford), 1963. Pp. viii+698. Price £ 7 net

SOLID STATE PHYSICS FOR METALLURGISTS by Richard J. Weiss (Pergamon Press Ltd, Oxford), 1963. Pp. xi+410. Price 84*s*. net

ADVANCES IN ELECTRON TUBE TECHNIQUES: Vol. 2 (Proceedings of the Sixth National Conference, September 1962) by David Slater (Symposium Publications Division, Pergamon Press Ltd, Oxford), 1963. Pp. viii+280. Price £ 7 net

NATURALLY OCCURRING OXYGEN RING COMPOUNDS by F. M. Dean [Butterworths & Co. (Publishers) Ltd, London], 1963. Pp. viii+661. Price 120*s*. net

RESTORATION OF FUNCTION AFTER BRAIN INJURY by A. R. Luria; translated from the Russian by Basil Haigh; translation editor O. L. Zangwill (Pergamon Press Ltd, Oxford), 1963. Pp. xiv+277. Price 70*s*.

NOTES & NEWS

New materials in nuclear technology

A conference on 'New Nuclear Materials Technology' organized by the International Atomic Energy Agency (IAEA) at Prague during July 1963 has brought together the work done in recent years on the production and fabrication of oxide fuels for nuclear reactors and other forms of non-metallic fuels as well as new materials for use as reactor components other than fuel. A major objective of current research in nuclear technology is to develop reactor materials that can withstand the effects of high temperature and intense radiations. Dr Sigvard Eklund, Director General of the IAEA, in his opening address drew attention to the recent experience regarding the stainless steel cladding of uranium fuel (instead of the conventional Magnox cladding) which has permitted the operation of reactors at higher temperature and hence at higher efficiency. Another advantage of non-metallic fuels is the possibility of achieving higher fuel burn-ups which permit better utilization of fuels and less frequent refuelling.

A paper from Czechoslovakia described the phase transformations in the manufacture of uranium dioxide from ammonium diuranate. Another paper from the same country dealt with the conversion of uranium hexafluoride (UF_6) to uranium dioxide. Uranium dioxide suitable for sintering is produced in France by the reduction of trioxide obtained by calcination of a precipitated ammonium uranate and details regarding this process were presented in a paper from that country. Another paper from France presented details regarding the preparation of sinterable uranium dioxide for the fabrication of the fuel elements for EL-4 reactor now under construction in France.

The purpose of sintering is to densify the dioxide powder in order to make it extremely compact in the form of either pellets or small grains lightly held together. The main features of a continuous furnace for industrial sintering were presented in a paper from France. Automatic operation at temperatures up to 1700°C., rigorous control of presintering and sintering atmospheres, flexibility of temperature regulation and high output (5 tons/month) are the main advantages of this furnace.

A process for producing small sintered spheres of uranium dioxide by forming the spheres in a die and pressing them by a special method was described in a paper from Italy. A paper from Canada referred to a recent discovery that a particular single crystal of uranium dioxide had a very high thermal conductivity at elevated temperatures, instead of the conductivity falling off with increase in temperature. Further investigations at Chalk River, Canada, have helped to explain the factors on which this enhanced conductivity depends. One important technological approach now being tried to overcome the problem of low conductivity of uranium oxides at high temperatures is to have a combination of ceramic and metallic materials called cermets. Results of experiments to explore the feasibility of fabricating cermets with a higher content of uranium oxide were presented in a paper from UK. The results have shown that UO_2-stainless cermet plates containing 30-50 per cent by volume of uranium dioxide could be fabricated successfully.

Another approach, viz. having fuel elements composed of thoria core and a uranium oxide ring, was discussed in a paper from France. An account of the techniques developed at the Hanford Laboratories for producing reactor fuel oxides possessing unique properties was described in a paper from the USA. By these techniques, it has been found possible to produce crystalline uranium and plutonium dioxides and solid solutions of various oxide mixtures at relatively low temperatures. These techniques might also be useful in the preparation of other magnetic fuels.

The preparation of uranium carbides by the carbon reduction process of uranium dioxide is beset with difficulties because of the oxidizing tendency of uranium oxide. Two methods of overcoming this difficulty were described in a paper from South Africa. Results of studies on the preparation of carbides by the direct reduction of oxides with carbon in vacuum over the temperature range 1300-1800°C. were reported in a paper from UK [*IAEA Bull.*, **5** (No. 4) (1963), 26].

A new method of measuring dielectric constant of low-loss liquids

A new method of measuring dielectric constant of liquids using waveguides and especially designed for low-loss liquids has been reported from the Department of Physics, University of Waterloo, Waterloo, Ontario. The complex value of the dielectric constant (ϵ) is determined in this method by finding the real part ϵ' and the imaginary part ϵ'' separately by measuring the standing wave ratio in a waveguide suitably terminated. ϵ' is determined from the relation

$$\epsilon' = \sigma^2\left[1-\left(\frac{\lambda}{\lambda_c}\right)^2\right]+\left(\frac{\lambda}{\lambda_c}\right)^2$$

where σ is the voltage starting ratio and λ and λ_c are the wavelength of the travelling wave and theoretical wavelength of guide respectively. The propagation constant $\bar{\gamma}$ of a wave in the guide is given by the expression

$$\bar{\gamma} = \alpha+j\beta = \frac{\pi\epsilon''}{\lambda[\epsilon'+(\lambda/\lambda_c)^2]^{\frac{1}{2}}} + j\frac{2\pi}{\lambda}\left[\epsilon'-\left(\frac{\lambda}{\lambda_c}\right)^2\right]^{\frac{1}{2}}$$

By actually measuring α the attenuation constant and the propagation constant $\bar{\gamma}$, the value of ϵ'' can be evaluated.

In order to carry out the measurements stated above, two separate waveguide cells termed the attenuation cell and impedance cell have been designed and either of these cells may be attached to a standard microwave system for determining standing wave ratios in the frequency range 8·2-12·4 Gc/s. The impedance cell consists

of a 25 cm. section of a standard waveguide, with one end closed off with a thin mica window held between a standard choke and flat flange; the other end is terminated by a long tapered spike of a chemically inert ceramic. The cell is filled with the liquid through holes placed on the broadside of the guide. The attenuation cell is 1 m. long and closed at either end by a thin mica window and the cell is followed by a conventional sliding short. Both the cells are kept in a constant temperature bath, throughout the measurements. The estimated error in ϵ' is less than 2 per cent, while values of ϵ'' agree well with literature values [*Canad. J. Phys.*, **41** (1963), 1314].

Study of atmospheric water vapour turbulence by radio refractometry

A microwave radio refractometer developed by scientists at the US National Bureau of Standards (NBS), Washington, has proved of definite value in the study of water vapour turbulence in the atmosphere. The refractometer has a considerably faster response for measurement of the fine structure of humidity than any of the conventional sensors and thus overcomes one of the chief limitations of the conventional sensors.

Comparison of the conventional atmospheric measurements and radio refractive index measurements indicated promising relations between the two. The radio refractive index of atmospheric air has been found to be a function of temperature, pressure and humidity. The NBS scientists pursued the subject further and extensively studied variation of the radio refractive index with various combinations of the parameters: temperature, pressure and humidity. The investigation indicated a high correlation (correlation coefficient, 0·8) between the refractivity and absolute humidity flux, showing that the short-term or high frequency variations in radio refractive index arise from changes in humidity. It has been observed that the turbulence characteristics of the radio refractive index (at three different levels, on a 50 m. tower) reflected systematically the turbulence characteristics of the absolute humidity; also the stability of the atmosphere was reflected prominently in the low frequency end of the energy spectra of the samples studied [*Tech. News Bull. U.S. Bur. Stand.*, **47** (1963), 127].

X-ray scattering data and properties of scatterer

Quantum theoretical studies on the application of approximate wave functions conducted at the US National Bureau of Standards have led to the development of techniques for obtaining from the experimental scattering data two quantities that are proportional to the values of two properties of the scatterer. These properties were not previously readily susceptible to experimental measurement but could be calculated by methods involving approximate wave functions. The techniques consist of two sum rules directly relating coherent X-ray scattering data to two properties of the scattering system. The first sum rule states that the integration of the X-ray scattering factor for spherically symmetrical systems over all possible scattering angles yields a quantity directly proportional to the diamagnetic nuclear shielding constant. The second rule, which analogously involves the X-ray intensity for spherically symmetrical systems or for gaseous molecules with random spatial and angular orientation, yields a quantity proportional to the self-energy of the charge distribution of the scatterer. These two rules, therefore, provide a new means of checking the accuracy of quantum mechanical calculations that involve approximate wave functions. Expectation values of properties of a system derived using various wave functions can be intercompared. Application of these techniques to systems for which the wave functions are known with sufficient accuracy will help to establish criteria for judging the adequacy of approximate wave functions to be applied to more complex systems [*J. Franklin Inst.*, **276** (1963), 76].

80-inch bubble chamber

The world's largest bubble chamber installed at the Brookhaven National Laboratory has now been commissioned for use in the United States Atomic Energy Commission sponsored studies. The 1500-litre stainless steel chamber weighing *c.* 10 tons contains liquid hydrogen at −414°F. under a pressure of 70 lb./sq. in. Accelerated particles from a target in the alternating gradient synchrotron (AGS) are guided electromagnetically (out of the 1½-mile circumference tunnel in which is located the AGS magnet) into the bubble chamber. The liquid hydrogen in the chamber, being in the state of a superheated liquid, begins to boil due to the stimulus of the charged particles entering the chamber. Hence the resulting track of bubbles (over 20 per inch) is clearly visible and can be photographed by four special cameras located behind a 6½ in. thick glass window on one side of the chamber. By the synchronization of these cameras with a high voltage fast-pulsed light source, together with the entering beam of bombarding particles and the motion of the 36 in. diam. piston controlling the pressure in the chamber, photographs are taken for each pulse of particles from the synchrotron. The tracks can be erased and the chamber made ready for photographing further sets of events by increasing the pressure. The advantages of the bubble chamber over the other detection techniques are: (i) the space resolution is better and (ii) it is possible to use magnetic fields over the tracks studied, which facilitates accurate measurement of track curvature and moments. Because of the use of liquid hydrogen in the bubble chamber, an additional advantage is that the studies made will present interactions in the simplest of all nuclei, viz. the protons; this results in considerable simplification of the analysis [*J. Franklin Inst.*, **276** (1963), 185].

A new system for thin-layer chromatography

A simple, easy to handle spreading device for use in thin-layer chromatography is described. The spreading device gives fine and even layers and the thickness of the layers will be practically independent of variation in the thickness of the glass plates. Another advantage is that the number of

plates which may be covered at any time is not limited.

The spreader, which is made from 'Perspex', is built like a frame with the same dimensions as 12×16 cm. plate. The inner lower edges of the long sides are cut out to form grooves guiding the spreader sideways when it slides over the glass plates put in a long row on the desk. The spreader is placed at the end of the row of glass plates and is then filled with a suitable amount of suspension of silica gel, polyamide, cellulose powder and drawn at a slow, steady speed along the row. It then rests on its shorter sides. The front side slides on the glass surface. In order to facilitate the movement, especially if the glass plates vary a little in thickness, the lower front edge is rounded somewhat like a sleigh. The long sides of the spreader do not fit tightly against the glass plate. There is a gap of *c.* 0·5 mm., but due to the viscosity of the suspension very little will leak out that way. The back side is lifted up a certain distance from the glass surface by means of two adjustable pins, thus forming a slit through which the suspension may flow when the spreader is pulled along. In this way the plates are covered with a thin layer, the thickness of which is determined by the protruding pin tips. In order to keep the plates from sliding they are put on a few drops of water. Special care is taken to ensure that the plates form a straight line. In the present device discarded photographic plates have been successfully used instead of the usual polished plates which are costly [*Nature, Lond.*, **198** (1963), 1229].

Preparation of benzynes

A convenient method of generating benzynes in high yields has opened the way to more extensive use of these reactive species as organic intermediates [*J. Amer. chem. Soc.*, **85** (1963), 1549]. The benzynes are generated by diazotizing an *o*-aminoarenecarboxylic acid such as anthranilic acid with an alkyl nitrite in some aprotic and inert solvent. The reaction is mildly exothermic and in most cases can be carried out at room temperature. The benzynes are prepared *in situ* and can then be reacted as formed with an appropriate acceptor to give the desired product directly. In this way substituted benzynes such as Cl, Br, NO_2, MeO and CH_3 derivatives have been prepared. The ease with which the benzynes can be prepared has opened the way for studying the effect of substituents such as Cl, F, Br, MeO and NO_2 on the mode of nucleophilic or electrophilic addition to benzynes. Under the mild conditions employed in this method, highly reactive species can also be used as benzyne acceptors. This method has also been extended for the preparation of a number of new heterocyclic arynes, such as 3-pyridyne, 2-pyridyne and 1- and 2-naphthynes [*Chem. Engng News*, **41** (24) (1963), 46].

A simple test for the classification of mycobacteria

A simple test, based on the heat-stable esterase activity of mycobacterial species, has been used for classifying and differentiating mycobacteria at the Kyushu University, Japan. The experiments were mainly carried out on *M. kansasii*, and using this test, the photochromogen originally isolated from patients has been differentiated from the photochromogenic mycobacteria isolated from tropical fish.

The heat-stable esterase test is carried out as follows. The substrate such as phenolphthalein dibutyrate (10 mg.) is dissolved in acetone (3 ml.) and the solution diluted with distilled water to 20 ml. A mycobacterial cell suspension (5-10 mg./ml.) is heated in a boiling water-bath at 100°C. for 10-15 min. and cooled in running tap water. To 1 ml. of the cell suspension in a test tube 1·5 ml. of the substrate solution is added. The tube is incubated at 37°C. for 3-6 hr and a drop of 1*M* sodium carbonate is added. The positive heat-stable esterase reaction is indicated by development of red colour. This esterase activity is found to be resistant to heating even at 121°C. for 10 min. The active principle can be extracted from the cell suspension by heating, but not extracted with organic solvents at room temperature. The extracted active principle is non-dialysable. The optimal *p*H of the reaction has been found to be 8·0-8·5 [*Nature, Lond.*, **198** (1963), 1113].

α-Oxidation of fatty acids

Odd-numbered long chain fatty acids and α-hydroxy fatty acids are found in the brain sphingolipids. The known mechanisms of biosynthesis of long chain fatty acids do not provide a plausible explanation for their formation. A. Hajra and N. R. Radin [*J. Lipid Res.*, **3** (1962), 327], based on their *in vitro* studies, have proposed that odd chain fatty acids are formed from propionate, but this pathway seems to be of less importance in view of the fact that propionate competes unfavourably with acetate in the whole animal. A novel 1-carbon degradation process, hitherto unknown for higher animals, has been suggested [Mead, J. F. & Levis, G. M., *J. biol. Chem.*, **238** (1963), 1634] to be the process for the formation of α-hydroxy fatty acids and long chain fatty acids. This is based on the ratio of active labelling pattern of the fatty acids of brain sphingolipids obtained 5 months after administering carboxy-labelled (C^{14}) sodium acetate to 15 days old rats intraperitoneally. The 23- and 24-carbon normal fatty acids and hydroxy acids were isolated and degraded stepwise to locate and measure the radioactivity. It was found that in the case of cerebronic acid (24 carbons) almost its entire activity was distributed equally among the odd carbons, while in the case of the 23-carbon acids (tricosanoic and α-hydroxy tricosanoic) the even carbons were predominantly labelled. It became apparent from this pattern that the 23-carbon acids were not formed by direct biosynthesis from the acetate but by degradation of acids that were synthesized in this manner. In an earlier paper, evidence for direct hydroxylation of normal acids to α-hydroxy acids was adduced [Fulco, A. J. & Mead, J. F., *J. biol. Chem.*, **236** (1961), 2416]. Based on these observations, Mead and Levis proposed a 1-carbon or α-oxidation system:

$$CH_3(CH_2)_{21}CH_2COOH \rightarrow CH_3(CH_2)_{21}CHOHCOOH \rightarrow CH_3(CH_2)_{21}COOH$$

The validity of this postulate has been further tested using enzyme preparations from rat brain [Mead, J. F. & Levis, G. M., *Biochem. Biophys. Res. Commun.*, **11** (1963), 319]. The substrate specificity of the decarboxylation activity of the enzyme was examined using 1-^{14}C labelled C_{18} and C_{23} normal and α-hydroxy acids. The hydroxy acids were readily decarboxylated whereas the normal acids were not attacked. In another experiment they found that 2-ketostearic acid-1-^{14}C was a much better substrate than 2-hydroxystearic acid; the product obtained after decarboxylation was characterized as margaric acid. The ready decarboxylation of the α-ketostearic acid suggested it to be an intermediate in the degradation of α-hydroxystearic acid to margaric acid. When α-hydroxystearic acid 9-10-^{3}H was incubated with the enzyme system in the presence of unlabelled α-ketostearic acid, both margaric acid and α-ketostearic acid were found to be radioactive.

These findings lend support to the postulate that very long chain fatty acids of brain sphingolipids are degraded by α-oxidation mechanism according to the following sequence:

$$CH_3(CH_2)_nCH_2COOH \rightarrow CH_3(CH_2)_nCHOHCOOH \rightarrow CH_3(CH_2)_nCOCOOH \rightarrow CH_3(CH_2)_nCOOH + CO_2$$

S. A. KUMAR

RNA and learning process

The fixation of experience upon which memory and learning are based is thought to result from processes that cause a permanent change in the neurons or neural network of the central nervous system. Ribonucleic acids have been suggested to be the critical sites of such structural changes [Hyden, H., *Proceedings, Fourth International Congress of Biochemistry*, Vol. 3 (Pergamon Press Ltd, London), 1959, 64]. There is empirical evidence to support this hypothesis [Gerard, R. W., cited in *Brain mechanisms and learning*, edited by F. J. Delapresnaye (C. C. Thomas & Sons, Springfield), 1961, 21; Schmitt, F. O., *Macromolecular specificity and biological learning* (MIT Press, Cambridge), 1962]. Recently, several workers have tested the validity of this hypothesis and the consensus of opinion is in favour of it.

The actual changes in RNA, both qualitative and quantitative, have been the yardstick in the experiments of H. Hyden and E. Egyhazi [*Proc. nat. Acad. Sci., Wash.*, **49** (1963), 618]. These workers had earlier reported an increased nuclear RNA with increased adenine/uracil ratio in the nerve cells of learning rats [Hyden, H. & Egyhazi, E., *Proc. nat. Acad. Sci., Wash.*, **48** (1960), 1366]. However, it was not clear whether these changes were specific or just a result of physiological stress on the neurons *per se*. In a reinvestigation of the problem, these workers have shown that the quantitative changes in the bases occur only in the Dieiters cells which are mainly involved in establishing the learning behaviour. In other nerve cells, increase in RNA/cell on stimulation was observed, but there was no change in the base ratio. These results, therefore, clearly indicate that the RNA changes observed during learning are specific and not due to the increased neural function *per se*.

The neuron and its neighbouring glia are linked in an energetic system and they possibly react as a functional unit; their biosynthesis of RNA is linked [Hyden, H. & Egyhazi, E., *J. cell. Biol.*, **15** (1962), 37]. These investigators found that during learning experiments the glial RNA increases and this RNA also contains an increased adenine/uracil ratio. On physiological stimulation, inverse changes occur in the nerve cell and its glia. The amounts of RNA, proteins and respiratory enzymes rise in the neuron and decrease in the glia [Hyden, H. & Pigon, A., *J. Neurochem.*, **6** (1960), 57]. These changes and the changes observed in RNA base compositions in both neuron and its glia demonstrate that the glia and the neuron compose a functional unit. It has been suggested by these workers that gene sites in chromosomes of neurons are induced to synthesize RNA in an acute learning situation in mammals. The mechanism is anchored in the genome and learning occurring during a life cycle is probably a superimposition on the genetically stable mechanism of the central nervous system reflected in behaviour. The production of RNA with specific base ratios in both neurons and glia could be considered as reflecting such a mechanism. It is possible that the glia and the glial RNA constitute a substrate for a short term memory since the folded membranes of the glia would be well suited for very rapid processes. The neuron and its mass of RNA could then house the substrate of long term memory.

In a different type of experiment, T. J. Chamberlain, G. H. Rothschild and R. W. Gerard [*Proc. nat. Acad. Sci., Wash.*, **49** (1963), 918] have tested the hypothesis by studying the effect of drugs which affect RNA metabolism and the learning capacity. Three behavioural situations were chosen to test these drugs and the results generally indicate faulty behaviour patterns in the drug administered rats.

If RNA is involved in the memory mechanism, it may be influenced at several steps and may, in turn, act by influencing protein synthesis. J. B. Flexner, L. B. Flexner and E. Stellar [*Science*, **141** (1963), 57] have shown that puromycin, which inhibits protein synthesis, when injected intracerebrally, destroys memory; upon recovery the animals were capable of learning again. Since these studies are incomplete the implications of protein synthesis in memory and learning processes are not certain.

How a particular RNA arises in response to experience is not clear. Also, the basic question of how a patterned flow of information can be stored in the neuron, so patterned as to be specifically responsible to the initial pattern and to emit appropriately patterned outflow impulses, is an unexplored one.— (Miss) P. MALATHI

Amino acid sequence of ribonuclease

The success achieved by Sanger with insulin led to the study of the amino acid sequence of other proteins and to the development of new methods for the fractionation of peptides formed by partial degradation. Bovine pancreatic ribonuclease became the

first enzyme with known primary structure when Moore and associates showed it to be a single chain of 124 amino acid residues with N-terminal lysine and C-terminal valine, joined together by four disulphide bridges. This sequence [Hirs, C. H. W., Moore, S. & Stein, W. H., *J. biol. Chem.*, **235** (1960), 633], however, disagreed with the results of R. R. Redfield and C. B. Anfinsen [*J. biol. Chem.*, **221** (1956), 385]; C. B. Anfinsen, M. Sela and H. Tritch [*Arch. Biochem. Biophys.*, **65** (1956), 156] and F. M. Richards and P. J. Vithayathil [*J. biol. Chem.*, **234** (1959), 1459]. The disagreement involved the nature of the amino acid residue at position 11. In the formula, a serine residue was assigned to this position and the sequence from residues 11 to 18 was given as Ser-Thr-Ser-Ser-Asp.NH_2-His-Met-Glu. The results of Anfinsen and Richards indicated that the residue at position 11 was glutamic acid or glutamine.

A thorough reinvestigation of the sequence in this part of the molecule was undertaken by D. G. Smith, W. H. Stein and S. Moore [*J. biol. Chem.*, **237** (1962), 1845]. They found that the principal source of error in the earlier experiments was the formation of pyrrolidine carboxylyl residue by cyclization of NH_2 terminal glutamine residue and the artifactual loss of serine and threonine during the course of the Edman degradation. The modified conditions for Edman degradation introduced by W. Koninsberg and R. J. Hill [*J. biol. Chem.*, **237** (1962), 2547] eliminated the loss of hydroxyamino acids. Using this procedure the sequence from positions 11 to 18 has been established as Glut.NH_2-Hist-Met-Asp-Ser-Ser-Thr-Ser.

Based on this experience the same authors undertook a thorough re-examination of the amino acid sequence of the whole molecule. In a recent report [*J. biol. Chem.*, **238** (1963), 227] they have revised the sequence of some other portions of the molecule also. Mainly by the use of Edman degradation under the modified conditions, the following further revisions of the structure have been documented: (1) The sequence from residues 69 to 71 has been changed from Thr-Asp.NH_2-Glut.NH_2 to Glut.NH_2-Thr-Asp.NH_2; (2) the sequence from 87 to 89 has been changed from Ser-Thr-Gly to Thr-Gly-Ser; (3) the sequence from 94 to 96 has been changed from Asp.NH_2-Ala-Cys to Asp.NH_2-Cys-Ala; and (4) the sequence from 101 to 103 has been changed from Asp.NH_2-Ala-Glu.NH_2 to Glu.NH_2-Ala-Asp.NH_2.

Extensive new data in the present communication confirm the sequence deduced for the rest of the 124 amino acid residues in the ribonuclease molecule. — C. R. RAMAKRISHNAKURUP

ADP — A hydrogen carrier in the respiratory chain ?

It has been generally accepted that ADP stimulates mitochondrial oxidation by acting as a phosphate (P_i) acceptor. However, in a recent study, V. P. Skulachev [*Nature, Lond.*, **198** (1963), 444] has found that with aged mitochondrial preparations having low internal adenosine nucleotide levels, ADP (and ATP) markedly stimulate succinate oxidation even in the presence of excess phosphorylation uncoupler, 2,4-dinitrophenol (DNP), indicating a role for ADP other than as a P_i acceptor. This stimulation of oxidation was not brought about by other nucleotides as AMP, GDP or CDP, chelators as EDTA or fatty acid binding agent like serum albumin or even P_i.

The author explains this ADP enhancement of uncoupled mitochondrial oxidation by assuming that ADP acts as hydrogen carrier. Early work has indicated that adenine and its nucleotides but not guanine, cytosine, uracil or thymine, may undergo facile electrochemical reduction in perchloric acid to give the 1,6-dihydropurine, with an absorption maximum at 229 mμ and a plateau between 250 and 310 mμ, followed by a reduction of the 260 mμ purine peak. Air oxidation of the dihydro compound abolishes the 229 mμ peak and restores the 260 mμ peak. A difference spectrum of the oxidized and reduced forms of the purine thus shows a characteristic minimum at 260 mμ and a maximum between 290 and 310 mμ. Somewhat similar difference spectra have been obtained by Chance and coworkers [Chance, B. & Nishimura, M., *Proceedings, Fifth International Congress of Biochemistry*, Vol. 6, 1961, 12; Chance, B. & Hagihara, B., *Proceedings, Fifth International Congress of Biochemistry*, Vol. 5 (Pergamon Press Ltd, London), 1961, 12] in their work with intact bacterial cells and phosphorylating heart muscle mitochondria, where a shoulder minimum at 260 mμ and a maximum between 310 and 315 mμ occurred and which is interpreted by V. P. Skulachev as being a combination of the difference spectra caused by purine and ubiquinone reductions. These spectral changes, along with the evidence that ADP depletion interferes with oxidation, whereas its readdition restores it, lends strong support to the hypothesis that ADP has a role as a hydrogen carrier in mitochondrial oxidation. Besides, the 8-9 cal./mole energy liberated during the oxidation of dihydroadenine may be used in intermediate pyrophosphate or NP bond formation prior to ATP formation.

The two schemes involved with ADP as a respiratory carrier in the (a) phosphorylating and (b) non-phosphorylating systems are envisaged as follows:

(a) $AH_2 + ADP_m \rightleftharpoons H_2ADP_m + A$
$H_2ADP_m + P_i \rightleftharpoons PH_2ADP_m$
$PH_2ADP_m + B \rightleftharpoons ATP_m + BH_2$
$ATP_m + ADP_e \rightleftharpoons ADP_m + ATP_e$

(b) $AH_2 + ADP_m \rightleftharpoons H_2ADP_m + A$
$H_2ADP_m + DNP \rightleftharpoons DNP.H_2ADP_m$
$DNP.H_2ADP_m + B \rightleftharpoons DNP + ADP_m + BH_2$

where A and B are respiratory carriers, and ADP_m and ADP_e are intra- and extra-mitochondrial nucleotides respectively.

D. E. Griffiths and R. A. Chaplain [*Biochem. Biophys. Res. Commun.*, **8** (1962), 497, 501] have demonstrated the formation of labile phosphorylated form of NAD during mitochondrial succinate oxidation which they believe to be an intermediate in ATP and NADH formation in oxidative phosphorylation. As this compound also has a 233 mμ peak, with a lowering of the 260 mμ absorption, the present author suggests that it may be the adenosine moiety of NAD which is reduced, thereby causing the spectral changes.

The structural similarity of barbiturates to the pyrimidine moiety of adenine is used to explain the barbiturate inhibition of respiration between $NADH_2$ and FAD. ADP (or the adenine part of NAD) is

implicated as hydrogen carrier between $NADH_2$ and FAD, cyt.*b* and cyt.*c*, and between cyt.*c* and cyt.*a*, i.e. at those points where ATP generation supposedly takes place on the respiratory chain.

Finally a pyrophosphate bond is implicated as essential for the combination of ADP with the 'ADP-reductase' as AMP itself is ineffective in enhancing oxidation.—S. MAHADEVAN

Biosynthesis of myo-inositol

W. H. Danghaday, J. Rarner and C. Hartnett [*J. biol. Chem.*, **212** (1953), 869] reported that C^{14} inositol could be recovered from rats given repeated injection of C^{14} glucose. Since the microorganisms in the alimentary tract are known to affect the mammalian metabolism profoundly, the observation of inositol formation in germ-free rats and mice [Freinkel, N. & Dawson, R. M. C., *Biochem. J.*, **81** (1961), 250] has established unequivocally the existence of a mammalian pathway for the biosynthesis of this cyclitol. Y. Imai [*J. Biochem.* (*Tokyo*), **53** (1963), 50] studied the localization of labelled atoms in inositol biosynthesized after administration of variously labelled sugars (monosaccharides) to the rat with a view to deducing the mechanism of its formation. Of the various substrates tested, the author found that glucose and galactose were the best precursors of inositol, and each hexose, even though differently labelled, contributed to inositol to almost the same extent, suggesting that an intact 6-carbon unit serves as a precursor for inositol in rat. D-Glucose-U-C^{14} was uniformly labelled in all the 'C' atoms of inositol. D-Gluco or Gal-1-C^{14} was maximally labelled in 4,6 'C' of inositol, G-Glu or Gal-2-C in 3,5 and D-Glu-6-C^{14} in 1 of inositol. However, D-glucoronolactone-6-C^{14} failed to be incorporated into inositol, suggesting that the cleavage of inositol to glucoronic acid is not reversible. Therefore, the cyclization of D-glucoronolactone might not be the mechanism for inositol biosynthesis in rat. D-Xylose, D- and L-lactate and glycerol were also incorporated into inositol to a less extent than glucose, suggesting that smaller molecular units did not serve as direct precursors of inositol in rat. G. Houser and V. N. Finelli [*Fed. Proc.*, **22** (1963), 655] reported that specific activity of both free and phosphatidyl inositol synthesized by the intact rat or rat kidney slices was less when the carbon 6 of glucose was labelled than with the label in carbon atoms 1 and 2, thus casting a doubt on 6-carbon unit serving as a precursor for inositol. I. W. Chen and F. C. Charalampous [*Biochem. Biophys. Res. Commun.*, **12** (1963), 62] and E. Frank (Jr) and A. H. Bolden [*Biochem. Biophys. Res. Commun.*, **12** (1963), 72] reported cell-free systems from yeast and rat testes respectively for the synthesis of inositol from glucose. The yeast enzyme system has a confactor requirement for NAD, Mg^{2+} and a nucleotide triphosphate as an energy source. Since these workers employed glucose-U-C^{14}, the mechanism of conversion of glucose to inositol is not conclusively established in the cell-free systems.—P. AJAYAKUMAR

Biosynthesis of tyrocidine and proteins

In view of the large number and variety of polypeptides found in living cells, the elucidation of the biosynthetic pathways of these substances presents a challenging problem. Recent findings have clarified many enzymatic processes involved in the incorporation of amino acids into protein [Zamecnik, P. C., *Harvey Lect.*, **54** (1960), 256]. It is of particular interest to determine whether or not the mechanisms of polypeptide biogenesis resemble those of protein synthesis. The gramicidin and tyrocidine group of antibiotic peptides found in *Bacillus brevis* offer a number of attractive features for the above purpose in that the structures of the cyclic tyrocidines A, B and C are known and the amino acid composition of the gramicidin peptides is well worked out.

B. Mach, E. Reich and E. L. Tatum [*Proc. nat. Acad. Sci., Wash.*, **50** (1963), 175] have investigated the biosynthesis of tyrocidine in *B. brevis*. The incorporation of labelled tyrosine or ornithine into the antibiotic is found to be linear with time for at least 20 min. Using the rate of incorporation of labelled tyrosine as a measure of polypeptide and protein synthesis, the effect of various agents on both the processes has been investigated. Inhibitors of protein synthesis such as chloramphenicol and puromycin have no effect on the incorporation of labelled amino acids into the antibiotic, while the synthesis of bacterial protein is completely inhibited. The effects of several amino acid analogues on the synthesis of protein and tyrocidine indicate that the synthesis of tyrocidine is inhibited without affecting that of protein.

Since chloramphenicol and puromycin interfere with the transfer of sRNA amino acids to ribosomes [Nathans, D. & Lipmann, F., *Proc. nat. Acad. Sci., Wash.*, **47** (1961), 497] it is suggested that the involvement of amino acyl sRNA in the formation of tyrocidine is unlikely. Hence it is concluded that the biosynthesis of tyrocidine differs from that of proteins and the inhibitor effect exerted by amino acid analogues on tyrocidine biosynthesis supports this conclusion. But Issamu Nemura, Kiyoshi Okuda and Theodore Winnick [*Biochemistry*, **2** (1963), 719] have arrived at a different conclusion based on their studies with *B. brevis*. These workers studied the incorporation of various amino acids into tyrocidine and gramicidin, by a cell-free system, prepared from sonicates of *B. brevis*. The cell-free system consists of ribosomes plus a 140,000 $\times g$ supernatant solution. This system requires the presence of both the Mg^{2+}, ATP, ATP generator and glutathione for maximal activity. Treatment with ribonuclease destroys the ability of the system to promote gramicidin or tyrocidine synthesis. The process of incorporation of labelled amino acids into polypeptides thus bears striking similarity to the corresponding general requirements for protein biosynthesis. The resemblance of both the processes extends even to the binding of the labelled products to ribosomes. The following observations suggest that it is unlikely that the antibiotic peptides are simply adsorbed to the ribosomes after synthesis in the soluble phase: (i) Both the ribosomes and the soluble phase are needed for optimum synthesis, (ii) the ribosomes are sensitive to magnesium ion concentrations, and (iii) ribosomes lose their ability to supplement the supernatant phase. Hence it is

concluded that the biosynthesis of tyrocidine and gramicidin resembles protein biosynthesis and it is suggested that the participating macromolecular components in the 140,000 $\times g$ supernatant solution include sRNA and amino acid activating enzymes. However, it remains to be seen what factors determine the selection of one or the other peptide forming system for the biosynthesis of polypeptides.—S. RAMANATHAN

Evidence for ring structure of polyoma virus DNA

The DNA of polyoma (PY) virus has two distinguishing features: It is unusually resistant to heat or formamide denaturation [Weil, R., *Proc. nat. Acad. Sci., Wash.*, **49** (1963), 480] and has two distinct components of sedimentation coefficient **14** and **21** respectively [Crawford, L. V., *Virology*, **19** (1963), 279]. The fast and the slow bands are designated as F and S respectively. R. Dulbecco and M. Vogt [*Proc. nat. Acad. Sci., Wash.*, **50** (1963), 236] have recently shown that molecules of PY virus DNA exist in different states in the F and S components and that the F component is made up of molecules in the ring form and the S component of molecules in linear or open form. It has been found that both F and S are infectious and produce plaques of similar type. In the F band the infectivity is uniformly distributed, whereas in the S band the infectivity is present only in the frontal part. The S band is thus heterogeneous and it is assumed to consist of infectious linear molecules in the frontal part, obtained by opening the ring. In the column of methylated albumin the S component is eluted at higher salt concentration than the F component. This contradicts the hypothesis that the S band is made up of monomer DNA molecules and the F band of end-to-end dimers as suggested by J. D. Watson and J. W. Littlefield [*J. mol. Biol.*, **2** (1960), 161] for the two components of papilloma virus DNA. This result is compatible with the ring hypothesis. In band sedimentation at *p*H 12·5 the F component gives two bands, one (SF band) sedimenting like the S component and the other sedimenting about 2·5 times faster than at *p*H 7·5. The ring molecules (F component) are resistant to denaturation presumably because they do not have free ends, and when denatured, they remain topologically unchanged, i.e. still coiled together and sediment very rapidly like incompletely denatured DNA [Freifelder, D. & Davidson, P. F., *Biophys. J.*, **3** (1963), 49]. Upon annealing they reconstitute the ring molecules, characteristic of the F component. The linear (S) molecules denature more readily, because they have free ends; upon denaturation they give rise to separate single strands at a rate similar to that of the native S. Pancreatic DNAase converts the F component into the S component with loss of infectivity. The kinetics of the conversion is unusual since it is of the first order. The interpretation is that the ring molecules are labile for reasons related to their shape. The ring form imposes a statistically higher stress on the phosphodiester bonds; hydrolysis of one bond may increase considerably the stress on the complementary bond, making it highly susceptible to hydrolysis by the same enzyme molecule. F to S conversion by DNAase entails loss of infectivity as a function of the time of exposure. In both the F and S components loss of infectivity is caused by complete scission.

These results indicate that the ring should be made of two complementary strands, each one separately closed on itself, plectonemically coiled and not cross-linked. It is likely that the ends of each polynucleotide chain are connected by a special ' linker ' as in ϕX DNA [Fiers, W. & Sinsheimer, R. L., *J. mol. Biol.*, **5** (1962), 424]. This is suggested by the presence of infectivity in the native linear molecules, in contrast to its absence in at least most of the linear molecules obtained by DNAase treatment.—K. SANTHANAM

Progress Reports

Indian Lac Cess Committee

The annual report of the Indian Lac Cess Committee for the year 1961-62 chronicles the research and developmental activities of the Indian Lac Research Institute, Namkum, and the Lac Extension Wing of the Indian Lac Cess Committee. During 1961-62 the production of all the four lac crops was 38·6 thousand metric tonnes as compared to 52·8 thousand metric tonnes during the previous year.

Evolution of improved cultivation practices for *palas* and *kusum* crops, biological control of insects, genetical, physiological cum cytological studies on the lac insect were the main fields of study in the Entomology Division. Genetical studies involving crossing of *Ranginee* females with *kusmi* males have shown the progeny to behave like *Ranginee* insects which indicates either they are different species and produce parthenogenetically, or they are hermaphrodites. A rearing technique for *Pristomeria sulii* has been evolved using *Corcyra cephalonica* as host.

Physiological cum cytological investigations on the lac insect have revealed that (i) lac resin glands have both uninuclear and binuclear conditions; (ii) the nucleus is deeply staining; (iii) cytoplasm is dense and granular with one or two vacuoles; and (iv) the equatorial region of the cell contains 15 per cent wax. At the Chemistry Division, a modified method has been evolved for the determination of bleach index of lac using photoelectric colorimetric readings of iodine solutions. An alternative method for the determination of moisture content of lac has been standardized.

A new method, superior to the alkali method, for the preparation of shellac from seedlac has been developed. The colour index and the storage stability of the shellac obtained by this method compare well with those of *bhatta* shellac.

A rapid method of bleaching lac has been worked out and is found to utilize 40-50 per cent less of bleach liquor than the conventional bleaching method. The colour index, solubility in alcohol and yield of bleached lac are similar to those obtained by the conventional bleaching method.

With a view to expanding the field of utilization of shellac, studies on the solubility, molecular weight and other properties of lac, development of shellac wash primers, shellac aqueous and spirit varnishes, shellac-based bed materials and copolymerization of lac with monomers were carried out.

Council of Scientific & Industrial Research, South Africa

The annual report of the Council of Scientific & Industrial Research, South Africa, for the year 1962 covers the activities of the 10 national laboratories besides giving the significant results of the sponsored research in progress or completed at the medical and non-medical research units.

During the year the research units covered a wide range of problems in the fields of cosmic rays, corrosion of reinforced steel rods, solid state physics and medical research. Study of the effect of weather on radars of various frequencies, measurements of radio noise levels below 30 Mc/s. and investigations on the characteristics of the ionosphere formed the main fields of investigation at the National Institute for Telecommunication Research. The institute has successfully put into operation the two major radio-tracking stations, the deep space station and the Minitrack for tracking near satellites and interplanetary space vehicles. The major operation of the deep space station was that of tracking the research vehicle, Mariner II, in the Venus 'fly past'. The institute has also been responsible for the invention and much of the subsequent development of the 'Tellumeter' system.

The National Research Institute for Mathematical Sciences has designed an automatic weather recording equipment which records the meteorological data, viz. temperature, radiation, wind velocity, direction, etc., in 30 sec.

The National Physical Research Laboratory (NPRL) has been responsible for the designing and construction of a pneumatically operated shutter for X-ray apparatus to control the exposure time of an X-ray beam. The NPRL, in collaboration with the Technical Services Department, has devised a cheap and portable antivibration table for precision balances. Atomic absorption and spectrographic techniques have been developed for the analysis of high-purity gold. As a result of studies on the determination of profiles of river beds covered by sand, carried out by NPRL and National Institute for Water Research, an electrical resistance method has been developed for determining the bottom profiles of river beds, clay concentrations in sand layers and tracing brackish areas in the river. A seismic hammer refraction method has been developed for bottom profile determination up to a depth of 90 ft. A pneumatic hammer capable of generating more energy than the conventional hammer is being designed for bottom profile determinations at greater depths.

At the Fishing Industry Research Institute, Cape Town, a dehydrated fish cake mix has been developed in which fish-fibre of hake is maintained to simulate the texture of fresh fish. Studies on the phospholipids of pitch and flesh have shown that lecithins, cephalins, sphingomyelins, inositides, cerebrosides and phospholipids of the cardiolipin are present in the chloroform-methanol extracts of fish tissue. Paper chromatographic study of the hydrolysis products obtained from the phospholipids has revealed the presence of choline, serine, ethanolamine, sphingosine, inositol, glutamic acid, threonine and several other ninhydrin-reacting substances.

Studies on devitrification, wetting behaviour and mineralogy of blast furnace slags, determination of the mineral phases in portland cements by X-ray techniques and investigations on the corrosion and relaxation of prestressing steel used in concrete formed the main lines of work at the National Building Research Institute. A new method for making low-density leather from hides by freeze-drying the unhaired hide is in an advanced stage of development.

Announcements

▪ *An international symposium on organic photochemistry*, sponsored by IUPAC, will be held in Strasbourg, France, during 16-24 July 1964. The number of participants will be limited, but junior chemists are encouraged to apply. Although lectures will be by invitation only, it may be possible to provide some financial assistance for other participants. Applications should be sent to the Scientific Director, Dr G. S. Hammond, Gates & Crellin Laboratories of Chemistry, California Institute of Technology, Pasadena, California, USA, before 15 March 1964.

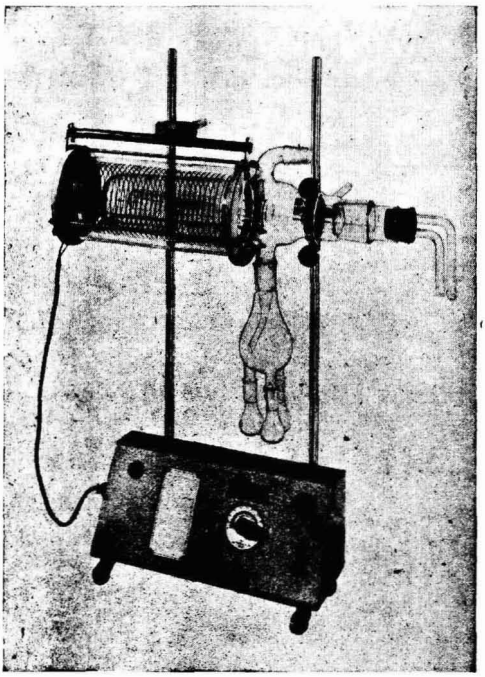
▪ *A seminar on salt and byproducts* will be held at the Central Salt & Marine Chemicals Research Institute, Bhavnagar, during 10-11 April 1964. The discussions at the seminar will cover the follwing fields: Scientific methods of winning salt for various purposes; Soil stabilization and use of mechanical appliances for pumping, harvesting, transport, etc.; Recovery of chemicals from brine, bittern and mixed salt; Utilization of salt and byproducts for manufacture of chemicals; Analytical methods and quality control in the manufacture of salt and byproducts; and General problems of salt and byproducts industry.

▪ *A symposium on testing and evaluation of materials* will be held at the Government Test House, Alipore, on the occasion of the Golden Jubilee of the Test House during the middle of March 1964. The subjects of discussion at the symposium are: Importance of testing and evaluation of materials in the context of economic development of the country; Statistical and mathematical approach to testing; Non-destructive testing of materials; Testing and standardization of electrical engineering materials and appliances; Recent advances in the testing and evaluation of boilers and pressure vessels; Testing and evaluation of metals, including finished engineering materials; Chemical products — petroleum products and lubricants, ores and minerals, ceramics, paper and paper products, rubber and plastics, leather, and paint and pigments; Modern physico-chemical methods of testing and analysis; Materials for building and road construction and sanitary fittings; Textile and allied materials; and Precision engineering measurements.

▪ *The Institution of Chemical Engineers, UK* — Examinations for Parts 1 and 2 of the Institution will be held during 1-2 and 3-4 September 1964 respectively and for Part 3 during October and November. Entrance forms are obtainable from the Assistant Registrar (E), The Institution of Chemical Engineers, 16 Belgrave Square, London SW 1. The last date for the receipt of completed entries for Parts 1 and 2 is 1 June 1964.

Gallenkamp

SLOPING CONDENSER MOLECULAR STILL



For the distillation under vacuum of many natural and synthetic materials of high molecular weight.

The heater operates at low voltage and consists of a borosilicate glass tube wound with nickel chromium tape. It is held concentric with boiler by asbestolite end plates and permits clear visibility of the contents of the still. The power unit is housed in the base of the apparatus and consists of a transformer with an energy regulator in its primary circuit. This provides stepless control of the heater temperature up to 150°C. An indicator lamp shows the operation of the regulator. A plastics covered chart fitted on the base provides a convenient means for recording energy regulator dial settings for various temperatures.

The whole still is mounted on a rotatable clamp so that the boiler can easily be set either vertically for filling and degassing, or horizontally for distillation.

Gallenkamp

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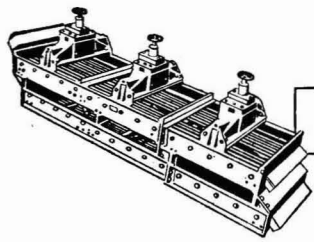

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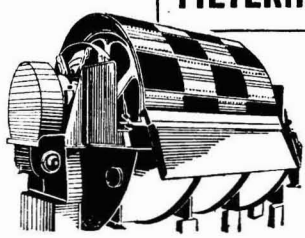

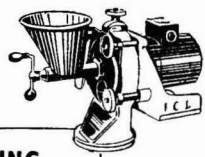

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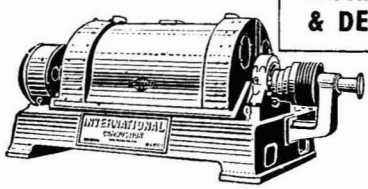

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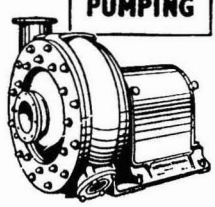

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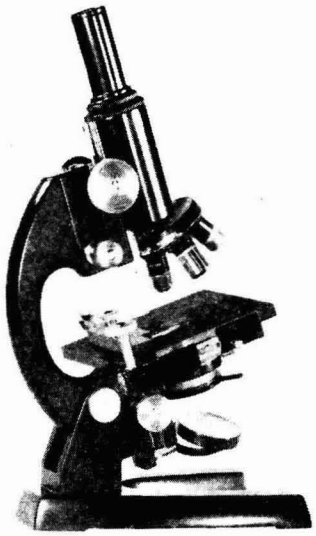

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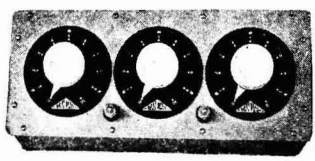

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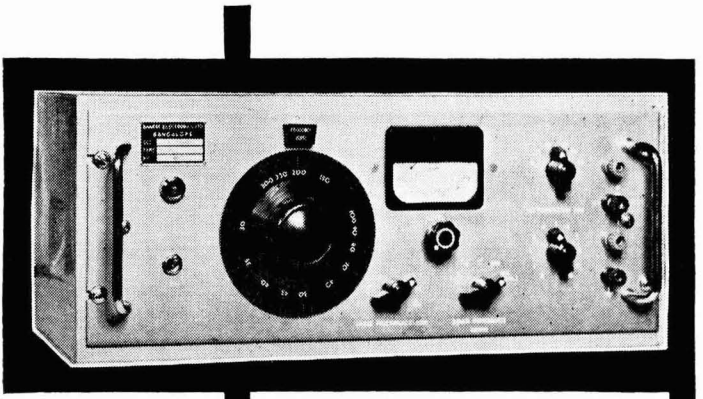

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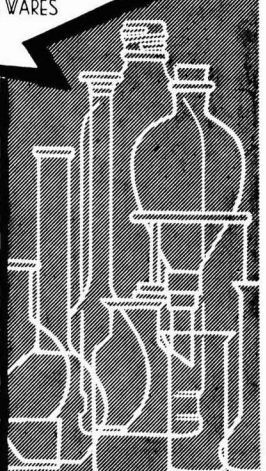

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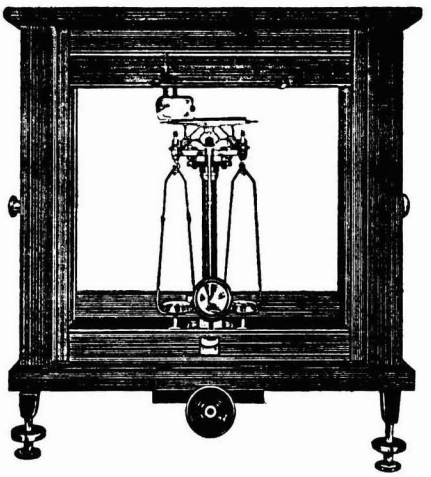

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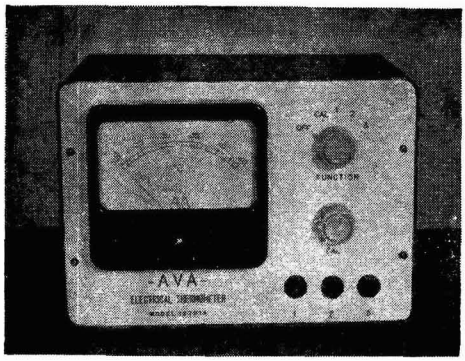

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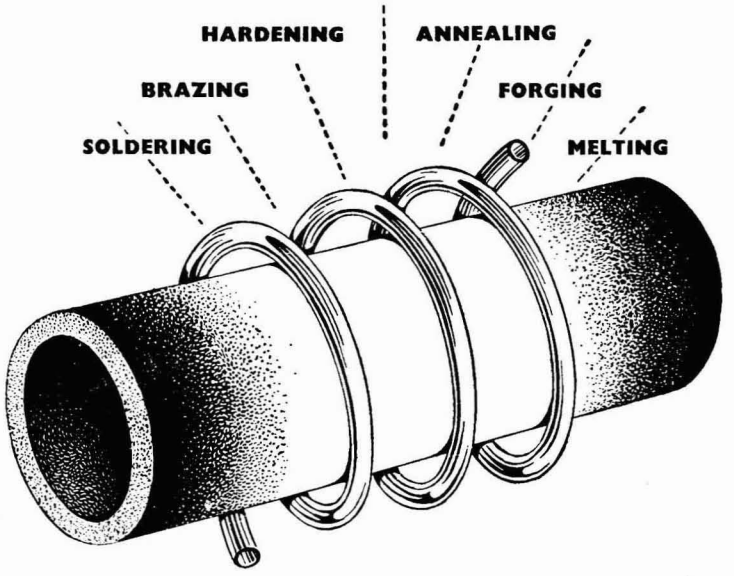

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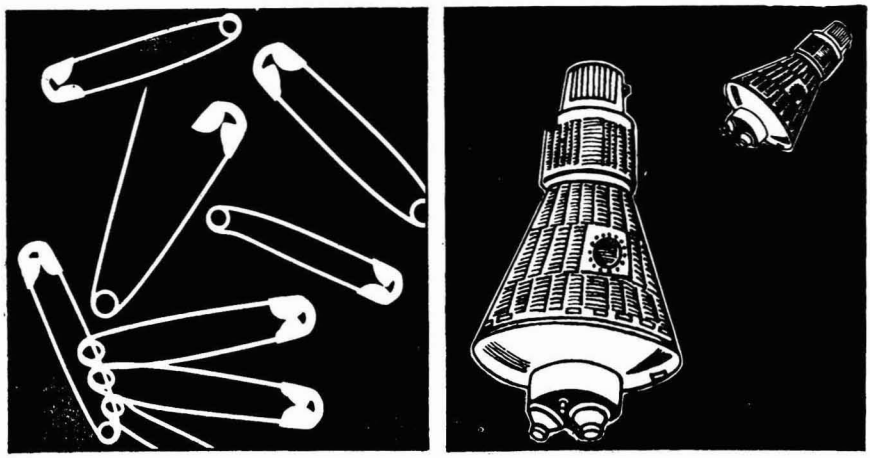

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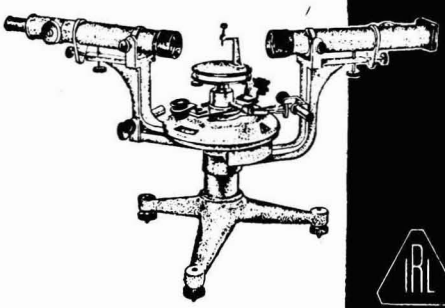

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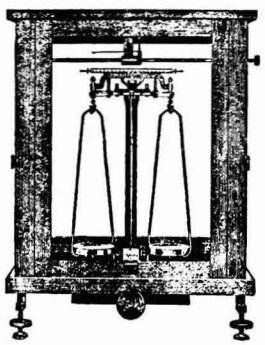

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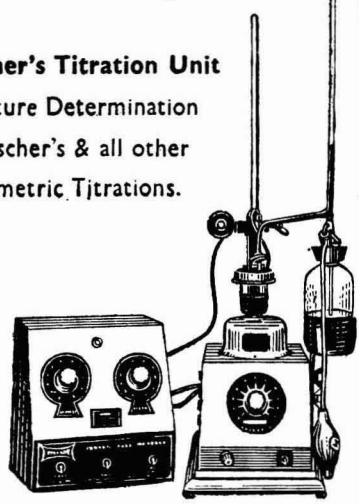

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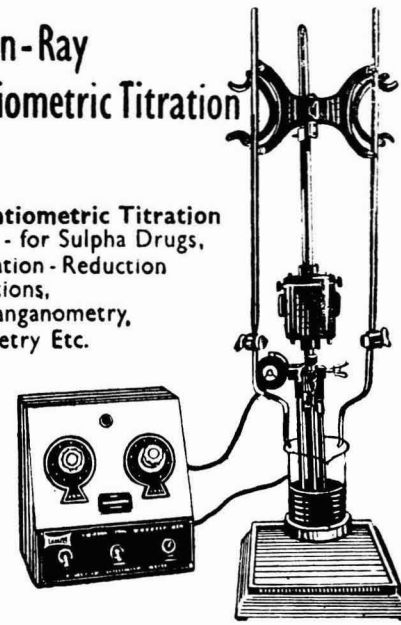

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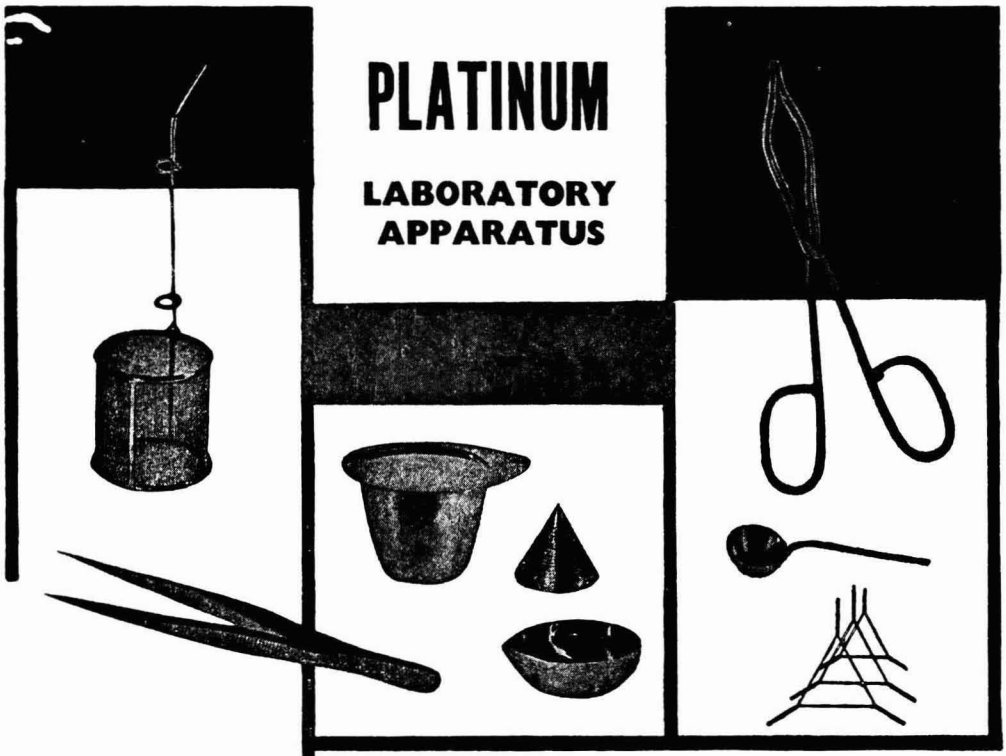

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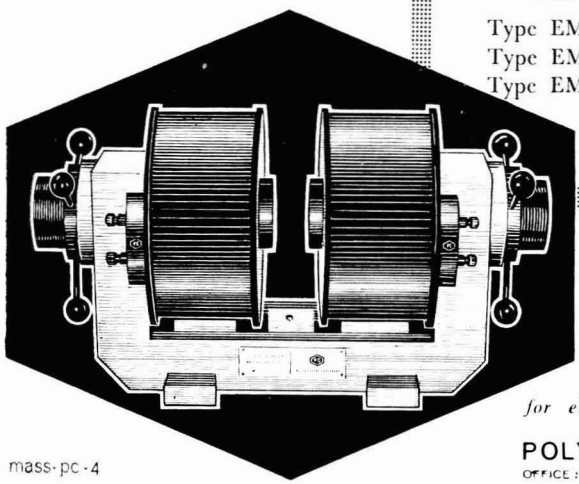

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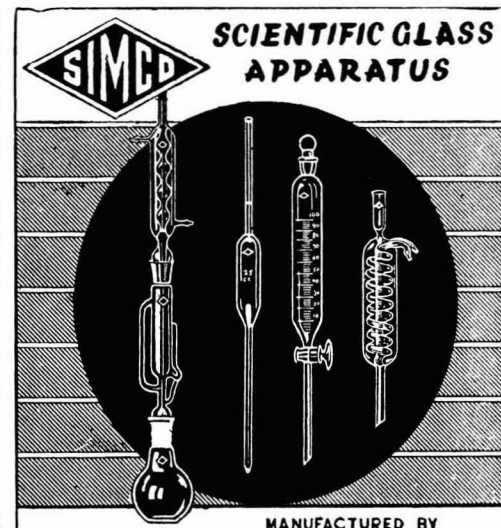

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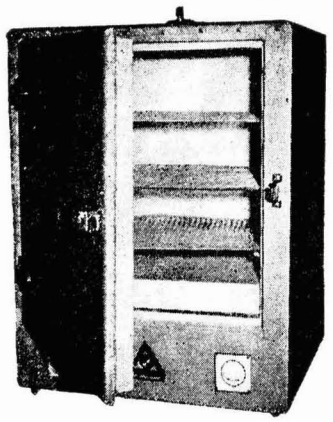

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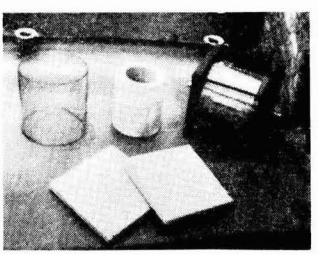

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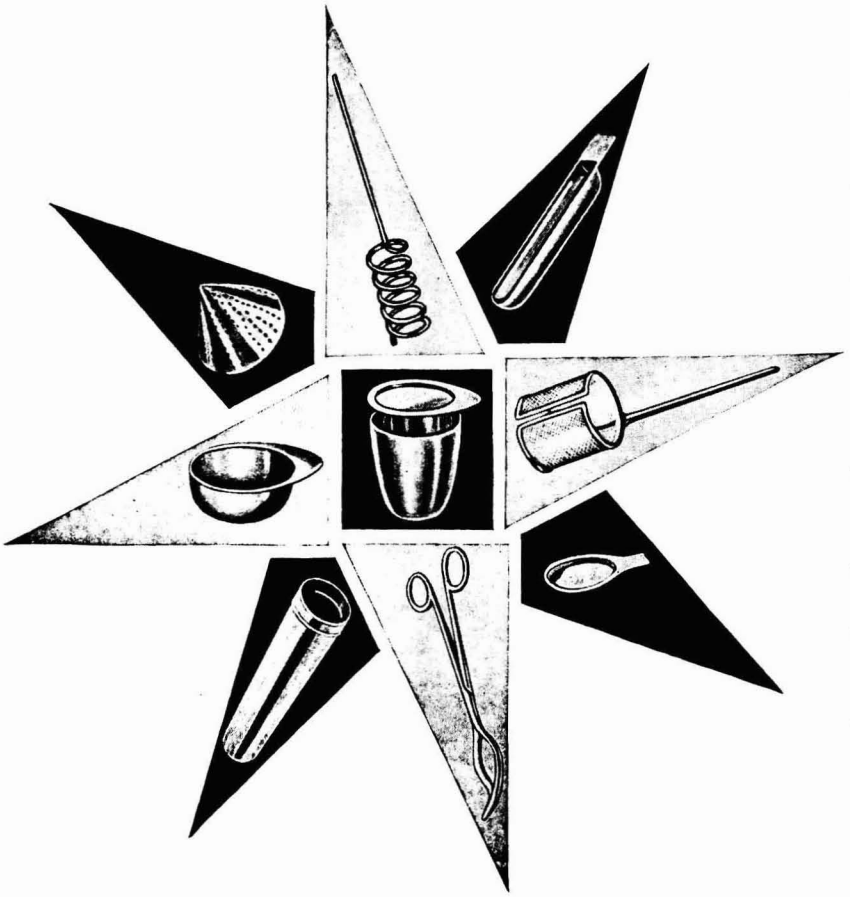

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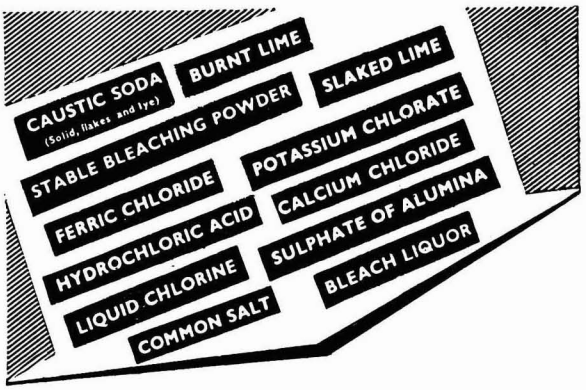

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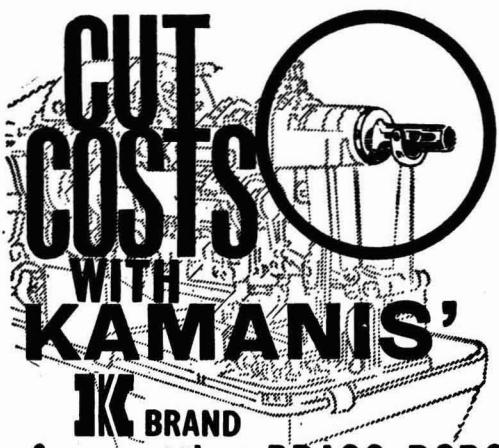

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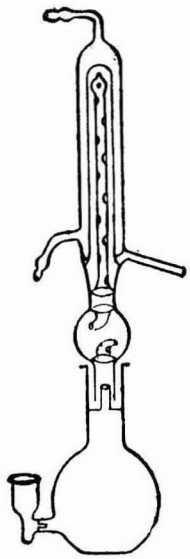

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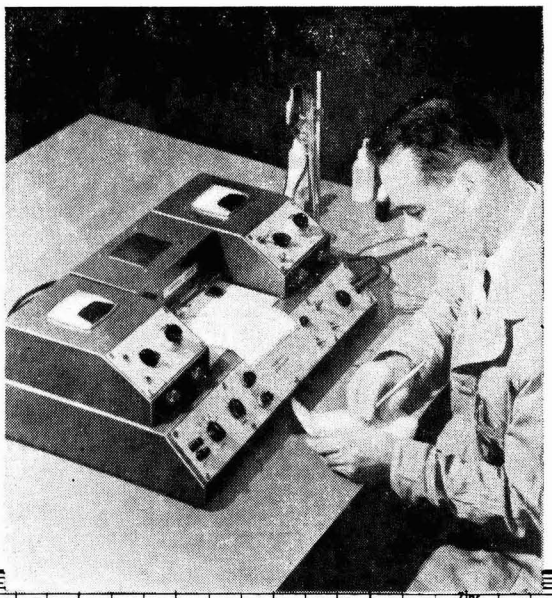

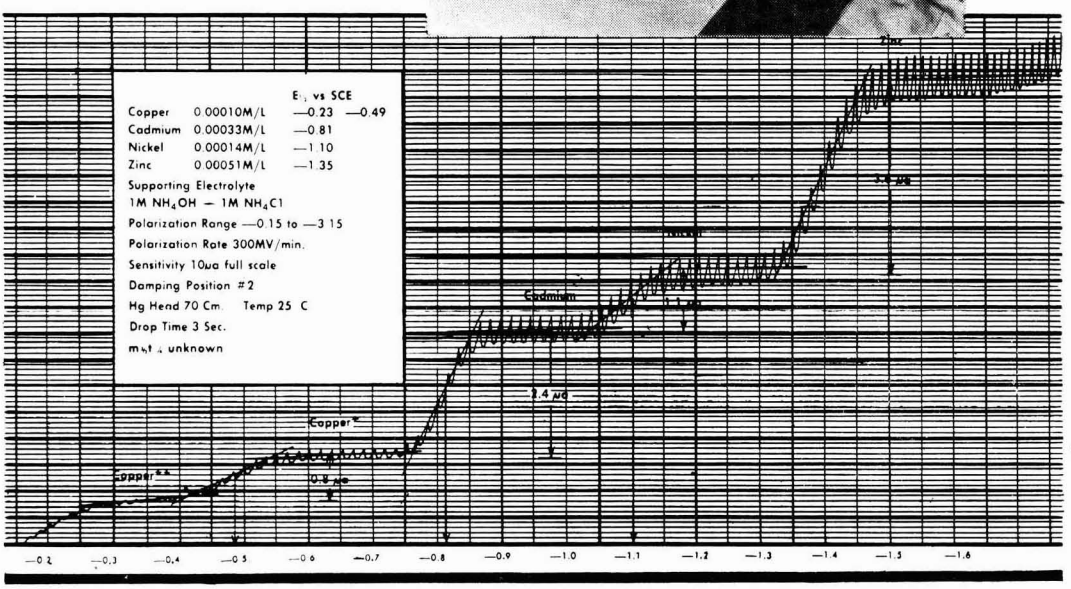

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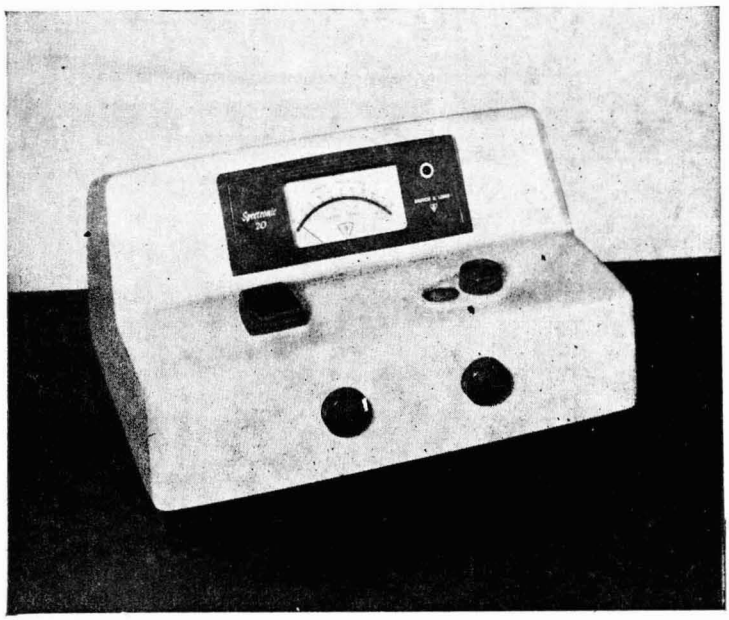

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