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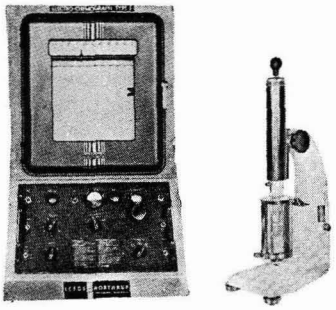

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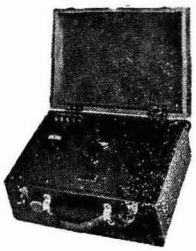

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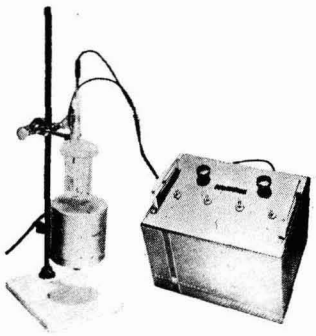

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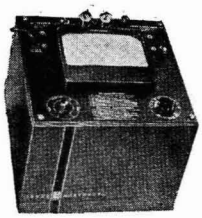

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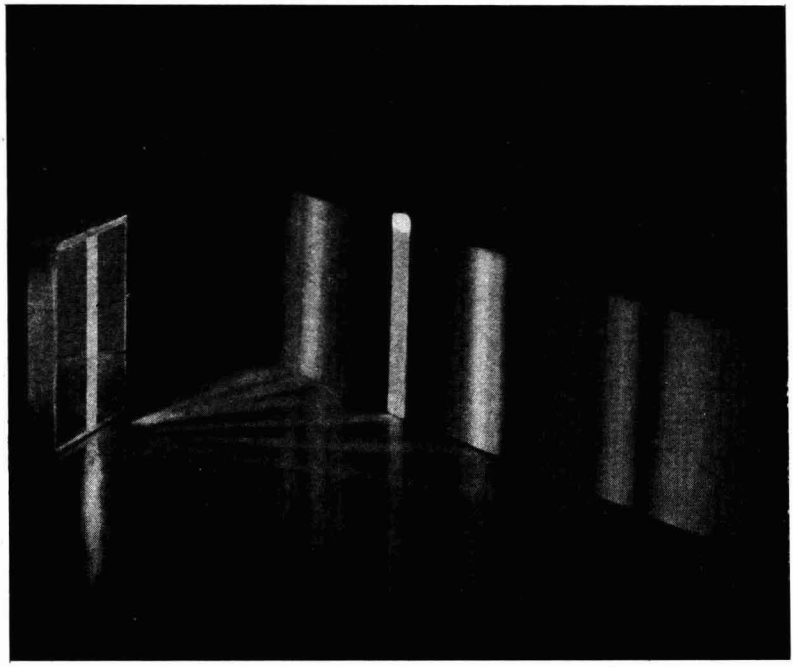

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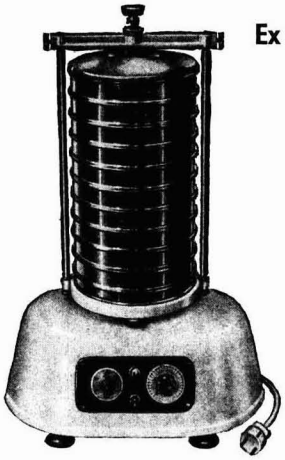

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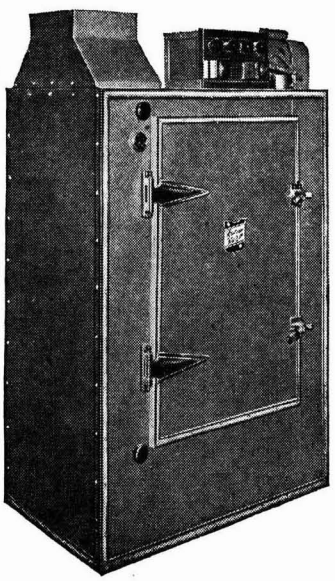

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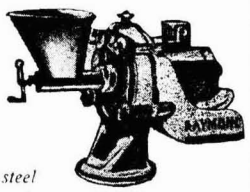

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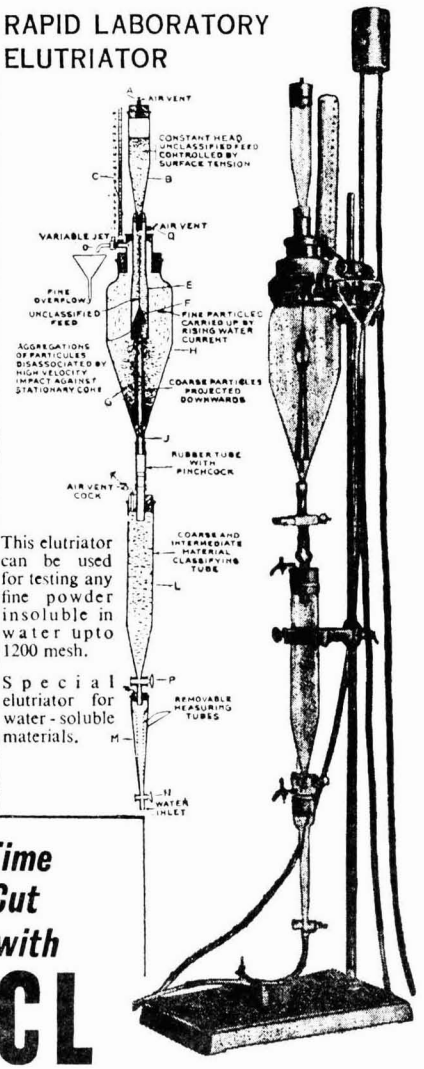

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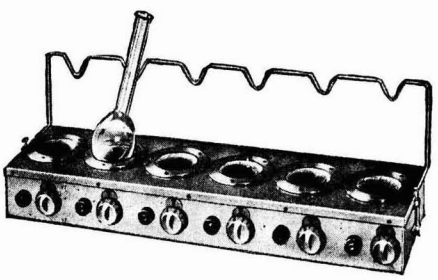

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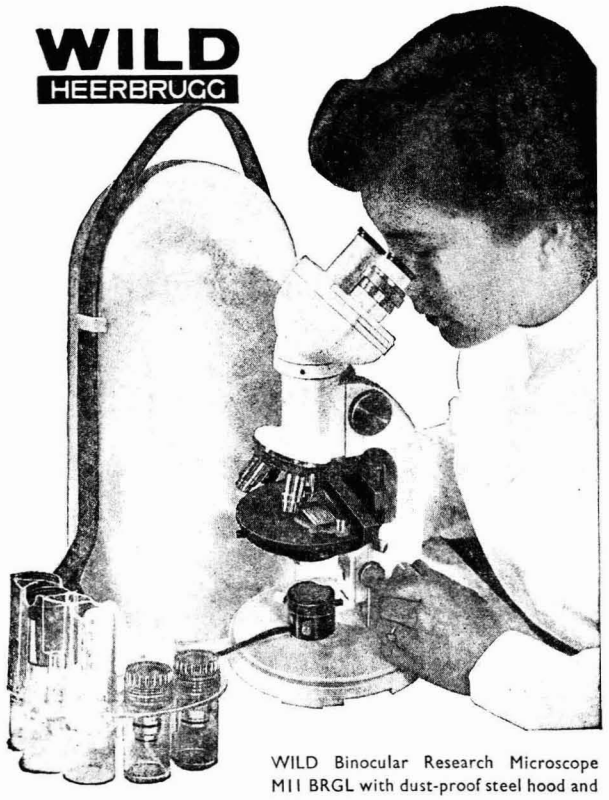

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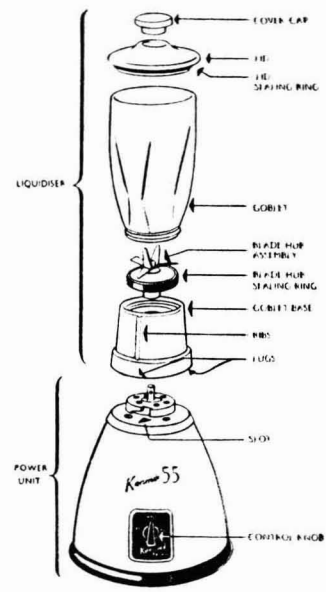

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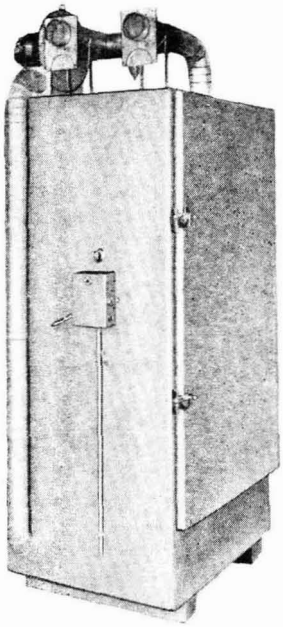

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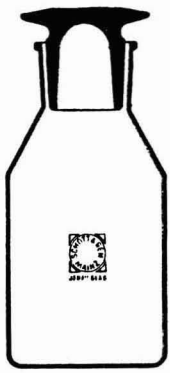

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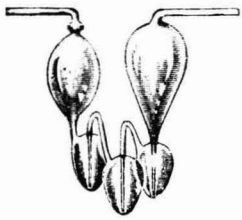

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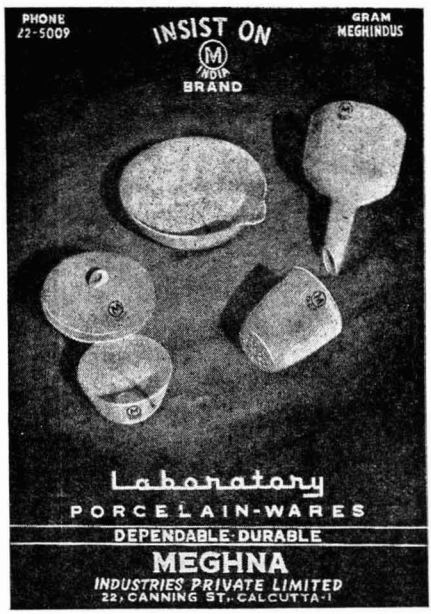

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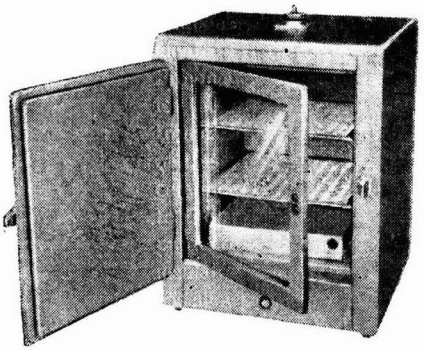

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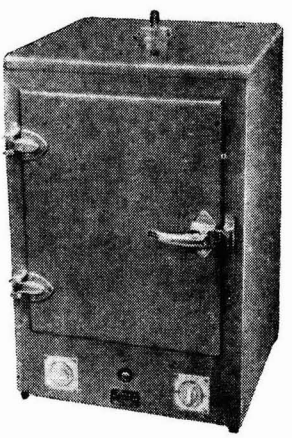

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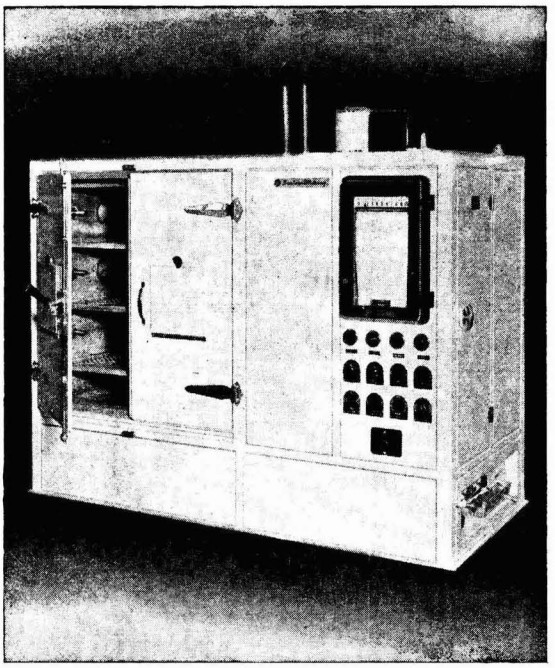

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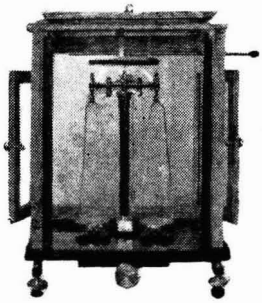

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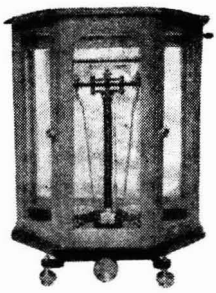

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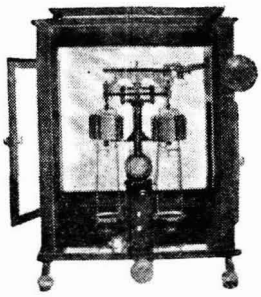

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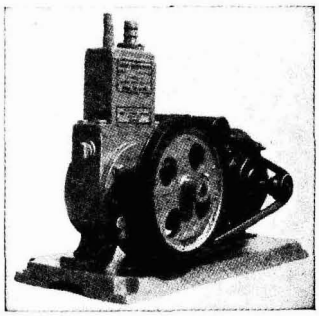

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Q METERS

Type	Freq. Range	Q Range	Tuning Capacity Range	Q Accuracy
260–A	50 kc to 50 mc	10 to 625	30–450 mmf	5% to 30 mc
190–A	20 mc to 260 mc	5 to 1200	7.5 to 100 mmf	7% to 100 mc

FM–AM SIGNAL GENERATORS

Type	Freq. Range	Output Range	Modulation FM	Modulation AM	Application
202–E	54–216 mc	0.1 to 200,000 μv	0–240 kc	0–50%	Mobile
202–F	175–250 mc	0.1 to 200,000 μv	0–240 kc	0–100%	Telemetering

SWEEP SIGNAL GENERATOR

Type	Freq. Range	Output Range	Modulation FM	Modulation AM	Markers
240–A	4.5 to 120 mc	1.0 to 300,000 μv	±10% to ±30% Center Freq.	30%	Crystal & Pip.

OMNI-RANGE SIGNAL GENERATOR (Crystal Monitored)

Type	Freq. Range	Output Range	Modulation	Application
211–A	88–140 mc	0.1 to 200,000 μv	0–100% am	Omni-Range Rcvrs.

GLIDE SLOPE SIGNAL GENERATOR

Type	Freq. Range	Output Range	Modulation	Application
232–A	329–335 mc	1.0 to 200,000 μv	0–100% am	Glide Slope Rcvrs.

WIDE BAND IMPEDANCE MEASURING EQUIPMENT—RX Meter

Type	Freq. Range	R Range	C Range	L Range
250–A	0.5 to 250 mc	15 to 100,000 ohms	0–20 μμf	0.001 μh–100 mh

RF VOLTAGE STANDARD

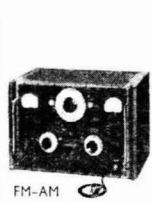
Type	Freq. Range	Calibrated Out.	Output Impedance	Application Calibrates
245–B	0.1 to 1,000 mc	0.5, 1.0,2.0 μv	50 ohms	Signal Generators

UNIVERTERS

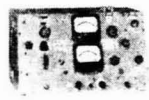
Type	Freq. Range	Output Range	Modulation FM	Modulation AM	Accessory to
207–E	0.1 to 55 mc	0.1 to 100,000 μv	0–240 kc	0–50%	202–E
207–F	0.1 to 55 mc	0.1 to 100,000 μv	0–240 kc	0–50%	202–F
203–B	0.1 to 25 mc	1.0 to 100,000 μv	1.5 to 30 mc	30%	240–A

FILM GAUGE

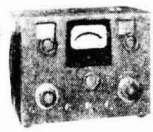
Type	Measures	Thicknesses
255–A	Non-magnetic Metals	0.000004" to 0.002"



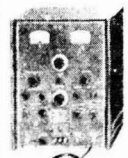
FM–AM SIGNAL GENERATOR TYPE 202–E



Q METER TYPE 260–A



Q METER TYPE 190–A



SWEEP SIGNAL GENERATOR TYPE 240–A

RX METER TYPE 250–A

RF VOLTAGE STANDARD TYPE 245–B

FILM GAUGE TYPE 255–A

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SISTA'S-EE-46

Current Topics

BIRLA INDUSTRIAL & TECHNOLOGICAL MUSEUM

THE OPENING OF THE BIRLA INDUSTRIAL & TECHNOLOGICAL Museum, Calcutta, the first of its kind to be established in India, by the Union Minister for Scientific Research & Cultural Affairs on 2 May 1959 marks a milestone in the movement for the popularization of science in the country. Planned by the Council of Scientific & Industrial Research, with a provision of Rs 20 lakhs in the first instance, the museum is housed in a three-storeyed building in a spacious park of 1,40,000 sq. ft area. The building and the park are the generous gift of the House of Birlas to the Government of India.

The museum aims at portraying three themes: contribution of technology to the welfare of mankind, recent advances in technology and the application of its methods in Indian industries. Also, in conformity with modern concepts that a museum should be 'live' and not be a mere repository of models and specimens of historical value, the Birla Museum has been designed to arouse in the minds of the people and particularly among the younger generation, a curiosity about science and its applications. With these objectives in view, developments in the following branches of science and technology, which are at present receiving considerable attention in the country, have been chosen for exhibition: electrical communication, electric power generation and transmission, nuclear physics, optics, transportation, civil engineering, textile engineering, chemical technology and mining and metallurgy. The galleries on electricity, metallurgy, electronics, nuclear physics, petroleum, television and optics have been completed. Emphasis has been laid on artistic display without sacrificing accuracy. Each gallery has a distinct style of its own, and the subject is presented in a logical manner beginning with basic principles and leading step by step to the recent advances in the field. For instance, the gallery on electricity, comprising 30 exhibits and a large number of informative and instructive charts, depicts the gradual evolution of static electricity, electromagnetism and current electricity. Working models can be operated by the visitors to the museum — this is a welcome feature. Specially trained staff is also provided for demonstration purposes.

Plans for the expansion of the museum during the Third Five-Year Plan period are being considered. It is proposed to double the present floor area and provide a fully equipped workshop for servicing, maintaining and fabricating models, a technical library and an auditorium.

The experience gained in the organization of this museum, it is hoped, will help in the setting up of similar institutions in all the important cities of the country. Many such institutions are needed to make the people scientifically and technologically minded, and the co-operation of the public and industry is essential in establishing them. It is gratifying to note that the Maneckji Cooper Education Trust of Bombay have offered to donate Rs 20 lakhs towards the setting up of a similar museum in Bombay.

TECHNICAL CERAMICS

THE PRODUCTION, TO DATE, OF OVER A MILLION ceramic capacitors in the experimental pilot plant, set up in 1956 at the National Physical Laboratory, New Delhi, is an achievement of significance to a number of industries. With a production capacity of 3500 pieces per day, the plant is at present serving the needs of the radio receiver, fluorescent lamp and electronic instruments industries. It is also catering to the needs of several government establishments, such as the Meteorological Department, Civil Aviation, Atomic Energy Department, All India Radio, Defence Services and the Indian Telephone Industries. The capacity of the plant is being stepped up by the end of June 1959 to about 5000 pieces per day to meet the growing demand of the fluorescent lamp industry which is estimated at present to be three times that of the radio receiver industry. The capacitors, based on titanium dioxide compositions and produced almost entirely from indigenous raw materials, have been found satisfactory under service conditions. They are comparable in quality and competitive in price with the imported product.

The ceramic capacitors project is part of a long-range programme for the manufacture of radio components utilizing indigenous raw materials initiated by the Radio Research Committee of the Council of Scientific & Industrial Research in 1950 in order that the development and manufacture of radio components goes on side by side with the establishment of an electronics industry in the country. Proving the suitability of indigenous raw materials for the manufacture of a vital component of the electronics industry is not the only important outcome of this project. It has stimulated further study of ceramic compositions in general and has already led to the development of suitable compositions for the production of steatite bodies and high frequency insulators. The successful working of this project has shown the way to the realization of the ultimate objective of the Radio Research Committee of developing an entire range of 'technical ceramics' from Indian resources.

LOW-COST SCIENCE BOOKS

FOR THE UNINHIBITED GROWTH OF SCIENCE AND technology, free and easy availability of standard works on science and technology is essential not only to science students and research workers but also to the interested non-scientists. Many of the standard books on science and technology are expensive and beyond the means of individual purchasers. The present need for such books in India is large and their purchase involves valuable foreign exchange. The initiative taken by Japanese publishers to produce at reduced prices Asian editions of certain titles of a leading American publisher is to be welcomed. This has not, however, solved the problem of foreign exchange. A further welcome step in this regard of interest to the Indian students of science is the launching by Messrs Asia Publishing House, Bombay, of a scheme to produce inexpensive editions of text-books brought out by well-known foreign publishers at half to one-third the price of the original editions. So far twenty-one selected titles in Chemistry, Physics, Mathematics, Civil, Chemical and Electrical Engineering and Accountancy have been issued. The Indian editions are exact replicas of the original editions and the quality of their production is comparable. The Association of Principals of Technical Institutions in appreciation of the scheme have offered their active co-operation in selecting titles of suitable books for reprinting. This collaboration will ensure the availability of standard works specially useful to Indian students.

International Symposium on the Chemistry of Natural Products

AN INTERNATIONAL SYMPOSIUM ON THE CHEMISTRY of Natural Products, being organized by the Australian Academy of Sciences under the auspices of the Section of Organic Chemistry of the International Union of Pure and Applied Chemistry, will be held from 15 to 25 August 1960 in Melbourne, Canberra and Sydney. The scientific sessions will be held in Sydney and Melbourne. Sir Alexander Todd will be the President of the symposium.

The symposium will be devoted to the organic chemistry of natural products, except macromolecular substances, the term natural product being used broadly to describe any substance produced by the metabolism of micro-organisms, plants and animals. In addition to the isolation, structure determination by physical and chemical methods, synthesis and general chemistry of natural products, the subjects to be dealt with include topics in biological chemistry, such as biosynthetic and metabolic studies and structure-activity relations, i.e. topics involving the application of organic chemistry to biological problems. Communications describing the identification of known substances or dealing with methods of analysis or manufacturing processes do not generally come within the scope of the symposium.

Papers to be discussed at the symposium will be grouped into four sections: (1) Aliphatic and Homocyclic Chemistry; (2) Heterocyclic Chemistry; (3) Biological Chemistry; and (4) Physical Methods in the study of the structure of natural products.

All correspondence concerning the symposium should be addressed to: Convener, Symposium Organizing Committee, Box 4331, G.P.O., Melbourne, Australia.

Council of Scientific & Industrial Research—Meetings of the Board & the Governing Body

THE Board of Scientific & Industrial Research and the Governing Body of the Council met in New Delhi on 30 and 31 March 1959 respectively. Important among the decisions taken were those relating to (1) the establishment of a research school in earthquake engineering at the University of Roorkee and (2) the creation of a Petroleum Council for co-ordinating and augmenting the existing facilities for training, research and documentation in petroleum technology. The setting up of a pilot plant for conducting studies on the synthesis of vitamin B_6 (pyridoxin hydrochloride) at the National Chemical Laboratory, Poona, at an estimated cost of Rs 80,000 was sanctioned. The plant will have a capacity of 0·25 kg. pyridoxin hydrochloride per batch and will use chloracetic acid as the starting material. The synthesis, involving a ten-step procedure, has already been achieved on a laboratory scale. A sum of Rs 25,000 was sanctioned for a project to be undertaken by the National Council of Applied Economic Research for carrying out a survey of the capacity in the country to absorb $4\frac{1}{2}$ million tons of finished steel per year that would be produced in the country by 1960-61.

The award of the Shanti Swarup Bhatnagar Memorial Award for 1958 to Dr K. S. Krishnan was approved by the Governing Body; this is the first time the award has been made.

New research schemes

The following new research schemes were sanctioned:

1. *Cyto-taxonomical and morphological studies in Rhamnaceae* — DR K. SUBRAMANYAM, Botanical Survey of India, Coimbatore

2. *Cytology of the endosperm of some Indian plants* — DR S. L. TANDON, Delhi University, Delhi

3. *Factors controlling growth and reproduction in mosses* — DR G. C. MITRA, Delhi University, Delhi

4. *Studies on some botanical aspects of oceanography off the Visakhapatnam coast* — DR T. SREERAMULU, Andhra University, Waltair

5. *Cyto-taxonomic revision of Indian Commelinaceae* — SHRI R. S. RAO & DR G. PANIGRAHI, Botanical Survey of India, Shillong

6. *Studies on the enzyme systems in Ciliata protozoa* — DR B. R. SESHACHAR, Central College, Bangalore

7. *Preparation of industrially important sesquiterpenes* — DR P. C. DUTTA, Indian Association for the Cultivation of Science, Calcutta

8. *Pharmacological studies on a new anti-tubercular antibiotic* — DR S. CHANDRASEKHAR, Vallabhbhai Patel Chest Institute, Delhi

9. *Investigation on surge voltage distribution in transformer windings and impulse strength of transformers* — PROF. D. J. BADKAS, Indian Institute of Science, Bangalore

10. *Evaluation of the deterioration of transformer oil during controlled aging in the laboratory* — PROF. D. J. BADKAS, Indian Institute of Science, Bangalore

11. *Self-excited alternator* — SHRI M. MARIA LOUIS, P.S.G. College of Technology, Coimbatore

12. *Application of photogrammetry and De Moire's fringes to structural problems* — DR JAI KRISHNA & SHRI H. L. OSWAL, University of Roorkee, Roorkee

13. *Evaluation of resistances of a rippled transporting bed* — SHRI AMRIT KUMAR, M.B.M. Engineering College, Jodhpur

14. *Ultimate strength of reinforced concrete beams in combined bending and shear* — SHRI K. SUBBIAN, P.S.G. College of Technology, Peelamedu, Coimbatore

15. *Axial flow pump research: Design of improved axial flow impellers based on cascade theory and vortex theory* — PROF. N. S. GOVINDA RAO & SHRI K. SEETHARAMIAH, Indian Institute of Science, Bangalore

16. *Studies on the hydraulic and other properties of granulated blast furnace slags in relation to composition* — DR DURGADAS LAHIRI, University College of Science & Technology, Calcutta

17. *Determination of the specific heats of the raw materials for the blast furnace* — DR D. SWARUP & DR RAJENDRA KUMAR, Banaras Hindu University, Varanasi

18. *Development of age-hardenable alloys from Indian commercial aluminium* — DR A. A. KRISHNAN, DR T. R. ANANTHARAMAN & SHRI B. S. SUBRAMANYA, Indian Institute of Science, Bangalore

19. *Furnaces for iron extraction and the need for further experiments to improve their efficiency* — SHRI MONI GHOSH (Sarba Seva Sangh)

20. *Study of the variation of the angle of arrival of the downcoming radio waves from the ionosphere* — DR S. S. BANERJEE, Banaras Hindu University, Varanasi

21. *Study of properties of semi-conductors and transistors* — DR G. P. SRIVASTAVA, Gorakhpur University, Gorakhpur

New institutes and centres

The proposal for the establishment of a research school in earthquake engineering at the University

of Roorkee was approved. The research programme of the school will include measurements on ground motion along the Himalayan arc, analysis of the data collected and structural response measurements in buildings, dams and other engineering works during earthquakes. It is also proposed to institute a post-graduate course in dynamic measurements and instrumentation at the school.

For assisting the proper development of fruit and vegetable industries, it was decided to establish regional research stations under the Central Food Technological Research Institute, Mysore, at Delhi, Poona, Gauhati, Kodur, Simla and Saharanpur and sub-regional stations at Jadavpur, Nagpur, Trichur and Kulu. The functions of these stations will be: (1) to undertake varietal trials on fruits and vegetables; (2) to attend to the day to day problems of the local fruit and preservation industries and to undertake research on problems connected with the industry of the region; and (3) if possible, to undertake training and demonstration programmes in fruit and vegetable preservation, to carry out pilot plant trials and to work out the economics for the processing of different types of products.

The setting up of a sub-station of the National Botanical Gardens, Lucknow, at Verinag in Kashmir for undertaking investigations on the cultivation of plants of temperate and alpine climate was sanctioned.

Symposia

The holding of the following symposia during the year 1959-60 was approved:

1. *Industrial catalysis in coal and petroleum technology*, Central Fuel Research Institute, Jealgora (February 1960)
2. *Shell structures*, Central Building Research Institute, Roorkee (March 1960)
3. *Utilization of byproducts of the leather industry*, Central Leather Research Institute, Madras (January-February 1960)
4. *Minor constituents in glass*, Central Glass & Ceramic Research Institute, Calcutta (December 1959)
5. *Amoebiasis in India and its therapy*, Central Drug Research Institute, Lucknow (March 1960)

In addition, two more symposia, to be held under the auspices of the Public Health Engineering Research Institute, Nagpur, were approved.

Colonel Amir Chand Trust Prizes, 1959

THE INDIAN COUNCIL OF MEDICAL RESEARCH invites applications for the annual Colonel Amir Chand Trust Prizes for the year 1959. These prizes, known as Shakuntala Amir Chand Prizes, will be awarded for the best published research work during 1958 in any subject in the field of medical sciences including clinical research. The term 'clinical research' covers research into the mechanism and causation of disease and its prevention and cure, and includes work on patients in hospitals, field studies in epidemiology and social medicine and observations in general practice.

It has been decided to award four prizes in 1959, each of Rs 300, to graduates of not more than ten years' standing. Medical as well as non-medical graduates are eligible for the award.

Applicants are required to submit 10 reprints of their papers published during 1958 so as to reach the Director, Indian Council of Medical Research, Medical Enclave, Post Box 494, New Delhi. The last date for the receipt of applications is 1 August 1959. The papers should be accompanied by a short biographical sketch and two copies of passport size photographs of the candidate/candidates concerned.

The award of the prizes will be announced at the annual meetings of the Council's Scientific Advisory Board and Advisory Committees in November/December 1959.

Development of Petroleum Resources of Asia & the Far East—ECAFE Symposium

M. B. RAMACHANDRA RAO
Oil & Natural Gas Commission, Dehra Dun

THE Asian and the Far Eastern countries have a third of the world's population and use up about 5 per cent of the world's total consumption of oil. They, however, produce only $2\frac{1}{2}$ per cent of their requirements of oil. Among the many countries in this region, only British Borneo and Indonesia produce oil in considerable quantities for export. Iran, which recently joined the ECAFE (but which has been usually considered with the Middle-East countries), is, of course, a large producer and well-known exporter. Burma produces just about enough for her own needs, while India and Pakistan produce a very small portion of their requirements. None of the other countries of this region has any appreciable production. It is, however, generally believed that there are vast potentialities for exploration and development of petroleum resources in most countries of the ECAFE region. Therefore, the symposium held at New Delhi for about two weeks in December last (3-16 December 1958) by the United Nations Economic Commission for Asia and the Far East was timely and opportune. It brought together a wide variety of interests that have adopted different means for organizing and controlling the activities of the petroleum industry. One hundred and forty delegates and observers from 20 countries—Afghanistan, Australia, British Borneo, Burma, China (Taiwan), France, Germany, India, Indonesia, Japan, Laos, Netherlands, Pakistan, the Philippines, Rumania, Thailand, the U.K., U.S.S.R. and U.S.A.— took part in the discussions. The representatives of International Labour Organization, International Federation of Free Trade Unions, International Co-operative Alliances, International Organization of Employees and the World Federation of Trade Unions had also sent observers.

The symposium considered 117 papers bearing on a variety of topics, which for the sake of convenience of discussion, were divided into ten topics:

1. Petroleum industry of the ECAFE region
2. Geology of petroleum deposits of ECAFE region
3. Petroleum potentialities and development possibilities in the ECAFE region
4. Petroleum exploration survey methods with special reference to ECAFE region
5. Status of petroleum exploration in the ECAFE region
6. Petroleum development programmes in the ECAFE region
7. Safety in petroleum exploration and development
8. Regulations governing petroleum resources development
9. Technical manpower and equipment for petroleum resources development
10. Technical training facilities for petroleum resources development

Dr D. N. Wadia, the principal delegate from India, was unanimously elected Chairman of the symposium.

The discussion for each topic was conducted through a Discussion Leader appointed by the Chairman specially for the occasion. Individual papers were not read, but the Discussion Leaders focussed attention on the salient features of the papers, and the members present took part in the discussions. This method proved more effective and livelier than could have been the case if the papers were presented individually by the authors or any others on their behalf.

The largest number of papers contributed and discussed related to the geological features of the petroleum deposits with special reference to the ECAFE region. It was noted that practically all the petroleum at present being produced in the ECAFE region comes from the chain of geosynclinal basins extending from Iran eastward through the Himalayan region, southward through Burma and Sumatra to the islands of the Indonesian archipelago, and then northward through Borneo, the Philippines and Taiwan to the islands of Japan. Elsewhere in the world some of the largest oilfields are located in the shelf areas or along the hinge lines of the geosynclinal basins. While most of the exploration in the ECAFE region had been directed towards the folded structures of the mobile belt, it was felt that more geological investigation should be undertaken in the shelf areas and the coastal tracts of this region. In a few countries, offshore exploration has begun recently and very likely it could be taken up by the other

countries wherever possible. The practical limit of offshore exploration surveys has now extended up to 600 ft depth, i.e. the limit of the continental shelf, whereas drilling has been so far successfully carried to depths of 100 to 150 ft. In regard to the petroleum survey methods, the symposium considered the latest developments in photogeology, gravimetric, magnetic and seismic methods. The question of direct detection of oil by electrical and radioactive methods was also discussed, but it was felt that no sound physical basis has yet been discovered for using these somewhat controversial methods. However, it was suggested by some that the study of elasticity and density of oil and gas saturation of formations could prove more useful in evolving methods for detection of oil.

The importance of adopting a uniform system of reporting the statistical information by using volumetric units for production figures was discussed. The consensus of opinion was that volumetric units should be adopted. The question of increasing the ultimate recovery of crude oil from the established producing fields by hydraulic fracturing, acidization, fire-flooding and other means of stimulating the oil flow in rocks of low permeability was discussed and it was recommended that attention should be paid in the ECAFE region to expand the training facilities in these techniques.

The technical manpower and equipment needed for developing the petroleum resources in the ECAFE region and the training facilities in this region were discussed at some length. The general feeling was that some establishments may be set up at suitable centres in this region for manufacturing machinery and equipment for the oil industry. There was also some discussion on the desirability of having a Petroleum Institute or Institutes in the ECAFE region for training and research in the various aspects of oil industry and technology.

A regional geological map of Asia and the Far East, which is already being compiled under the auspices of the ECAFE, will also indicate the oil and gas fields of this region. Such a map would indeed be very welcome.

The symposium had a working group on Regulations Governing Petroleum Resources Development. As the question of legislation and regulation vested solely within the competence of the Governments concerned, the working group had only mutual exchange of views. As a matter of fact, it was a creditable feature of this symposium that discussions on all the other topics and papers too were steered mostly on the technical level, without getting into political controversies. A spirit of mutual understanding and friendly co-operation prevailed throughout the proceedings.

The ECAFE secretariat are likely to publish the proceedings of this symposium fairly soon. A large body of persons interested in the oil industry throughout the world will no doubt eagerly look forward to this publication and would also watch for the convening of a second symposium which is proposed to be held in 1962 or 1963.

In conclusion, it may be said that this symposium succeeded not only in bringing together a large body of geologists, geophysicists, engineers, chemists and others devoted to the various aspects of the oil industry, but also in focussing attention on the need and the urgency to solve the problems of developing the petroleum resources of the Asian and Far Eastern countries in whose industrial advancement oil can play a large part.

Microwave Spectroscopy & Nuclear Magnetic Resonance—A Symposium

A SYMPOSIUM on 'Microwave Spectroscopy and Nuclear Magnetic Resonance', sponsored by the Council of Scientific & Industrial Research, was held at the Muslim University, Aligarh, during 23-25 February 1959. Research workers from different institutions in the country engaged in this field of study participated in the symposium. Sixteen papers were presented and discussed. In addition, there were six review papers on different topics.

The symposium was inaugurated by Prof. R. K. Asundi of the Department of Atomic Energy, Trombay, who briefly surveyed the contribution of spectroscopy to the development of physics. Taking the determinations of the internuclear distance of CO molecule by various spectroscopic methods in the chronological order as an example, he illustrated the increased accuracy available owing to the high resolving power and dispersion characteristic of microwave spectroscopy. An accurate study of the weaker interactions made possible by this and other powerful spectroscopic methods has greatly increased our knowledge of such interactions in molecules.

The experimental work, now in progress, at Aligarh University on CD_3NH_2 and the results obtained in the region 34,000-38,000 Mc/s. were presented in a paper. The several lines obtained could be classified according to the different types of Stark patterns they exhibit. It has been possible to fix the lower J values and J's for some of these lines. The results obtained in the microwave spectrum of CH_3CN have indicated that the spectrum obtained for the transitions $J = 1 \rightarrow 2$ and $J = 2 \rightarrow 3$ corresponding to the vibrational states $V_8 = 1$ could be explained on the basis of Nielsen's theory of l-type doubling in symmetric top molecules, yielding a value of 0·94 for the Coriolis interaction constant, consistent with that obtained from infrared spectral data. By reassigning some of the already measured transitions for CH_3NC, CH_3CCH and CF_3CCH, it is possible to obtain values of Coriolis interaction constants for these molecules also, in close agreement with those obtained from infrared spectra.

Work on the rotational magnetic moment μ_J indicated that the Zeeman effect for the rotational spectra of gases affords a simple method of determining μ_J in $^1\Sigma$ molecules. Slipping of valence electrons along with their normal orbital motion gives rise to 'cosine interaction' and a semi-empirical relationship between the cosine interaction constant and μ_J has been derived.

The results of a theoretical study to explain the isotropic part of the hyperfine structure in paramagnetic resonance were presented. The difference in the exchange interactions of unpaired electrons with the two paired s-electrons is considered to create a finite spin density at the nucleus, thereby producing the isotropic hyperfine splitting through the Fermi-type interactions. The calculations were made by variational method and satisfactory agreement was found for Mn^{++} ion.

Determinations of the relaxation times carried out in different types of glasses from the Si^{29} nuclear magnetic resonance signals have indicated that the relaxation time is a function of the particle size of the glass.

Two interesting papers from the Indian Institute of Science, Bangalore, related to instrumentation in nuclear magnetic resonance. The first paper dealt with the improvements in an earlier proposed synchronous magnetic recorder and the second paper described a simple and useful method for reducing the radiation damping in high resolution nuclear magnetic resonance.

Other specific problems which were discussed at the symposium are enumerated below:

Gaseous microwave spectroscopy — Hindered rotation in microwave spectra of methyl alcohols and methyl amines; microwave spectral data corresponding to the transitions $J = 5 \rightarrow 6$ and $J = 6 \rightarrow 7$ of CCl_3CN; microwave spectral data for the rotational transition $J = 5 \rightarrow 6$ for the two isotopic species of IBr (IBr^{79} and IBr^{81}) and derivation of molecular constituents and quadrupole coupling constants; and methods for accurate determination of the dipole moments of molecules in the ground and excited vibrational states from the Stark effect on the rotational lines in the 'microwave' spectra, with special reference to the parallel plate cell method.

Paramagnetic resonance spectroscopy — Design of a simple transmission cavity spectrometer and methods for improving its sensitivity; studies on paramagnetic resonance spectra of organic free radicals and their hyperfine structure, e.g. proton hyperfine structure in spectra of benzosemiquinone ions, and of the free radicals formed in the reactions of tetraphenyl hydrazine with different reagents.

Nuclear magnetic resonance — Latest experimental techniques; spin-lattice and spin-spin relaxations in nuclear magnetic resonance experiments on bulk

matter; chemical shifts in high resolution nuclear magnetic resonance in the case of: (i) aqueous solutions, alkali chlorides and alkaline earth chlorides, (ii) O^{17} resonance in aliphatic alcohols, acids and ketones and (iii) Hg resonance in some mercury compounds; proton resonance spectra of amines; application of nuclear magnetic resonance to quantitative chemical analysis of deuterium in ordinary water and in the study of cis-trans conversion and reaction rates in cobaltic complexes; measurement of quadrupole coupling constants from the quadrupolar splittings observed in Li^{17} resonance in powdered $LiCO_3$; theoretical and experimental values of nuclear moments; and experimental techniques in the significant but little-known overlap region between the infrared and microwave region.

The Chemistry of Insulin*

THE elucidation of the structure of insulin opens up the way to similar studies on other proteins. The exact chemical structure of proteins will help in the understanding of their specific functions in normal conditions and may reveal changes that take place in disease.

On the basis of the dinitrophenyl (DNP) method, together with phenylisothiocyanate method, it seems probable that the chains of insulin are joined together by the disulphide bridges of cystine residues. Performic acid oxidation of the disulphide bridges results in cysteic acid residues thus breaking the cross-linkages. From the oxidized insulin two fractions A and B could be separated by precipitation methods. Fraction A contains glycine and fraction B, phenylalanine N-terminal residues. Fraction A is acidic and has a simpler composition than insulin in that the six amino acids — lysine, arginine, histidine, phenylalanine, threonine and proline — are absent in it. It thus has no basic amino groups which are found only in fraction B. From a quantitative determination of the end groups it has been concluded that fraction A contains about 20 residues per chain, four of these being cysteic acid, and fraction B has 30 residues, two of which are cysteic acid. Since the yield of each fraction is greater than 50 per cent in terms of the N-terminal residues present and since they appear to be homogeneous it seems likely that there is only one type of glycyl chain and one type of phenylalanyl chain.

As a result of the acid hydrolysis of DNP derivative of fraction B it has been concluded that all N-terminal phenylalanine residues of insulin are present in the sequence Phe.Val.Asp.Glu. This suggests that if there are two phenylalanyl chains, then these two are identical. Similar results have been obtained with fraction A, and it has been shown that the N-terminal glycine residues are present with the sequence Gly.Isoleu.Val.Glu.Glu.

The above studies have shown, for the first time, that the insulin molecule is composed of only two types of chains, and that if the molecular weight of insulin were 12,000, then the molecule is built of two identical halves. The other alternative, which has been shown to be the case, is that the actual molecular weight of insulin is 6000.

For determining the sequence in the two chains containing 20 and 30 residues respectively, first, fraction B has been subjected to partial hydrolysis with acid. Since the mixture is too complex for direct analysis by paper chromatography, it has been found necessary to carry out certain preliminary group separations in order to obtain fractions containing 5-20 peptides that can then be separated on paper. This separation has been accomplished by ionophoresis, ion-exchange chromatography and adsorption on charcoal. These simplified mixtures are then fractionated by two-dimensional paper chromatography. The peptide spots are cut out and the material eluted from the paper, subjected to complete hydrolysis and analysed for their constituent amino acids. As a result, it could be concluded that the fraction B contains only peptides of cysteic acid and since there are only two such residues in fraction B all these peptides must fit into two sequences. In this way about 45 peptides have been identified in the various fractions of the partial acid hydrolysate and it is concluded that the following five fractions are present in the phenylalanine chain:

(1) Phe.Val.Asp.Glu.His.Leu.$CySO_3H$.Gly. (N-terminal sequence); (2) Gly.Glu.Arg.Gly.; (3) Thr.Pro.-

*Condensed from the Nobel Lecture delivered by Prof. F. Sanger before the Swedish Academy in Stockholm, on 12 December 1958.

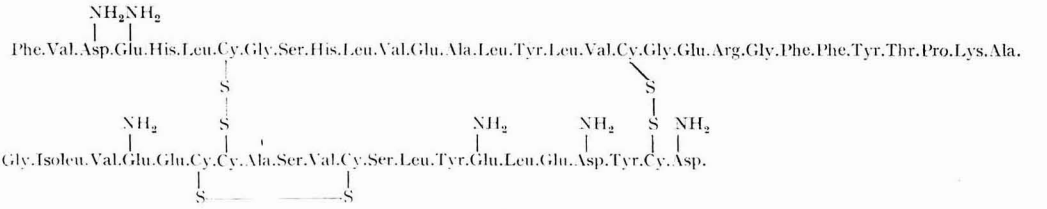

CHART I.—STRUCTURE OF INSULIN

Lys.Ala.; (4) Tyr.Leu.Val.$CySO_3H$.Gly.; and (5) Ser.-His.Leu.Val.Glu.Ala.

Further information as to the manner in which the above five sequences are joined together in fraction B has been obtained by the use of proteolytic enzymes. Proteolytic enzymes are much more specific than acid since only a few of the peptide bonds are susceptible. They give rise to larger peptides (which are few and hence the mixtures are less complex) which in general are more difficult to fractionate by paper chromatography. However, it has been recently found that better separations can be achieved by ion-exchange chromatography and ionophoresis. By studying peptides obtained by the action of pepsin, trypsin and chymotrypsin it has been possible to find out how the various sequences are arranged and deduce the complete sequence of the phenylalanyl chain which is shown below:

Phe.Val.Asp.Glu.His.Leu.$CySO_3H$.Gly.Ser.His.Leu.-Val.Glu.Ala.Leu.Tyr.Leu.Val.$CySO_3H$.Gly.Glu.-Arg.Gly.Phe.Phe.Tyr.Thr.Pro.Lys.Ala.

Similar methods have been used to determine the sequence of fraction A. Although the fraction A is the shorter of the two chains, the determination of its structure has been more difficult. Fraction B contains several residues that occur only once in the molecule and this helps considerably in interpreting the results whereas fraction A has only a few such residues and these are all near one end. Also fraction A is much less susceptible to enzymic hydrolysis. Fraction A contains the sequence $CySO_3H.CySO_3H$ and this gives rise to a number of water-soluble peptides which do not fractionate easily by paper chromatography. However, it has been found that by paper ionophoresis at *p*H 2·75 they can be well separated since they are the only acidic peptides present. At this *p*H, —COOH groups are uncharged, $-SO_3H$ groups carry a negative charge and $-NH_2$ groups a positive charge. Peptides without cysteic acid are all positively charged, those with one cysteic acid are neutral and could be separated as a group and those with two cysteic acids are negatively charged; if a slightly higher *p*H (3·5) is used, the —COOH groups become slightly charged and all the peptides containing one cysteic acid residue move slowly towards the anode and can thus be fractionated. In this way the sequence of fraction A has been found to be:

Gly.Isoleu.Val.Glu.Glu.$CySO_3H$.Ala.Ser.Val.$CySO_3H$.-Ser.Leu.Tyr.Glu.Leu.Glu.Asp.Tyr.$CySO_3H$.Asp.

The position of NH_2 groups in insulin has been determined by studying the ionophoretic rates and amide contents of peptides derived from enzymic hydrolysates.

The manner in which the disulphide bridges in the insulin molecule are arranged has been arrived at from the observation that the molecular weight of insulin is 6000, so that it consists of two chains containing three disulphide bridges, and not of four chains as was originally considered. The fact that fraction A contains four cysteic acid residues, whereas fraction B has only two, indicates that two bridges must connect the two chains together and one must form an intra-chain bridge connecting one part of the A chain with another part of the same chain.

The actual location of the disulphide bridges in the insulin molecule has been determined from a disulphide intercharge reaction that occurs in acid, alkaline and neutral solutions. During the hydrolysis of the unoxidized insulin peptides, a random rearrangement of the disulphide bonds occurs with the consequent production of cystine peptides which are not actual fragments of the original insulin. The rearrangement which occurs in acid solution has been found to be different from that occurring in neutral and alkaline solutions and instead of being catalysed by —SH groups, it is actually inhibited by them. Not only does this show that a different reaction is involved but it is also possible to prevent its occurrence during acid hydrolysis. Thus when insulin is treated with concentrated acid to which a small amount of thioglycollic acid is added, cysteine peptides can be isolated which are in fact true breakdown products and from which the distribution of the remaining two disulphide bonds can be deduced. The complete structure of insulin is shown in Chart I.

Living Polymers

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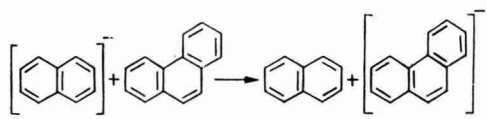
THE growth of polymer chemistry as a distinct branch of physical science in recent years was actuated by the recognition of organic polymers as constructional materials based on their own merits. The early investigations in the field of polymers were characterized by a pronounced empiricism of approach and it was only in 1920, with the publication of the epoch-making paper by Staudinger[1] that a rational hypothesis regarding the structure of polymeric materials was made available.

The general acceptance of Staudinger's views provided the necessary impetus for the systematic scientific investigation of the modes of polymer formation. It was soon realized that polymeric materials could be produced by two distinct types of reactions, namely condensation and addition polymerization. Of these, the latter type of reaction stimulated greater interest due to several reasons. The process is one of simplest types of organic chain reaction and the sole product of the reaction is a macromolecule, the structure of which is determined by the rates and mechanisms of the individual steps constituting the overall change. Further, the kinetic study of the reaction provided the possibility of determining the active life time of a free radical centre which is of paramount significance to the fundamental problems of chemical kinetics of chain reactions.

The overall process of addition polymerization involves three discrete steps: initiation, propagation and termination. In the initiation process the monomer molecule is excited by reaction with catalyst and in the propagation process the excited monomer molecule grows by successive addition of monomer units until the growth is finally stopped by the termination reaction. Most of the initiators initially investigated were of the free radical type, although several instances of cationic types of polymerization were known. The systematic study of the latter class of initiators was rendered difficult due to the uncertainty regarding the nature of ionogenic processes involving the initiation reaction. Yet another class of initiators which brings about addition polymerization through carbanionic intermediates was recognized only very recently[2], although several such compounds have been patented without an understanding of the actual mode of reaction. It was one of such catalytic systems which was employed by Prof. Szwarc in his synthesis of 'living polymers'[3,4] which is considered to be one of the basic contributions in polymer science.

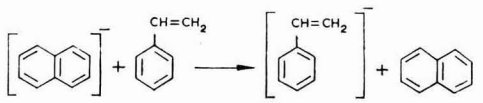
The essential feature of the synthesis of 'living polymers' consists in the fact that if by an appropriate choice of reaction conditions the termination reaction in the overall process of conversion of monomer to polymer is precluded, the growing ends will not be destroyed and would be capable of subsequent growth if additional amounts of monomer were made available. The ingenuity of the experiment thus consists in the choice of a unique catalytic system in which all the required conditions are fulfilled.

The catalytic system chosen by Prof. Szwarc was the sodium-naphthalene complex in tetrahydrofuran solution. It had been shown by Scott and co-workers[5] that metallic sodium reacts with aromatic hydrocarbons in solvents like the dimethyl ether of ethylene glycol in an inert atmosphere to form intensely coloured metal-hydrocarbon complexes. Scott[6] later showed that the system was capable of initiating the polymerization of conjugated olefins. Paul, Lipkin and Weissman[7], by a study of the stoichiometry of the reaction and the analysis of the magnetic properties, electrical conductivity and the absorption spectra of the complex, demonstrated that the primary reaction products were the hydrocarbon free radical negative ions and sodium cations. They further showed that hydrocarbon free radical ions were capable of functioning as electron transfer agents, e.g. on the addition of phenanthrene to sodium-naphthalene complex, the following electron transfer reaction was shown to occur.



The case of the electron transfer reaction depended upon the relative electron affinities of the hydrocarbons and the conclusions based on the reaction were in agreement with the known electron affinities of the hydrocarbons. It was suggested by Prof. Szwarc that the same type of electron transfer was

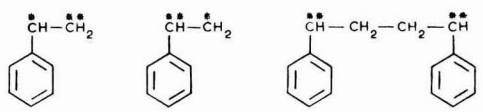
responsible for the initiation of polymerization. For example, when styrene was added to the sodium-naphthalene complex in the absence of air at −80°C. the primary reaction was shown to be as follows:



I II III IV

The structure of styrene ion can be represented by either (V) or (VI).

Both (V) and (VI) are capable of initiating polymerization, one end growing as a free radical and the other as a carbanion. But at the low temperature of the experiment the free radical ends dimerize to give species of the type (VII).



V VI VII

It is obvious that both ends of (VII) are capable of propagating polymerization by an anionic mechanism. The termination in such a case can be brought about by the transfer of a proton from the solvent or that of an electron to the catalyst molecule. Use of a non-proton-donating solvent like tetrahydrofuran prevents the possibility of termination by proton transfer from solvent. Further in tetrahydrofuran, which solvates the ions well, termination by electron transfer is energetically unfavourable.

These expectations were fully confirmed by Prof. Szwarc in the case of polymerization of styrene. Thus on the addition of styrene monomer to the tetrahydrofuran solution of the catalyst under high vacuum conditions the green colour of the sodium-naphthalene complex was observed to change to red due to electron transfer to styrene. The red colour was found to persist for days after the formation of polymer indicating the presence of living ends. The living ends, however, are not capable of eternal existence since there are great many reagents which convert living ends into dead ends and the formation of ' living polymer ' is entirely dependent on the rigid exclusion of all such substances from the reaction system. It was shown that even minute traces of impurities like oxygen or water vapour were sufficient to bring about the destruction of living ends. The conversion of living ends to dead ends is, therefore, not inevitable but under the complete control of the experimenter.

Termination by electron transfer from living ends to naphthalene molecule would lead to change of the red colour to green colour, characteristic of the sodium-naphthalene complex. Further the living ends deprived of electrons would become free radical ends consequent on which further polymerization might ensue leading to an increase in the viscosity of the system. The total absence of these phenomena confirmed the view that the living ends were not destroyed by such a process.

On the other hand, if additional amount of styrene is added to the system further polymerization could take place. If the molar ratio of styrene to solvent is maintained as that in the first batch the concentration of polystyrene should be constant. Despite this, the viscosity of the system was found to increase which indicated that the second batch of the monomer polymerized on the living ends of the first batch. It was also found that if a second monomer like isoprene or butadiene was added to living polystyrene, block copolymers were formed by the polymerization of the second monomer on the living ends of the first monomer[8].

It follows from the mechanism of the reaction that the degree of polymerization of ' living polymers ' is given by the ratio $[M]/\frac{1}{2}[C]$ where $[M]$ is the monomer concentration and $[C]$ that of the catalyst. The validity of this expression has been verified experimentally. Further, in all such polymerizations, e.g. that of styrene, butadiene and isoprene, the number-average molecular weight of the polymers obtained was found to be equal to the weight average molecular weight indicating that the polymers were of monodisperse nature[9]. The synthesis of monodisperse polymers has been an unsolved problem[10] and ' living polymers ' perhaps constitute the closest approach to this objective.

The synthesis of ' living polymers ' has opened up the possibility of strict correlation of physical and mechanical properties of polymeric materials and their chemical constitution by the preparation of block copolymers of desired composition and the study of their physical properties[11]. Further polymeric materials with the desired end groups can be prepared by the appropriate choice of the terminating agent. The production of polymers of required physical properties to suit specific application has been one of the major objectives of polymer chemistry and this has been rendered easier by the synthesis of ' living polymers '.

The chemistry of ' living polymers ' is still in the throes of development and the subject is receiving growing attention of many research laboratories.

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Lubricating Oil Additives: A Review

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LUBRICATING oil stocks obtained from a suitable crude oil and refined properly according to the modern methods of solvent extraction often fail to meet the lubrication requirements of modern machinery, as a result of design changes and severe operating conditions. Certain chemical compounds, called 'additives', have, therefore, to be incorporated in the refined oil to improve some of its existing properties and to impart to it certain desired characteristics, which were previously absent. The use of additives not only results in an improved lubricant, but also decreases the cost of refining and widens the scope of crude oil selection. Additives, in general, are no substitute for the quality of lubricating oil base stocks and cannot also eliminate the use of oil as a heat transfer medium and a sealing agent. Formulations are empirical and rigorous testing is done in order to ascertain that an additive would be effective under actual service conditions and, at the same time, would not have any adverse effect on the functional properties of the oil.

In the present paper, the general types of lubricating oil additives in use currently are reviewed and their mechanism of action has been discussed in relation to their chemical compositions. Some typical additives, which have been successfully used by the petroleum industry, are described along with the different laboratory methods and the full-scale engine bench tests used for evaluating the characteristics of the additive-treated oils.

Since 1935 there has been a progressive development in the use of chemical additives in lubricating oils so that today almost all superior engine, industrial, railroad and marine lubricating oils contain one or more of these additives. A well-established chemical industry dealing with research, manufacture and evaluation aspects of additives has come into being. An idea of the estimated world annual consumption of lubricating oil additives can be had from the data given in Table 1.

The subject of petroleum additives has been dealt with in detail by many workers[2-7]. The patent literature on the subject is voluminous and is continuously increasing. Large sums of money are being spent on the development of new additives, which either replace or improve the previous ones. As additional information about their mechanism of action

TABLE 1 — ESTIMATED WORLD ANNUAL CONSUMPTION OF LUBRICATING OIL ADDITIVES[1]

ADDITIVES	TYPICAL DOSAGE % *wt*	TOTAL AMOUNT USED	
		Million kg.	Million Rs
Detergents/anti-wear	2-10*	196	400
Antioxidants	0·2-2	45	93
Extreme pressure agents	5-10	40	107
V.I. improvers	0·5-10	40	107
Pour point depressants	0·1-1·0	4	14
Anti-foaming agents	0·0001-0·001	—	67
Oiliness improvers	0·1-1·0	—	
Anti-rust agents	0·1-1·0	—	

*The heavy duty engine oils (Series-3 oils) introduced in 1956 may contain 15-25 per cent additive, substantially in the form of detergent.

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becomes available, less costly and more effective additives are placed on the market.

Classification of additives

The commonly used lubricating oil additives may be classified as follows:

1. Oxidation-corrosion inhibitors
2. Dispersant-detergents
3. Pour point depressants
4. Viscosity index (V.I.) improvers
5. Rust preventives
6. Oiliness, film strength, extreme pressure and anti-wear agents
7. Anti-foam agents
8. Dyes

The above classification is not rigorous on account of the fact that many additives are multi-functional in nature, e.g. acryloids act both as viscosity index (V.I.) improvers and pour point depressants. An oxidation inhibitor may improve V.I. and a fluorescent dye may also prove to be a good pour point depressant.

There is a class of lubricants called 'Voltolized' or 'Elektrion' oils[8], which are without any additives. Various grades of such oils possess the properties of oiliness, solubilization and peptization to a greater extent than the conventional oils. How the passage of silent electrical discharge brings about these changes in lubricating oils is still not understood.

Antioxidants — Ideally, all types of lubricating oils should maintain their original properties without any change for an indefinite period of time. However, all lubricating oils deteriorate in service, principally due to oxidation and the complex oxygenated compounds formed are responsible for causing bearing corrosion, ring sticking, lacquer and sludge formation and increased viscosity. In order to prolong their use in service, small concentrations of additives, called antioxidants or oxidation inhibitors, are incorporated.

With a view to understanding the nature and mechanism of oxidation occurring in lubricating oils, the oxidation of pure hydrocarbons belonging to the paraffinic, naphthenic and aromatic series has been studied by many workers[4]. From the results it is difficult to predict the behaviour of the complicated mixtures such as those occurring in lubricating oils. Oxidation of the paraffinic and naphthenic hydrocarbon components[5] of lubricating oils tends to yield oil-soluble compounds of an acidic nature, while oxidation of aromatic constituents tends to yield oil-insoluble sludges and varnishes. Due to the complexity and diversity of the hydrocarbons and other molecules involved, few specific oxidation products have been identified except such degradation materials as water, carbon dioxide, carbon monoxide and some of the lower boiling carboxylic acids. However, it is generally believed that organic peroxides are the first oxidation products formed through a free radical chain reaction[6] as indicated below:

(1) *Initiation*: $RH \longrightarrow R^{\bullet} + H^{\bullet}$

(2) *Propagation*: $R^{\bullet} + O_2 \longrightarrow ROO^{\bullet}$ (peroxide)

$ROO^{\bullet} + RH \longrightarrow ROOH + R^{\bullet}$ (hydroperoxide)

From branching reactions of the type $ROOH \rightarrow RO^{\bullet} + OH^{\bullet}$, a variety of compounds containing oxygen can be formed, such as water, aldehydes, alcohols, ketones and acids. They are further oxidized and react to form high molecular weight polymers. Some of them are oil soluble and the others are oil insoluble such as resins, varnish, lacquer and hard carbon which get deposited on metal parts.

Both the initiation and propagation reactions may be activated or accelerated by the presence of metallic ions, heat or light.

(3) *Termination*: $R^{\bullet} + R^{\bullet} \longrightarrow RR$

$2\ ROO^{\bullet} \longrightarrow ROOR + O_2$

The formation of stable end-products, cutting down of the oxygen supply and the exhaustion of reactive components result in the termination of the chain reaction.

Factors affecting oxidation — Oil oxidation is greatly dependent upon factors[6] such as temperature, time, catalysts (metals like copper, iron, lead, and dust, fuel combustion blow byproducts), contact with air or oxygen and the chemical composition of the lubricant. They largely help to determine the type of additive that is most suitable for a specific purpose.

Inhibitor action — Oxidation inhibitors or antioxidants may react in two different ways. One type of oxidation inhibitor functions by reacting with the free radicals formed and terminate the chain reaction. The end-products formed are stable and do not take part in any further reaction. The other type, which is not a true antioxidant, functions indirectly by passivating the metal or metal ions, which catalyse oxidation and acts as a catalyst 'poison' by forming a protective chemical film or coating on the metal surface by physical adsorption or chemical bondage.

The mechanism of oil oxidation and the inhibiting action of antioxidants are complex and still not completely understood on account of the many factors involved. However, it is known that the 'induction period' of an oil is considerably increased by the use of an antioxidant.

The addition of an antioxidant to an oil is by no means a universal cure-all but is only a preventive. It is the detergent additive, which is a cure against the formation of the oxidation products of the oil.

Since oils widely differ in their susceptibility to antioxidants, it is necessary to select a combination of base stock and additive, which will result in a stable product.

The antioxidants now widely used are mainly organic substances containing sulphur and phosphorus or phosphorus and nitrogen, amines, complex phenols or metal derivatives of such compounds. They are represented by tributyl phosphite, triphenyl phosphite, tri-*p*-tertiary-amyl phosphite, zinc dialkyl dithiophosphates, alkyl phenol sulphides, sulphurized fatty oils, sulphurized terpenes, reaction products of phosphorus sulphide with olefines and fatty oils, and other fatty products containing phosphorus and sulphur. β-Naphthol, phenyl-α- and phenyl-β-naphthylamines and phenol derivatives are recommended for turbine oils[2].

Examples of some commercial inhibitors[2] available in the market are: Santolubes 393, 394-C, 395, 520 and 220; Paranox 14, 19, GB, 441, 492; Monto 202, 204; Ionol; GX-3; Calco MB; Aerolub 76 and 77; and Lubrizol.

Different laboratory oxidation test methods are followed by workers in different countries. The temperature of oxidation, the duration, the rate of air or oxygen blown, sample size and the catalyst employed vary from test to test. The information obtained by these tests is comparative and primarily of theoretical interest, and is mostly used for the initial stage screening of the oils.

Engine tests for evaluating the oxidation characteristics of crankcase oils are carried out according to the CRC-L-4 technique[9]. It is proposed to replace it very soon by the CLR-38 technique[10,11]. The screening tests are conducted on smaller engines, like Petter W-1[12].

Detergent dispersants — The formation of deposits and sludges in internal combustion engines at high as well as low temperatures is a serious handicap to their efficient performance. As the major cause of such formations is the oxidation of lubricating oil used in the crankcase, antioxidants are incorporated in the lubricant to inhibit oxidation. They are quite efficient at relatively low temperatures but become less effective at high temperatures encountered in the piston zone and in the combustion chamber. Thus the oil deteriorates forming carbonaceous deposits within the combustion zone, sludge gets accumulated in the channels and finally settles down affecting the performance of vital engine parts. This is overcome by the use of detergent-dispersant additives, which act as a cure and not a preventive for oil oxidation.

It is believed that these additives keep the engine parts[6] such as piston rings, oil screens, crankcase pan, etc., clean and do not allow the colloidal carbonaceous particles composed of oil oxidation products, fuel soot, resins and other oil-insoluble materials to agglomerate and to settle by keeping them in a fine and stable suspension in the oil. They might act by coating metal surface with an adsorbed layer, thereby preventing adherence of soot and resin. Others believe that such additives direct the chemical reactions occurring so as not to form oil-insoluble deposits. It is claimed that some of the more effective detergents are basic in nature so that they have a neutralizing effect on acidic oxidation products to prevent the formation of deposits. It is probable that the detergent-dispersant additives[6] act according to any one or a combination of the several ways indicated above depending upon the particular operating conditions involved.

These additives are widely used in heavy-duty oils. The classification of such oils, as MIL-L-2104A, Supplement-1, Series-2 and Series-3, mostly depends upon the amount of detergent-dispersant additive used in a given oil. The concentration of the detergent added increases in the order of oil mentioned. In Series-3 oils, 15 to 25 per cent of additive[13] is present in the oil, substantially as detergent additives.

An important role[3] played by a detergent is that it basically reacts and neutralizes acidic bodies such as petroleum oxy acids, hydro-halogenic and sulphur acids formed as a result of oil oxidation and blow-by fuel contamination during actual engine operation. The 'over-basic' alkaline earth metal phenates of alkyl phenols or alkyl phenol sulphides, 'basic' salts of high molecular weight sulphonic acids, principally those derived from petroleum oils and long chain alkyl-substituted benzenes are some of the examples.

It is believed that 'basically' reacting detergents prevent the reactions to proceed further by their own combination with the oxy acids to form inert oil-soluble or oil-dispersible salts and are also capable of 'washing' away freshly deposited oxy acids from hot engine parts[13]. But they are not so effective once the oxy acid molecules have condensed or polymerized to tightly adherent insoluble deposits.

With possibly a few exceptions, detergent dispersants[2] are represented by metallo-organic compounds. The metallic component is generally calcium, barium, magnesium or aluminium[5], although many other metals have been tried. The functional group can be sulphonate, hydroxyl, carboxyl or mercaptan. An oil solubilizing group, like high molecular weight straight or branched paraffin chain, aromatic or naphthenic rings, etc., is also necessary.

Patent literature constitutes the principal and often the only published source of information on the subject of additives. Aluminium naphthenate, calcium dichlorostearate and calcium chlorophenyl

stearate[13] were used commercially in early detergent oils but have since been superseded by less costly and more effective additives. The most effective present-day detergent additives[13] are represented by the following general chemical classes:

1. Normal and basic salts of 'mahogany' acids, i.e. preferentially oil-soluble sulphonic acids derived from petroleum
2. Normal and basic metal salts of high alkyl-substituted benzene sulphonic acids
3. Normal and basic metal phenates of alkyl-phenols, alkyl-phenol sulphides and alkyl-phenol aldehyde condensation products
4. Metal salts of acidic materials obtained by partially hydrolysing the reaction products of poly-olefins, such as polybutene and phosphorus sulphides

The concentration of metal detergents in the lubricating oil can be ascertained from the percentage of sulphated ash.

Recently, the so-called 'ashless', i.e. metal-free detergents have also been introduced, for example, the detergent made by copolymerizing lauryl methacrylate with diethyl-aminoethyl methacrylate[13].

Under mild operating conditions, such as those encountered in a city delivery van, there is more contamination of the crankcase oil by the fuel, which results in the oil carrying more resin-forming material to the piston zone. Certain detergents, which are effective at high temperatures, may not prove to be effective under these operating conditions. Thus, the action of the additive for such service[6] should be to disperse and to dissolve the resinous material formed under low temperature engine operating conditions. Experience has shown that with increased concentration of usual detergents, low temperature engine deposits are fairly reduced resulting in a cleaner engine. As for example, the use of oils of Series-2 detergency level results in a cleaner engine than with the use of an oil of MIL-L-2104A detergency level, those of Supplement-1 level being intermediate.

In addition to their main intended function of engine cleanliness, certain additives often affect other properties of a lubricant. Some of these effects are beneficial, such as improved rust protection and reduced corrosion wear, whereas others are undesirable such as increased tendency to foam and emulsify.

Various laboratory tests have been suggested to evaluate the detergents but the results do not always agree with the full-scale engine bench tests[2,13,14]. One of the recently reported bench tests for detergency involves the microscopic examination of a used oil at various elevated temperatures extending from 60°C. to above 200°C. The resistance of the contaminative particles in the oil to flocculation with increasing temperature is taken as a measure of the detergent power of the oil[15,16].

Full-scale engine bench testing for detergency is carried out according to CRC-L-1[9] or IP 124/55 or IS: 496-1955 Appendix G. Petter AV-1 engine is now generally used for screening purposes. A detailed discussion about the engine testing of heavy-duty lubricating oils with respect to their oxidation stability and detergency characteristics has been recently published by the authors[10].

Pour point depressants — A pour point depressant, when added to a lubricating oil, lowers the temperature at which it ceases to flow. The high pour point of a waxy oil is due to the crystallization of wax to form a semi-solid mass. In order to prepare an oil of low pour point, it is necessary to dewax such an oil. The presence of dissolved wax in the oil is beneficial, because a dewaxed oil has invariably a lower viscosity index and higher carbon residue. However, low pour point in an oil could be achieved by the addition of a pour point depressant to a partially dewaxed oil.

The existence of pour point depressants had been observed as early as 1887 but they were not developed for commercial use till early 1930s. They may be divided into two categories: natural and synthetic.

Natural pour point depressants — Asphaltic materials are natural pour point depressants. They can be isolated from spent percolation clays and asphalt-bearing stocks, cracked residue, hydrogenated tars, tar pitch, oxidized waxy hydrocarbons, solvent extract, etc., by proper treatment. But their efficiency is low and they impart certain undesirable properties to the lubricating oils.

Synthetic pour point depressants — Synthetic pour point depressants, on the other hand, have been found to be much more efficient and free from any objectionable properties. Kalichevsky and Kobe[2] have listed nearly 200 U.S. patents relating to these depressants. Their chemical composition is varied, but they are all of high molecular weight. Some of them act also as V.I. improvers, antioxidants, detergents and even as fluorescent agents. The depressants widely used in commerce are 'Paraflow', 'Montopour 208', 'Santopour' and 'Acryloids'. Paraflow is a condensation product of chlorinated wax and naphthalene[5]. Santopour[2,5] is obtained by condensing phenol with chlorinated wax followed by further condensation with phthalyl chloride; while acryloid[2,5] is a high molecular weight polymerization product of esters of methacrylic acid and higher fatty alcohols such as lauryl or cetyl. The latter type of compounds also improve viscosity index.

Pour point depressants[2,5] are supposed to function by forming a protective or insulating film around the

wax crystals when formed so as to prevent the separate wax crystals from agglomerating and trapping the oil. It is believed that pour point depressants are specific and the crude source and the mode of refining may determine their susceptibility.

The phenomenon of ' pour point reversion'[2] occurs generally in poorly dewaxed oils containing these depressants, when the oil has been subjected to such a temperature cycle that wax crystals are allowed to exist for an extended period of time, e.g. in winter storage, and the oil tends to solidify at a temperature much above its depressed pour point. These conditions nullify the effect of the pour point depressant. The plausible explanation is that the protective coating of the additive becomes ineffective and the interlocking of wax crystals is gradually increased till the pour point of the base oil is reached.

In waxy oils[2] pour point depressant can be incorporated by treating the oil itself with adipyl chloride or stearyl chloride, by voltolization or by exposure to ultraviolet light.

The pour point of the original and doped oil is determined by the ASTM method D97-47 or IP 15/55.

Viscosity index improvers — Successful operation of lubricating oils in internal combustion engines demands that the rate of change of viscosity with temperature should be minimum, i.e. they should have a high viscosity index (V.I.). Solvent refining raises the V.I. of lubricating oil stocks to a certain extent depending upon the crude oil composition and the method and the depth of refining. However, the desired additional improvement can be brought about by chemical compounds, called V.I. improvers. These additives are generally long chain high molecular weight polymers, which disperse colloidally in the oil. The best known examples[2] are: Paratones, polymers of isobutylene; Santodex, an alkyl-styrene polymer; and acryloids, polymers of the esters of methacrylic acid and higher fatty alcohols. Due to their high molecular weights many of them often also act as pour point depressants.

The behaviour of polyisobutylenes, polymethacrylates, polyvinyl esters of fatty acids, various diesters and voltolized oils[2] as V.I. improvers has been studied in some detail. It may be stated, in general, that the V.I. improving action of these substances is probably due to the fact that their molecules[17] are spiralized at low temperatures and occupy little space, thereby contributing very little towards the viscosity of the doped oils. Whereas at higher temperatures they ' uncurl ', dissolve in the oil and considerably increase the viscosity of the oil, the extrapolated viscosity of the V.I. improvers themselves ranges from 5000 to 13,000 cs. at 100°F.

Since the effectiveness of a V.I. improver depends upon its solubility in the base oil, it becomes a primary criterion for its selection and also determines the optimum concentration of the additive to be used in the oil. Secondly its effectiveness also depends upon shear stability, which differs from additive to additive. These facts show that the specific service, for which a product is intended, must be considered carefully in order to make the best selection of V.I. improver and base oil combination. The best improver for light oils may not be the best for heavy oils.

Viscosity index before and after the addition of the improver is determined from the viscosity at 100° and 210°F. of the oil by the ASTM method D 367-53 or IP 73/53.

Rust preventives — The use of anti-rust additives is of recent origin. Two distinct types of rust preventive oils have been developed. One of them is used to put a comparative thin film over the metal surface to protect it against rusting; the other is a rust inhibited lubricating oil. In the former case, higher concentrations of active ingredients are needed, while in the latter case, much smaller amount is necessary because of the constant flow of fresh oil over the given surface. This type of rusting is to be distinguished from the high temperature type oxidation encountered in engines during operation, which is taken care of by the use of antioxidants.

Preservative type of oils[3], which are generally used as thin films over metal surfaces, have to be effective in rust inhibition during periods of storage, shipment, shut-down and use. On the other hand, rusting in lubricating systems is usually a result of water contamination and its prevention might well be considered a problem of design and maintenance. In turbine oil installations rusting is a serious problem and has been overcome by the use of stable oxidation inhibited oils.

Within the past few years, a large number of patents covering various types of compounds as rust inhibitors have been taken out. Products of liquid, semi-solid or solid consistency, based on lubricating oil, petrolatum and paraffin wax, are manufactured for various applications. They are organic compounds[3] containing an oil solubilizing group together with one or more polar groups. They are surface active agents that probably function by being preferentially absorbed on the metal surface through the polar group and thus preventing direct contact between metal and water.

The action of moisture on films of oil, both with and without anti-rust additives on steel strips, has been studied by Pilz and Farley[18]. They have established a relationship between contact angle and rust preventive ability by correlating water drop

spreading on the surface as an indirect measure of the strength and extent of orientation at the oil-metal surface. In general, the lower the contact angle the greater the protection against rusting.

The chemical compounds[3] that have been found to be effective for rust prevention are the alkaline earth metal salts of high molecular weight, petroleum sulphonic acids, and certain complex amines and amine salts and phosphates. Their effectiveness is dependent on such factors as the strength of polar bond between the additive and metal, the nature of the monolayer formed, the temperature conditions and base oil characteristics so that for most satisfactory results the oil blend should be tailored to the specific conditions that exist. For example, some rust inhibitors require the presence of a certain amount of water before they can play it out and form a protective coating on the metal.

There are various methods by means of which the different rust preventives used for different purposes are evaluated. One of them is ASTM method D 665-50T.

Oiliness, film strength, extreme pressure and anti-wear agents — The severe operating conditions encountered in modern machinery with increased load and pressure on various parts, like gears and bearings, have led to the development of lubricants having oiliness, film strength, extreme pressure (EP) and anti-wear properties, because in such cases straight mineral oils would fail to lubricate the machine parts properly.

During the process of lubrication, the thickness of the film of the lubricant between the surfaces determines the type of lubrication. The mechanism of lubrication and the agent required for the purpose vary considerably with the prevailing circumstances. Three sets of conditions are encountered, namely fluid, boundary and extreme pressure.

In fluid lubrication, the relative speed of the two components is high, the specific pressure is not excessive and thickness of oil film is relatively great in comparison with the other types. Under ideal conditions of lubrication, one of the surfaces ' swims ' on the lubricant and there is no abrasive wear. The frictional drag is related to the viscosity of the oil.

If the relative speed between two lubricated surfaces makes the thickness of oil film extremely small, the friction increases considerably and becomes independent of viscosity. This is the case of boundary lubrication. Boundary friction is attributed to intermolecular forces[17] at the points of contact and is influenced both by the chemical nature of lubricant and the underlying surfaces. Fatty acids, fatty alcohols and esters[17] are said to possess greater oiliness as compared to hydrocarbons and hence are more effective as boundary lubricants. X-ray and electron diffraction[17] studies have revealed that these long chain polar molecules are absorbed as a thin molecular layer on metal surfaces, the polar groups being ' anchored ' in the metal and hydrocarbon chain sticking up. Further, the acids react with metal surfaces forming a coherent film of the metallic soap. On account of strong lateral adhesion between hydrocarbon chains, these absorbed films protect the surfaces and minimize metal-to-metal contact and facilitate sliding.

It has also been found that at the points of ' asperities ', metal-to-metal contact[17] welding by plastic deformation still occurs but the extent of surface damage is much smaller than in the absence of lubricant. The friction is due to the shearing of the metal junctions and the lubricant film. In extreme cases, the temperature at the points of contact may rise sufficiently high to melt when appreciable quantities of molten metal may be transported to cooler spots leading ultimately to local welding or seizure of components. In mild cases, this results only in a gradual smoothing of the metal surfaces known as ' running in '.

The addition of polar compounds[17] to improve the oiliness of a lubricant can help to increase the allowable specific pressures by a factor of three to five. However, in certain heavily loaded machine parts, particularly in gears, the occurrence of extremely high local pressures cannot be avoided. Lubricants of a better quality than those discussed above and termed ' extreme pressure ' (EP) lubricants are then used. Their development was largely necessitated by the use of hypoid gears, which have certain mechanical advantages but are very exacting in their lubrication requirements because of high loads and sliding velocities involved. They are in wide use both in hypoid gears and in other types of gears and heavily loaded bearings.

EP lubricants contain certain additives capable of reacting with metal at high local temperatures and form a thin coating of the reaction product[17], which together with the oil constitutes the surface supporting the load.

The additives generally incorporated into a mineral oil base are organic compounds[17] containing one or more of the active elements in combination, such as oxygen, sulphur, chlorine, phosphorus and lead. These compounds may be used singly or in combination of two or more to achieve the desired results. In order to take care of all the conditions of high and low speeds and torques under which some gears are required to operate, it may be necessary to use oiliness additives along with extreme pressure compounds. Compounds[6] such as tricresyl phosphate and zinc

thiophosphate have been found to be effective as anti-wear agents.

Various laboratory ' film strength ' testing machines employed for initial stage screening to test the load-bearing capacity of this type of lubricants are the Timken, Four Ball, SAE, IAE, Floyd and Falex[4].

The U.S. Ordnance Department Specification MIL-L-2105 for a gear lubricant prescribes two full-scale hypoid gear tests. One of them, called a ' high speed axle test ', is to be run at high speeds and low torque and the other, known as ' high torque axle test ', is to be run at low speeds and high torque. Bench test machines, either alone or in combination, are not adequate to predict the performance of a lubricant in both of these tests.

With the introduction of the gear lubricant specification, the development of an improved lubricant with such characteristics as thermal stability, permanent oil solubility, non-corrosiveness, sulphur activity, etc., was necessitated. However, experience[13] with full-scale tests have shown that the lead soap-active sulphur and sulphur-chlorine lubricants were found to be satisfactory for the high speed type of operation but were almost completely ineffective under high torque conditions of operation. Additives[13] of proved effectiveness in the high torque test, when added to a chlorine-sulphur lubricant, only provides a lubricant which can pass the high speed but not the high torque test or vice versa, thereby negating or reducing the effectiveness of the companion additive in the other test.

The U.S. Ordnance Department Specification MIL-L-2105 has been superseded by MIL-L-2105A, which is a good deal more rigorous[8]. With further developmental work by the oil companies, new additives have been made available in the market. They pass both high speed and high torque tests and are truly universal gear additives.

Differentiation between the oiliness carriers and extreme pressure agents is artificial and may depend upon the quantity and not on the nature of the additive. There are numerous patents pertaining to oiliness carriers and extreme pressure agents. Many of them are multi-functional and some are recommended for specific uses. A few of the EP additives[2] that have found commercial use are: Santolube 31 (phosphite ester of alkylated phenol), Santopoid S and Santopoid SRI (chloronaphtha-xanthates), Parapoid 10C, Viscose B, Lubrizol 702 and Lubrizol 745, Anglomol 77-X and 82, Monto-gear B, etc.

Anti-foaming agents — Vigorous agitation and aeration of lubricating oils in moving machine parts, particularly in running engines, give rise to foam, which may entail loss of oil and interfere with the smooth running of the engines. Excessive foaming of crankcase engine oils may cause failure by feeding mixtures of oil and air to the pressure pumps or displacement and loss of oil from the lubricating oil system or by giving erroneous readings of oil levels in the supply system. Viscous oils and those containing antioxidants and detergent additives[6] have a greater tendency to build up persistent foam. Consequently such oils are treated with anti-foaming agents, which facilitate disengaging of the air and gas bubbles from the oil. They[6] act by reducing the interfacial tension around the small air bubbles, which coalesce to form larger bubbles, quietly rise to the top and break almost as rapidly as they are formed.

A number of chemical compounds are effective as anti-foam agents when added to mineral oils, the best of all being the silicone polymers[5] (polymethyl siloxanes). They are extensively used in minute concentrations in motor and gear oils and have no effect on other oil properties. A typical and well-known commercial anti-foam agent is Dow Corning Fluid 200. Most of these anti-foaming agents are included in commercial detergents like Santolubes 303A and 507-X-4 and others.

The foaming characteristics of lubricating oils before and after doping are determined by the ASTM method D892-46T or IP 165/55T. Unlike other tests, data[3] obtained by this test have been correlated well with field service data with the result that this test has been included in the specifications for heavy-duty oils.

Dyes — Dyes are added to the refined lubricating oils to impart a particular fluorescence required from the sales point of view. Customers associating the ' green ' bloom of the paraffinic base oils with superior performance of lubricating oils might still look for this colour, although the appearance of the oil has nothing to do with its performance. Sometimes a dye may be necessary for distinguishing different lubricating oils[6], e.g. for leak detection in an equipment, where more than one type of lubricant is used.

Oil-soluble organic compounds with high colouring power are used to impart the required fluorescence. Parasheen[2], a green liquid, is an example of a dye used to impart a green cast to pale or red oil having a bluish or some other undesirable tint. Parashade is an oil-soluble dye used to change a pale or light coloured oil to a red oil.

Classification of crankcase oils — Prior to 29 April 1952, the nomenclature for crankcase oils was Regular, Premium and Heavy Duty. The classification has since been revised to MS, MM, ML, DS and DG. The first three pertain to gasoline or other spark-ignition engines and the latter two to diesel engines. The new classification indicates the type of service conditions under which the different crankcase oils are to be used. The choice and the quantity of

additives depend on the type of service, for which the oil is intended and the chemical composition of the oil.

Automotive, diesel and all purpose heavy-duty oils[2] may contain a pour point depressant, a V.I. improver, an oxidation inhibitor, a corrosion inhibitor, an oiliness carrier, a detergent and an anti-foam agent. An EP lubricant may contain these additives with the exception of V.I. improvers and detergents. However, a rust inhibitor may be added in its formulation. Turbine oils may contain an oxidation inhibitor and a rust preventive. Other lubricating oils may have an equally complex composition.

Evaluation of additive oils

The subjects of engine testing of lubricants and of the additives are interconnected. The ultimate development of any satisfactory additive type of lubricant is dependent upon a rigorous and complete testing programme. The various engine tests used for evaluating the performance of additive-treated motor oils have recently been reviewed by the authors[11]. Each type of lubricant is subjected to specific tests, which have been indicated at appropriate places in the text including the engine tests. According to the latest British Military Specification DEF-2101B (30 September 1957) (E. R. Palmer, private communication), all qualifications more than four years old automatically become obsolete. Additives and oils used in qualification tests must have been manufactured within the previous twelve months.

In the initial stages a number of laboratory bench tests[6] are used to screen the additives under consideration. After tests, the formulations, which appear promising, are subjected to simulated service tests, which have been designed to reproduce a certain condition or set of conditions to which the lubricant will be exposed to in actual service and which are generally carefully controlled. However, at present there is no known substitute for actual field trials in interpreting these test results.

For use in automotive equipment[6], the additive type lubricants are further subjected to road trials. One group of vehicles are run at high temperature and high speed conditions, and another group at low temperature, low speed stop-and-go type of conditions. Covering the two extremes of test conditions, normally encountered in service, generally provides adequate assurance that the products will also perform satisfactorily at intermediate conditions.

For lubricants intended for other types of equipment and uses[6], the test lubricant under development may be used in a few units in actual service. In these field tests close checks are maintained on the test units for information on improvement in performance effected by incorporating new additives as well as for detection of abnormal or adverse conditions that might arise.

Before marketing, the lubricating oil is further checked under actual service conditions[6] by distributing it in a limited area for a short period. The performance is checked very closely and carefully to find out that no adverse conditions will develop due to occurrence of a peculiar combination of uncontrolled conditions, which could not be predicted by the various laboratory tests and field trials conducted previously.

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Construction of a Schmidt Camera

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WHILE designing an optical system for photographic work the main characteristics of the system to be considered are (i) achromatism, (ii) sharp focus over a large field of view and (iii) speed. These requirements are approximately met in a small objective by cementing together a number of lenses made of different kinds of glass and of different curvatures. In astronomical work where large apertures are required the cost of casting highly homogeneous and strain-free glass discs becomes prohibitive. So mirrors, which have the additional advantage of being perfectly achromatic, are substituted for lenses. If the reflecting surface is figured to a paraboloid of revolution it will produce a sharp image of a distant object lying on its axis. But for off-axis objects, defects like coma, astigmatism, distortion and curvature of the field ruin the image. Coma, the most prominent defect in the vicinity of the axis, increases in proportion to the distance of the object from axis and also to the square of the *f*-ratio. Since the fastness of a system for extended objects varies as the *f*-ratio, coma and speed go together.

The Schmidt camera

To avoid coma over a large field of view and to have a high speed at the same time, Schmidt used a spherical surface in place of a paraboloid. The uniqueness of a spherical surface lies in the fact that it has no fixed axis. Any straight line passing through the centre of curvature can be taken to be its axis, so that the incident light can always be considered to be coming along the axis. Thus the defects due to the off-axis location of the object will be absent in a spherical mirror. If a screen with a narrow hole be placed at the centre of curvature of the spherical mirror, the size of the incident beam will be limited and, therefore, the spherical aberration will be practically absent, with the result that a parallel beam of light will come to a point focus. If a number of parallel beams inclined to one another are incident, they will come to point foci lying on a spherical surface concentric with the mirror and of a radius of curvature equal to the focal length of the mirror. On increasing the size of the diaphragm, the image is no longer sharp as the spherical aberration becomes prominent. To elimninate spherical aberration a thin aspheric lens is introduced in the incident beam very near the centre of curvature. One surface of the lens is flat, or slightly spherical, while the cross-section of the other face is a curve of the fourth degree. The overall effect of the correcting lens on a beam, traversing parallel to the axis, is to produce slight convergence at central zones and slight divergence at outer zones so that after reflection from the mirror the rays come to a point focus in between the paraxial and marginal foci of the mirror. Rays traversing at moderately oblique angles are deviated slightly more but this is unimportant as the absolute deviations are small. To receive these oblique rays the mirror is made larger in comparison with the corrector lens as otherwise there will be appreciable loss of light at the edge of the field.

There is a certain amount of chromatic aberration due to the introduction of the corrector. But this is negligible as ordinarily the corrector plate is very nearly plane parallel. However, in the case of a Schmidt of aperture greater than the focal length, the curve is quite steep and the chromatic effects become appreciable. This may be remedied by using two plates of different refractive indices.

The corrector plate

In order to eliminate spherical aberration a spherical mirror is figured to a paraboloid. The thickness of glass to be removed in order to convert a spherical surface of paraxial focal length f into a paraboloid of focal length f' is easily calculated by writing down the cartesian equations of the curves of the two surfaces[1]. Taking P, the pole of the mirror, as origin, the X-axis along the axis of the mirror and Y-axis along the tangent at the pole, the profile of the spherical mirror is given by

$$(x-2f)^2+y^2 = (2f)^2$$

Solving this for x in the form of a power series in y, we get

$$x = \frac{1}{4f}\cdot y^2+\frac{y^4}{64f^3}-\frac{y^6}{512f^5} \quad \ldots \quad (1)$$

The term in y^6, being small in comparison with the first two terms taken together, may be neglected.

The profile of the parabola is given by

$$y^2=4f'x, \text{ or } x=\frac{y^2}{4f'} \quad \ldots\ldots \quad (2)$$

The horizontal distance δ between these two surfaces is given, as a function of y, by the difference between the expressions (1) and (2) as follows:

$$\delta=\frac{y^4}{64f^3}+y^2\left(\frac{1}{4f}-\frac{1}{4f'}\right) \quad \ldots\ldots \quad (3)$$

Removal of a thickness δ of the glass amounts to introducing a retardation $2\delta \cos i$ in the path of the light ray incident at the point y. The angle of incidence, i, is very small for the whole of the wave surface; $\cos i$ may, therefore, be taken as unity. This retardation may, however, be effected by keeping the spherical shape of the mirror intact and interposing, instead, a glass plate of variable thickness in the path of the rays. Since a thickness d of the interposed material retards the wavefront, at almost normal incidence, by a path length $(n-1)d$, the retardation 2δ would be obtained with a plate of thickness

$$\Delta=\frac{2\delta}{(n-1)}$$

The variation in the thickness of the corrector plate should, therefore, be

$$\Delta=\frac{y^4}{32f^3(n-1)}+\frac{y^2}{(n-1)}\left[\frac{1}{2f}-\frac{1}{2f'}\right]$$

$$=\frac{1}{32f^3(n-1)}(y^4-ay_o^2y^2) \quad \ldots\ldots \quad (4)$$

where y_o, the radius of the corrector, is the maximum value of y and the dimensionless parameter, a, is given by

$$ay_o^2=32f^3\left[\frac{1}{2f'}-\frac{1}{2f}\right]$$

The parameter a can be varied by giving different values to f'. Thus a family of curves is available for the purpose of eliminating the spherical aberration. We choose that particular value of a for which the corrector plate introduces least chromatic aberration.

Now the dispersion of colours, being greater for greater deviation of the beam, would depend upon the angle of incidence which, in turn, is determined by the slope of the profile. Consequently the chromatic aberration will be most pronounced at that point where the profile has its maximum slope. Equation (4) gives the slope (m) of the profile as

$$m=\frac{d}{dy}\Delta=\frac{1}{32f^3(n-1)}[4y^3-2ay_o^2y]$$

This would be maximum at $y=y_{max.}$ given by

$$\frac{d}{dy}[4y^3-2ay_o^2y]=0, \text{ i.e. } y_{max.}=\sqrt{\frac{a}{6}}\cdot y_o$$

Here the numerical value of m would be

$$\frac{1}{4f^3(n-1)}\cdot y_o^3\left(\frac{a}{6}\right)^{3/2}$$

an increasing function of a.

Besides this stationary point, the slope will be greatest at $y=y_o$, which is the upper limit of y. The numerical value of m here would be

$$\frac{1}{8f^3(n-1)}\left(1-\frac{a}{2}\right)\cdot y_o^3$$

a decreasing function of a. To produce the best effect, the two values should be of equal magnitude. This occurs when $a=\frac{3}{2}$.

Construction of the camera

The camera to be described has the following constants. The mirror is of 12 in. aperture and has a focal length of 16 in. The corrector plate is of 9 in. aperture stopped down to 8 in. and is $\frac{1}{4}$ in. thick. A 3 in. diameter film holder covers a field of 10° with slight loss of light at the edges.

Mirror — A Pyrex-moulded blank whose diameter was slightly larger than 12 in. and thickness over 2 in. was used. The two surfaces were ground roughly plane and parallel to within 0·1 mm. The edge was ground truly circular and square with the face. When shaped, the disc was 12 in. in diameter and 2 in. thick. The back surface was fine ground and polished. The front surface was hollowed 0·57 in. deep using a half-sized convex cast iron tool with 80 carborundum. Fine grinding was carried out with a full-sized glass tool of equal and opposite curvature. The polishing and figuring were done in the usual manner.

To study the nature of the surface, knife-edge test was applied with some modifications. To test the mirror at its centre of curvature, the source of light must emit a beam of wide enough angle to illuminate uniformly the whole aperture of the mirror. The angle of the beam required is $\frac{12}{32}\times 57{\cdot}3°$, i.e. 21·5°.

Such a wide angle beam was obtained by using a microscope objective of numerical aperture 0·25 and focal length 1 in. A 0·5 mm. pinhole illuminated by a 12 V., 35 W. lamp and ground glass interposed

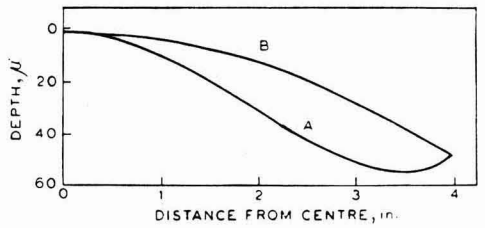

FIG. 1 — PROFILES OF THE FACE OF THE CORRECTOR LENS [Curve A, profile given by equation (3); and curve B, starting surface for producing the corrector plate]

in between, was placed at 8 in. from the microscope objective which formed a diminished image 0·07 mm. in diameter at a distance of $\frac{8}{7}$ in.

θ, the angle of the beam produced, is given by

$$\theta = 2 \sin^{-1}(\tfrac{7}{8} \times 0{\cdot}25) \simeq 25°$$

The other alteration effected in the usual procedure of the test is to have both the source and the knife-edge on the optical axis as, otherwise, due to the large f-value of the mirror even a slight off-setting of the hole causes astigmatic effects. This was achieved by keeping the light source in a line at right angles to the optical axis and reflecting the light on to the mirror by means of a thin microscope cover glass making an angle of 45° with the axis. The microscope cover glass should be fairly flat and it should be mounted in a way that does not cause flexure. The beam of light after reflection from the mirror passes through the cover glass where it is intercepted by the knife-edge. A true spherical surface, as evidenced by uniform darkening all over, was obtained.

Corrector lens — A 9 in. aperture, $\frac{1}{4}$ in. thick plate glass, free from strain and striae, was selected. The diameter of the plate was purposely kept 1·0 in. greater than required so that the edge, which is troublesome to figure, could be masked out. One face of the plate was made flat, correct to half a wavelength, by grinding it against two glass discs of equal size in the conventional sequence. During the process of fine grinding with equal sized glass tools, difficulties were experienced due to unequal distribution of heat. Evaporation takes place from the outer region of the surface when it is exposed during a part of the stroke. The central region, therefore, being at a comparatively higher temperature, is ground away faster, resulting invariably in a concave surface irrespective of the relative position of the surface and the tool. The difficulty was overcome by carrying out fine grinding on a cast iron tool, which is flat to one wavelength and of $\frac{4}{3}$ times the size of the surface to be worked. Polishing was also done on $\frac{4}{3}$ sized tool.

The other face was then ground so as to make the edge thickness the same all round to within a few microns. This face was to be figured to the complex curve given by equation (3) and represented by curve A (Fig. 1). The depths of various zones, calculated by taking $a = \frac{3}{2}$, $f = 16$ in., $y = 4$ in. and $n = 1{\cdot}51$ are as follows:

Radius of zone, in.	0	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4
Depth, μ	0	2	9	19	30	42	51	55	49

The lens was first convexed to the curve B shown in Fig. 1. This not only reduced the amount of glass to be removed during figuring but also provided with a surface of revolution to start with.

Tools — To conform the spherical curve to the aspheric one, flexible tools which may adapt themselves to the changing curvature of the surface are to be employed. This flexibility is attained by cementing a $\frac{1}{2}$ in. thick sponge rubber* disc on to an aluminium plate, with the grinding facets affixed on the rubber. Pitch or Dunlop adhesive may be used as a cement. The grinding facets have been arranged in different patterns by various workers. Hendrix and Christie have used rectangular glass or unglazed ceramic tile facets arranged in the form of a ring, the radius of the ring corresponding to the radius of the zone to be cut. A number of such ring tools of different dimensions are employed for complete figuring of the lens. Cox[2,3] used a full-size tool with lead facets arranged in the shape of petals in such a way as to ensure that the amount of lead passing over any given zone in each stroke was proportional to the amount of glass to be removed. Such a tool is expected to figure the lens in a single figuring operation.

The former type of tool leaves hard zones which must be eliminated by local figuring in order to give a regular blended figure to the lens. The second type of tool did not prove to be successful when tested in this laboratory, most probably because of the large area of the grinding facets and the absence of ring character which is essential for the tool to conform itself to the changing curvature of the lens. It was finally decided to figure the lens in steps, using ring tools and to arrange the grinding facets so as to give a smooth surface. The different types of tools used for figuring are shown in Fig. 2 (A, B, and C). A half size tool, intended to work over the central region of the lens, was made by arranging small glass facets in the form of petals as shown in Fig. 2A. The thick-

*The flexibility of rubber was found out by a preliminary experiment. The type of rubber used for ring tools is depressed through 0·020 mm. under a pressure of $\frac{1}{10}$ lb./sq. in. A softer variety was employed for full-sized grinding and polishing tools. This is depressed through 0·16 mm. under the same pressure.

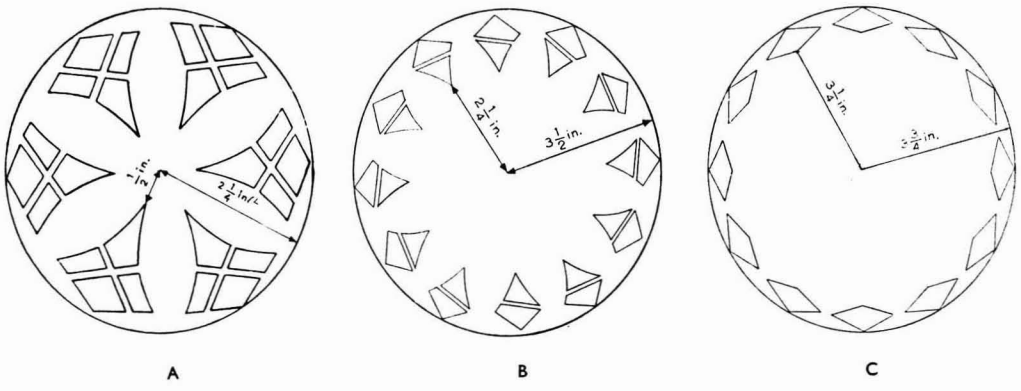

FIG. 2 — TOOLS USED FOR FIGURING DIFFERENT PARTS OF THE CORRECTOR PLATE [A, for the central region; B, for the 3 in. zone; and C, for the 3-4 in. zone]

ness of the glass facets is $\frac{1}{20}$ in. and they are spaced $\frac{1}{10}$ in. apart. Six such petals, one in each 60° sector, were cemented on to the rubber disc, with three alternate ones slightly displaced radially relative to the other three, in order to avoid zones.

Grinding and figuring

The tool was ground against a flat glass plate in order to smooth out any irregularity in the surface of glass facets. It was then worked over the convexed lens using a 1 in. stroke, the mean position of the stroke coinciding with the centre of the lens; the turntable carrying the lens made 2 r.p.m. while the tool made 20 strokes/min. During initial stages of grinding 20 min. emery* was employed, the pressure on the lens being $\frac{1}{10}$ lb./sq. in. Spherometer test was applied to study the contour of the surface after every half hour of grinding. The depths of various zones resulting after three hours of grinding are shown plotted in Fig. 3A. A second tool (Fig. 2B) was used to produce maximum effect round the 3 in. zone. This tool was worked for 6 hr with strokes varying between 1 and $1\frac{1}{2}$ in. The resultant figure of the lens is shown in Fig. 3B. But for the 3-4 in. zone, the coincidence was satisfactory. To cut off this latter zone, another tool (Fig. 2C) was used and worked for 3 hr using $\frac{1}{2}$ in. strokes. The spherometer readings for the resultant profile, as plotted in Fig. 3C, lie very close to the calculated contour.

To smooth out any zone which might have developed during zonal grinding, and to fine-grind the surface, a full-size flexible tool was made by cementing

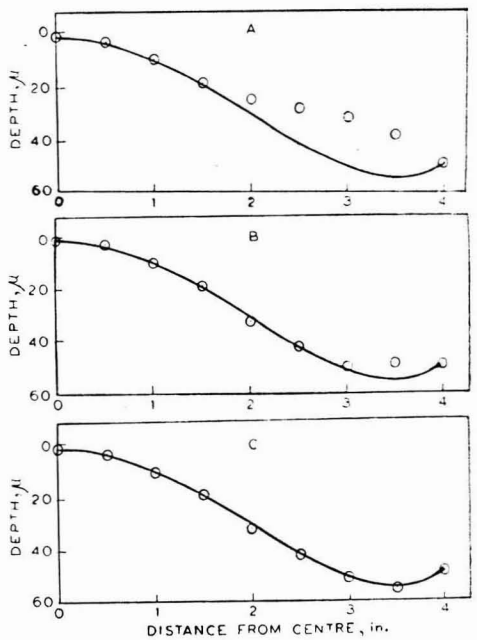

FIG. 3 — VARIOUS STAGES IN THE DEVELOPMENT OF THE CORRECTOR PLATE SURFACE [The continuous curves represent the calculated values; the circles indicate the actual depths at different distances from the centre obtained after figuring; A, after 3 hr with tool shown in Fig. 2A; B, after 6 hr with tool shown in Fig. 2B; and C, after 3 hr with tool shown in Fig. 2C]

on to $\frac{3}{8}$ in. thick rubber of softer variety, small glass facets 8 × 4 mm. and smaller, in the form of rings of different radii. The shorter sides of the rectangular facets were kept radial and the longer ones tangential. Two consecutive facets in a ring were separated by a distance slightly greater than the length of the facets and the corresponding facets of two consecutive rings

*Commercial emery available in the market is not generally well graded; it must, therefore, be sorted out before use. The different sized grains are allowed to fall through a vertical column of water 20 cm. high and various groups taking different times are separated. The finest grade employed takes 60 min. in falling through this height.

were shifted relative to each other by about the same amount. The various facets composing any particular ring were not exactly confined to a circle, they were fixed slightly displaced around the circular periphery with the result that the rings were broken; the radial distance between two rings varied up to about 2 mm. This eliminated any possibility of the tool producing zones. The areas of the facets in different rings were calculated to produce uniform grinding over the whole surface. By increasing or decreasing the area of the facets in a particular ring the corresponding zone may slightly be deepened or elevated.

Polishing

The figuring was guided during the grinding stage by means of a spherometer which was made by mounting a precision screw on a rigid tripod, the legs terminating in knife-edges, the lines of which are parts of the circumstances of an 11 in. diameter circle. The flat face of the lens is placed on a 12 in. flat glass plate correct to half a wavelength, the legs of the spherometer also resting on the plate. With care, an accuracy of measurement up to 1 μ can easily be achieved. A corrector lens figured to this accuracy serves creditably well. The supporting of the corrector plate during grinding and polishing is very important and it should be held free from any uneven pressure and should be readily available for frequent tests. A circular aluminium plate with raised edges and inside diameter $9\frac{1}{4}$ in. was used for the purpose. A $\frac{1}{8}$ in. thick sponge rubber pad, slightly smaller in diameter than the lens, was placed at the base and the inside of the edge was also lined with sponge rubber of the same thickness. The lens just fits into this case and projects out of the casing by $\frac{1}{8}$ in. so that it can easily be taken out when required. There is no relative motion of the lens and the casing, with the result that if some grain of abrasive gets at the back of the lens it does not scratch the surface. For supporting even thick mirrors this arrangement has been used in preference to the usual practice of pitching a metal plate to the back of the mirror.

Full-size flexible tool with circular grooves was employed for polishing. A $\frac{3}{8}$ in. thick soft rubber disc was covered with $\frac{1}{10}$ in. thick layer of pitch. For efficient working of the polishing lap, proper hardness of pitch is essential. A too soft pitch lap produces turned down edge, does not produce a true surface of revolution and is deformed very soon. A too hard lap does not easily make good contact with the surface to be polished, produces sleeks and polishes very slowly. To test the quality of pitch an iron rod, weighing 1·0 kg., one side of which is tapered to an angle of ten degrees ending in a small circle of 0·5 mm. diameter is employed. This rod is supported on a

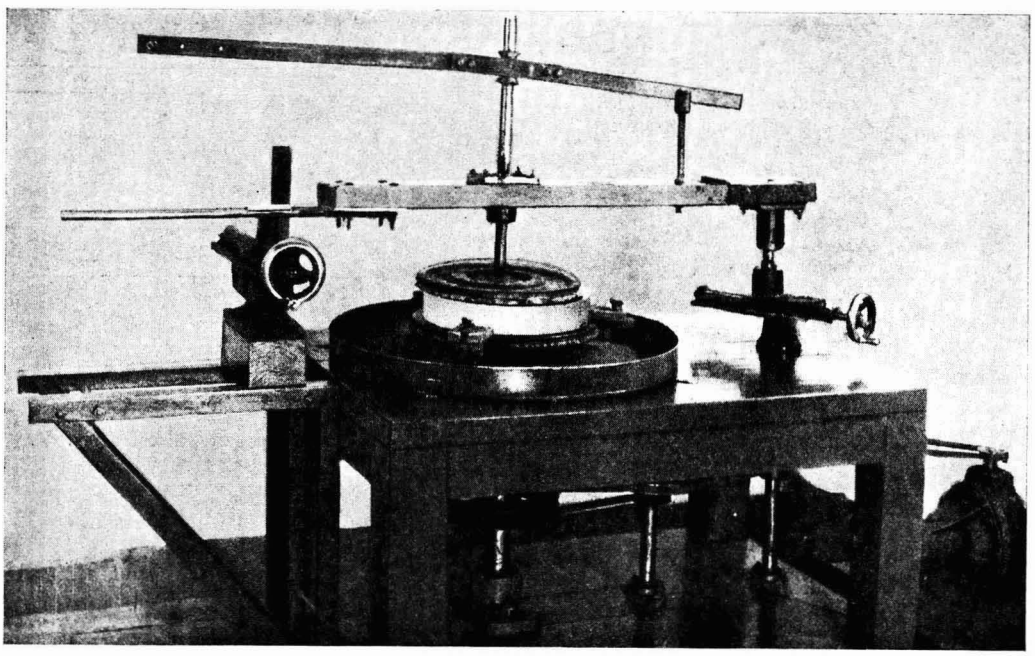

FIG. 4 — GRINDING AND POLISHING MACHINE

sample of pitch to be tested and the time taken for a descent of 1 mm. is noted. If it is more than 2 min. the pitch is on the harder side, if it is less than 1 min. the pitch is on the softer side.

The polishing lap was heated in a water bath to a temperature at which the pitch becomes quite soft. It was then pressed against the surface to be polished, through a netting cloth moistened with soap and glycerine. This produces tiny facets about $\frac{1}{10}$ in. square on the surface of pitch, which produce good contact between the tool and the glass. Circular grooves were cut on a lathe and the tool was made of the same pattern as the one used for final grinding described earlier. This tool worked satisfactorily, its action being uniform over the whole surface. It took about 10 hr for polishing the lens to a finish.

Grinding and polishing were carried out on a machine, as mechanical working has been found to be more successful than working with hand. The following scheme of operations should be rigidly adhered to. Firstly, the throw of the crank which controls the amplitude of the stroke should be altered frequently. In the machine which was constructed (Fig. 4), this was achieved by incorporating a screw-and-slide arrangement which changed the length of the stroke while the machine is running, thus avoiding the necessity of stopping the machine every time the stroke is to be changed. Secondly, the distribution of pressure over the surface of the work should be uniform. The vertical shaft connecting the horizontal driving arm to the tool ends in a pivot which slips into a V-shaped hole at the back of the tool. Clearance of $\frac{1}{10}$ in. was kept between the pivot and the hole with the result that the weight of the shaft does not exert any pressure at the centre of the tool and thus avoids non-uniform pressure. To increase the pressure over the work, small weights, distributed uniformly, are placed directly on the back of the tool, preferably with rubber pads in between. In this arrangement the rotation of the tool is automatic. The work too is often rotated relative to its support. Thirdly, frequent lateral displacements of the tool relative to the work should be possible. This is achieved by mounting the bearing, through which the end of the driving arm slides, on a nut holding on to a long screw perpendicular to the driving arm. By means of this screw the tool can be shifted to any zone from the centre to the edge of the work, during the running of the machine. With the provision of these adjustments, a true surface of revolution is produced and astigmatism is completely avoided.

Testing

The final testing of the corrector lens was carried out in conjunction with the primary spherical mirror. The lens was placed at the centre of curvature of the mirror. A small size wire gauze of about 200 mesh illuminated by a 6 V., 3 candle power lamp was placed facing the mirror at the infinity focus of the camera. The image of the gauze was observed by keeping the eye in line with the centre of the lens and mirror, and at a distance where the image filled up the whole lens. When the eye is moved right or left, the image travels across the lens in the same direction, the wires showing up as straight lines, whereas in the absence of the corrector lens the images of the wires begin to curve and become convex towards the centre. More rigorous tests are available for determining the surface of the lens but this simple test is good enough for figuring the lens to an accuracy required for most purposes.

Acknowledgement

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Prepackaging Studies on Fresh Produce: *Capsicum grossum* Sendt. & *Capsicum acuminatum* Fingh.

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Prepackaging studies of *Capsicum grossum* Sendt. (sweet pepper) and *Capsicum acuminatum* Fingh. (green chillies) in bags made of different packaging films such as (1) polyethylene, (2) plain transparent cellulose, and (3) moisture-proof heat-sealable transparent cellulose (M.S.T.), with and without aeration vents, have been carried out at different temperatures and relative humidities. These studies have indicated that the shelf life of sweet pepper can be nearly doubled by prepackaging it in 150 gauge polyethylene film with adequate respiration vents and also in M.S.T. bags at (i) 100°F. and 90 per cent R.H., (ii) 76-80°F. and 65-75 per cent R.H., and (iii) 47-50°F. and 80-90 per cent R.H. The beneficial effect of prepackaging green chillies is seen only when they are packed in polyethylene bags at (i) 76-80°F. and 65-75 per cent R.H., and (ii) at low temperature in all the three types of bags. The ascorbic acid content of both sweet pepper and green chillies is not affected by prepackaging.

AMONG the more recent developments in the marketing of fresh produce, prepackaging of fruits and vegetables has revolutionized the trade practices in U.S.A. and in some parts of Western Europe. More than 20 per cent of the total produce valued at about 11 billion dollars are prepackaged and sold through the grocers' stores in the U.S.A. This method of merchandising of fresh produce has materially benefited the producer, grocer and the consumer[1].

Prepackaging is generally understood to mean packaging the produce in convenient consumer size containers for retail sale. The produce is first prepared by trimming off waste materials like leaves, stalk, stem, culls, etc., washed, cleaned and weighed quantities put into suitable size containers, so that the housewife could use the contents without any further treatment. From the point of view of marketing, prepackaging has been found to have advantages like reduced transport costs, better eye appeal, easy handling, quick turn-over, saving in labour costs and increased shelf life. This seems to be the main reason for the popularity of 'Self Service Stores', in western countries. Concomitant with this development, the manufacture of a variety of packaging materials suitable for specific uses has also increased to a great extent. Thus, depending upon the nature and physico-chemical characteristics of the produce, it could be given a longer shelf life, by the use of suitable packaging materials.

In India, fruits and vegetables are at present marketed without any packaging. Consequently, it is often seen that in the green grocer's shop, a fair quantity of the produce goes to waste. With improvement in the standard of living of our people and efforts that are being made to conserve and utilize the fresh produce, packaging is bound to assume considerable importance.

Studies have, therefore, been initiated in this Institute to determine suitable conditions which will prolong the shelf life of perishable commodities stored in retail stores or kept in homes. The investigation includes all varieties of fruits and vegetables, cut flowers, etc. These studies would lead to the development of suitable package for bulk transport also. In our earlier communication, prepackaging of betel leaves (*Piper betel* Linn.) has been described[2]. The present paper relates to the prepackaging of two varieties of capsicum, viz. *Capsicum grossum* Sendt. (sweet pepper) and *Capsicum acuminatum* Fingh. (green chillies).

Materials and methods

Freshly harvested sweet pepper and green chillies were obtained from a local orchard and washed in running water to remove any external dirt, insecti-

cidal residue, etc. In the case of sweet pepper, the stem was trimmed off to a length of $\frac{1}{2}$ cm. and both the varieties were conditioned at 65°F. for about 18 hr. One pound lots were used for studies on pepper and $\frac{1}{2}$ lb. lots in the case of green chillies. The experiments were carried out in triplicate and data obtained were confirmed by repeating the entire series.

Packaging materials — Three types of packaging films, inexpensive and readily available in India, and which are easy to handle, were used. The films used were: (1) polyethylene (150 gauge), (2) plain transparent cellulose (P.T.) and (3) moisture-proof heat-sealable transparent cellulose (M.S.T.).

The films were made into bags of suitable size. The bags used for sweet pepper were 10 × 14 in. while those used for green chillies were 7 × 9$\frac{1}{2}$ in. Polyethylene and M.S.T. bags were prepared by heat sealing and P.T. film bags were made by sealing the edges with an adhesive tape. The bags were carefully cleaned and dried before use and the filled bags were closed by tying with thread. It is known that if adequate ventilation is not provided, fruits and vegetables in an airtight package will soon develop off-flavours due to anaerobic changes in the produce[3]. In order to study the effect of ventilation on the shelf life of the produce, polyethylene bags having 2, 16 and 24 vents of $\frac{1}{4}$ in. diameter corresponding approximately to 0·05, 0·4 and 0·6 per cent respectively of the total area of the film were used. In the case of green chillies the bags had 2, 14 and 22 vents corresponding to 0·1, 0·7 and 1·1 per cent respectively of the total area of the film.

The filled bags were stored under the following conditions: (1) 100°F. and 90 per cent R.H., (2) 76-80°F. and 65-75 per cent R.H., and (3) 47-50°F. and 80-90 per cent R.H. No. 1 represents the atmospheric conditions during summer in most parts of the country; No. 2 those during the cooler months; and No. 3 the optimum cold storage conditions for capsicum.

Packages stored under the above conditions were withdrawn at definite intervals, and the physiological loss in weight and their marketability were determined. The following factors were taken into consideration for determining the shelf life of the product: (a) general appearance, (b) fungal or microbial spoilage, (c) development of off-flavour, (d) ripening and (e) physiological loss in weight. The overall shelf life was assessed by a panel of judges. In addition, the physiological loss in weight above 15 per cent was considered uneconomical from the point of view of marketability.

Apart from the samples packaged in various films, samples were kept as such without any packaging under the above conditions to serve as control.

In order to study the effect on the moisture loss by the number, size and distribution of vents, keeping the total area of ventilation in the package constant, an additional set of samples packaged in polyethylene bags having 25 vents of $\frac{1}{5}$ in. diameter and 64 vents of $\frac{1}{8}$ in. diameter were included in the trials. Each of the above bags had a total ventilation area of 0·4 per cent corresponding to the polyethylene bag of the same size having 16 holes of $\frac{1}{4}$ in. diameter. Samples from this set were withdrawn at the same time as above and the moisture losses determined.

Under packaged conditions, using relatively less permeable films, the accumulation of respiration gases, particularly carbon dioxide, produces anaerobic changes in the commodity. In order to determine the progressive build-up of carbon dioxide in the bags during storage, three more sets of samples packaged in P.T., M.S.T. and polyethylene films without ventilation were included in the study. This was done only in the case of green chillies. A 12 in. rubber tube was introduced into each of these bags and the bags tied tightly and the loose end of the rubber tube closed with a pinch cock. The carbon dioxide content in the bags was determined at periodic intervals by means of a Hartmann Braun portable gas analyser.

Pepper and green chillies are known to be good sources of vitamin C. In order to determine the extent of retention of vitamin C in the materials packaged in various types of films, stored at different conditions, vitamin C was estimated at the end of the storage period by the dye titration method[4]. The changes in total acidity at the end of the storage period were also followed up.

Results and discussion

The results of various trials are recorded in Tables 1-6.

Sweet pepper — The results presented in Table 1 show that minimum loss in weight is observed when pepper is packed in polyethylene bags without any vents. Although the M.S.T. film is a good moisture barrier, it is ineffective under high humid conditions and, therefore, does not prevent desiccation of fresh produce packaged in it. In ventilated polyethylene bags, the loss in weight increases with increased ventilation, under all the three conditions of storage. Sweet pepper packaged in polyethylene bags with no ventilation and with 2 holes showed signs of fungal damage, and off-flavour at the end of 5-7 days at 100°F. and 10-14 days' storage at 78-80°F., while it was in a good condition in bags with 16 and 24 vents under the same conditions. However, in the latter case the loss in weight was greater. Thus, while the conrol samples became unmarketable after 3-5 days' storage at 100°F. and for 5-6 days at 80°F.,

TABLE 1 — SHELF LIFE OF AND MOISTURE LOSS IN SWEET PEPPER

(Shelf life expressed in days and weight loss in percentage at the end of shelf life; the figures given in parentheses refer to weight loss)

Type of packaging	Storage conditions		
	°F.: 47-50 R.H. %: 80-90	76-80 65-75	98-100 90
Control (unwrapped)	8-10 (11·7-15·1)	5-6 (12·5-15·1)	5-6 (9·8-11·0)
P.T.	10-12 (6·6-6·7)	5-6 (9·3-11·6)	8-10 (10·1-12·0)
M.S.T.	12-14 (2·7-2·8)	10-12 (8·2-10·5)*	10-12 (8·5-11·1)
Polyethylene without vents	18-20 (0·7)	12-14 (2·7-2·9)†	5-7 (0·4)
Polyethylene with 2 vents	19 (0·9)	10-12 (1·7)†	5-6 (1·0)†
Polyethylene with 16 vents	14-16 (3·7-4·8)	12-14 (8·3-9·1)	10-12 (3·0-4·1)
Polyethylene with 24 vents	14-16 (6·4-7·4)	10-12 (8·2-13·2)	12-14 (5·1-6·2)

*Signs of ripening.
†Signs of fungus attack.

TABLE 2 — SHELF LIFE OF AND MOISTURE LOSS IN GREEN CHILLIES

(Shelf life expressed in days and weight loss in percentage at the end of shelf life; the figures given in parentheses refer to weight loss)

Type of packaging	Storage conditions		
	°F.: 47-50 R.H. %: 80-90	76-80 65-75	98-100 90
Control (unwrapped)	9-12 (14·5-18·0)	2-4 (9·0-16·0)	4-6 (9·0-17·5)
P.T.	12-14 (13·1-15·0)	4-6 (12·6-17·0)	4-5* (6·0-9·1)
M.S.T.	12-14 (2·5-3·1)	3-5† (2·1-3·5)	1-2‡ (nil)
Polyethylene without vents	12-14 (nil)	3-5† (nil)	1-2‡ (nil)
Polythylene with 2 vents	12-14 (nil)	3-5† (0·5-0·7)	2-4‡ (nil)
Polyethylene with 14 vents	13-15 (8·0-11·1)	5-6 (2·9-3·8)	4-6† (1·5-3·0)
Polyethylene with 22 vents	13-15 (8·5-12·0)	5-6 (4·8-5·9)	4-6 (4·0-9·3)

*Desiccated appearance and sub-oxidative smell.
†Shine, firmness and colour normal; incidence of large-scale stem-end rot.
‡Shine, firmness and colour normal; definite sub-oxidative smell which persists even after aeration.

they had a shelf life of 10-12 days and 12-14 days respectively in polyethylene bags with 16 vents. Increasing the ventilation to 24 vents in polyethylene bags the product showed a slight decrease in shelf life at 76-80°F.

At low temperatures (45-50°F.), P.T. film did not check the loss of moisture, with the result that the shelf life of the produce was not appreciably more than that of the control. By reducing the ventilation in polyethylene bag the physiological loss

TABLE 3 — INFLUENCE OF NUMBER AND SIZE OF VENTS ON MOISTURE LOSS

(Sweet pepper stored in polyethylene bags at 76-80°F. and 65-75% R.H.)

Number and size of vents	Moisture loss (%) after storage for				
	3 days	5 days	7 days	10 days	12 days
16 vents; $\frac{1}{4}$ in. diam.	2·3	3·9	5·5	7·3	8·6
25 vents; $\frac{1}{5}$ in. diam.	2·9	4·7	6·1	8·4	9·2
64 vents; $\frac{1}{8}$ in. diam.	3·5	4·9	7·0	9·0	11·5

The total area of the vents in all bags was 0·4% of the surface area of the bag.

TABLE 4 — CARBON DIOXIDE CONTENT IN PACKAGED CHILLIES

Storage conditions		Storage period *days*	Carbon dioxide (% *by vol.*)		
Temp. °F.	R.H. %		Polyethylene (without vents)	M.S.T.	P.T.
47-50	80-90	4	6·20	4·0	5·20
		6	4·50	2·5	4·00
		9	4·50	2·2	4·70
76-80	65-75	3	6·50	4·5	8·00
		5	6·75	4·0	8·25
98-100	90	3	8·75	13·5	9·00

in weight was reduced considerably, thereby the product had an increased shelf life over that of the control. Polyethylene bags with no holes gave the product a shelf life of 18-20 days while that in M.S.T. film the shelf life of the produce was only 12-14 days. Pepper stored in polyethylene bag with 2 holes had a shelf life of 19 days as against 8-10 days of the control. In polyethylene bags with 16 and 24 vents, the product had nearly double the shelf life of the control. Adequately ventilated bags, in addition to checking moisture losses, provide also for the exchange of gases formed as a result of respiration of the material.

The results in respect of the influence of number, size and distribution of vents in the package on moisture loss of the product shown (Table 3) indicate that moisture loss is relatively more in a bag having larger number of vents than in the one having smaller number of holes even when the total area of the vents is the same. This observation is of considerable significance when dealing with prepackaging of products having very high respiration rates. Further work on this aspect is in progress.

As regards the changes in vitamin C content of the produce under various conditions of packaging

TABLE 5 — ASCORBIC ACID AND TOTAL TITRATABLE ACIDITY IN SWEET PEPPER STORED UNDER DIFFERENT CONDITIONS

(The values for ascorbic acid and total titratable acidity are expressed on the same moisture basis; titratable acidity is expressed in ml. of N/10 NaOH required to neutralize an extract from 100 g. of sample. Ascorbic acid content is expressed as mg. per cent. Initial ascorbic acid content of sample, 91·4 mg. Initial titratable acidity of sample, 24·5 ml. of N/10 NaOH)

Type of packaging	Storage conditions								
	°F.: 47-50 R.H. %: 80-90			75-80 65-75			98-100 90		
	Shelf life *days*	Ascorbic acid *mg. %*	Acidity *ml. N/10 NaOH*	Shelf life *days*	Ascorbic acid *mg. %*	Acidity *ml. N/10 NaOH*	Shelf life *days*	Ascorbic acid *mg. %*	Acidity *ml. N/10 NaOH*
Control (unwrapped)	8-10	95·4	23·3	5-6	95·7	21·1	5-6	84·3	—
P.T.	10-12	105·0	22·4	5-6	88·8	25·1	8-10	94·4	—
M.S.T.	12-14	98·3	20·5	10-12	102·0	23·7	10-12	91·8	—
Polyethylene without vents	18-20	96·8	24·0	12-14	94·2	28·9	5-7	100·1	—
Polyethylene with 2 vents	19	102·9	28·0	10-12	98·3	21·6	5-6	—	—
Polyethylene with 16 vents	14-16	95·8	24·3	12-14	90·4	21·2	10-12	98·0	—
Polyethylene with 24 vents	14-16	92·8	20·6	10-12	91·1	22·2	12-14	95·4	—

TABLE 6 — ASCORBIC ACID AND TOTAL TITRATABLE ACIDITY IN GREEN CHILLIES STORED UNDER DIFFERENT CONDITIONS

(The values for ascorbic acid and total titratable acidity are expressed on the same moisture basis. Titratable acidity is expressed in ml. N/10 NaOH required to neutralize an extract from 100 g. of sample. Ascorbic acid content is expressed as mg. per cent. Initial ascorbic acid content of sample, 84·4 mg. Initial titratable acidity of sample, 37·2 ml. N/10 NaOH)

Type of packaging	Storage conditions								
	°F.: 47-50 R.H. %: 80-90			75-80 65-75			98-100 90		
	Shelf life *days*	Ascorbic acid *mg. %*	Acidity *ml. N/10 NaOH*	Shelf life *days*	Ascorbic acid *mg. %*	Acidity *ml. N/10 NaOH*	Shelf life *days*	Ascorbic acid *mg. %*	Acidity *ml. N/10 NaOH*
Control (unwrapped)	9-12	75·4	—	2-4	81·2	39·0	4-6	65·5	36·3
P.T.	12-14	89·4	44·8	4-6	76·0	38·9	4-5	—	—
M.S.T.	12-14	78·5	45·7	3-5	77·7	35·0	1-2	—	—
Polyethylene without vents	12-14	88·4	43·8	3-5	67·2	33·6	1-2	—	—
Polyethylene with 2 vents	12-14	80·0	48·3	3-5	81·1	35·0	2-4	71·2	41·7
Polyethylene with 14 vents	13-15	96·7	39·1	5-6	85·0	39·4	4-6	93·9	38·7
Polyethylene with 22 vents	13-15	82·6	41·2	5-6	83·9	42·4	4-6	68·4	32·5

and storage, no appreciable loss of vitamin C was observed (Table 5). Similarly, the total titratable acidity remains unchanged.

Green chillies — The results given in Table 2 show that prepackaging of green chillies in any film for storage at 100°F. and 90 per cent R.H. does not increase the shelf life of the product. As in the case of sweet pepper, green chillies packaged in M.S.T. and polyethylene film bags with no vents and with 2 vents showed anaerobic changes. Even P.T. and polyethylene film with 14 and 22 vents did not prove better than the control which had a shelf life of 4-5 days.

Stored under 76-80°F. and 65-75 per cent R.H. in unventilated bags of P.T., M.S.T. and polyethylene and polyethylene with 2 vents, green chillies developed stem-end rot and off-flavour in 3-4 days. However, with polyethylene bags having 14 and 22 vents, the product had a shelf life of 5-6 days as against 2-4 days in the case of control.

At low temperatures (45-50°F. and 80-90 per cent R.H.), the shelf life of the product is enhanced in all types of packaging by 4-5 days over the control.

When the produce is stored in unventilated bags at 100° and 76-80°F., there is a fairly rapid build-

up of carbon dioxide, resulting in the development of off-flavour and stem-end rot in the samples. This emphasizes the need for the use of adequately ventilated packages.

As observed earlier, in the case of sweet pepper, vitamin C content and total titratable acidity are not appreciably affected by either the conditions of storage or the type of packaging film used (Table 5).

The above studies have revealed that prepackaging of sweet pepper in M.S.T. and polyethylene film (150 gauge) with adequate vents nearly double its shelf life under all the three conditions of storage studied. Plain transparent cellulose film (P.T.) appears to be not of much use for the prepackaging of capsicum, since the film does not prevent moisture loss. Further, by prepackaging capsicum for storage under any climatic condition, nutrients like vitamin C are in no way affected.

Prepackaging of fresh produce thus offers many advantages both to the retail green grocer and the householder, particularly when low temperature storage facilities are not available. Even where refrigerated storage is employed prepackaging produce in materials like polyethylene which prevents loss of moisture enhances the shelf life of the produce to a considerable extent.

Summary

1. The effect of storing sweet pepper (*Capsicum grossum*) and green chillies (*Capsicum acuminatum*) prepackaged in plain transparent cellulose film (P.T.), moisture-proof heat sealable transparent cellulose film (M.S.T.), and polyethylene film with and without provision for ventilation has been studied under (1) 100°F. and 90 per ceut R.H., (2) 76-80°F. and 65-75 per cent R.H., and (3) 47-50°F. at 80-90 per cent R.H.

2. Polyethylene film bags (area of film: 7·0 × 9·5 in.) with 16 or 24 vents have been found to enhance the shelf life of sweet pepper by 4 days at 100°F. and 8 days at 80°F. At low temperatures (47-50°F.), polyethylene bags with 2 holes have been found to be most suitable.

3. Prepackaging of green chillies in the above films has no effect on its shelf life at 100°F. and 90 per cent R.H.; only polyethylene film with vents enhances the shelf life by one or two days at 76-80°F. and 65-75 per cent R.H. The beneficial effect of prepackaging of green chillies in the above films on the shelf life was observed only in the case of produce stored at low temperature, the shelf life being enhanced by 3-4 days.

4. Prepackaging of sweet pepper and green chillies does not materially affect their ascorbic acid content.

Acknowledgement

The authors are thankful to Dr V. Subrahmanyan, Director, Central Food Technological Research Institute, Mysore, for his valuable suggestions and keen interest in these studies.

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REVIEWS

THEORETICAL PRINCIPLES OF ORGANIC CHEMISTRY: Vol. II, by Walter Hückel (Elsevier Publishing Co., Amsterdam, London, New York, Princeton; *Sole Distributors*: D. Van Nostrand Co. Ltd, London), 1958. Pp. xi + 1046. Price 95*s*.

Vol. I, containing Books I and II of the translation by Prof. Rathmann of Prof. Hückel's well-known German book, was reviewed earlier in this *Journal* [**14A** (1955), 393]; Vol. II contains Books III and IV. Though the volume has its independent pagination and has its own author and subject index, the chapters are numbered in continuation of Vol. I.

Book III, entitled *Constitution and Physical Properties*, consists of seven chapters dealing with the following topics: Chapter XI: Theoretical consideration of physical properties, thermal magnitudes; Chapter XII: Electrical properties of molecules; Chapter XIII: Behaviour of substances in an alternating electrical field; Chapter XIV: Relation between cohesion and constitution; Chapter XV: Ordered states of organic substances; Chapter XVI: Colloid chemical problems in organic chemistry; and Chapter XVII: The chemical bond. Book IV, entitled *Constitution and Reaction Velocity*, contains the remaining three chapters: Chapter XVIII: Theory of reaction velocity; Chapter XIX: Reaction velocity constant and constitution; and Chapter XX: Reaction velocity and equilibria.

The characteristic features of the treatment mentioned in regard to Vol. I are found fully in Vol. II also. Except for the involved sentences, which are also reminiscent of German construction, the book contains a wealth of information that will be highly useful for teachers and students of organic chemistry. There are good accounts of dipole moments (70 pages), of infrared and Raman spectra (26 pages), X-rays (70 pages), magnetic properties (26 pages), mesomerism and colour (40 pages) and steric hindrance (25 pages), with particular reference to their application to organic compounds. The discussion on ' the chemical bond ' is similarly very useful. The development of ideas from earlier days is given in proper perspective. Specialists in particular fields may find the treatment of certain aspects not so full but the subject in the hands of a single author has the advantage of properly balanced presentation.

There is no doubt about the value of the book to students of organic chemistry for gaining proper understanding of theoretical principles. At the same time it will be useful also to those who specialize in physico-organic chemistry. Originally, physical chemists used generally to deal with simpler inorganic systems. But now the study of the more complex organic molecules is becoming more popular. For this purpose the two volumes of Hückel's book will be very helpful.

The cost of the book is quite high and not within the reach of ordinary teachers and students, particularly in India. It will be a very useful volume in the libraries of all departments of chemistry and will probably be widely used as a reference book. Appropriately the index is a detailed one, covering 110 pages. The present volume also contains addenda and corrigenda to Vol. I.

T.R.S.

MATHEMATICAL THEORY OF COMPRESSIBLE FLUID FLOW — APPLIED MATHEMATICS AND MECHANICS: Vol. III, by Richard Von Mises. Completed by Hilda Geiringer & G. S. S. Ludford (Academic Press Inc., New York; *Distributors in India*: Asia Publishing House, Bombay), 1958. Pp. xiii + 514. Price $ 15.00

The first chapter is devoted to the formulation of basic equations on which the mathematical theory of compressible flow is based. The role of boundary conditions is clearly stated; the steady state motion ($\delta/\delta t = 0$) and the plane motion ($\delta/\delta z = 0$, $q = 0$) are considered as boundary conditions only. This is quite common in turbulence where homogeneous and isotropic turbulence are considered as boundary conditions imposed on the field. The author makes a departure from the conventional method of introducing the energy equation and introduces a novel concept of, what he calls, the specifying equation, which clarifies the role of thermodynamics in the mechanics of compressible fluids. The discussion on this equation is illuminating and it is worth while comparing this approach with that of S. R. De Groot in his essay " Hydrodynamics and Thermodynamics " [*Proc. Sym. appl. Math.*, Vol. IV, edited by M. H. Martin (McGraw-Hill Book Co. Inc., New York)]. As a result of this study a general principle emerges which has been stated as: *At each moment and for each particle the material derivatives of the five unknowns* $\vec{q}$, p, ρ *are determined as functions of the instantaneous values of* p, ρ, $\vec{q}$ *at the point* x, y, z *and in a neighbourhood of the point.*

A critical discussion of the definitions of temperature and entropy when the gas is in motion could have been profitably included in this chapter.

In the second chapter the general theory of characteristics is treated in a masterly fashion with detailed applications. The third chapter is devoted to one-dimensional flow. The author is not satisfied with considering shocks as discontinuities occurring in the flow of inviscid compressible fluids and he has sought a deeper understanding of the problem. It has been shown that the differential equations for the theory of an inviscid and non-conducting fluid admit no solutions corresponding to certain boundary conditions which can be enforced by simple physical arrangements. Invoking ideas of asymptotic analysis (like boundary layer theory in incompressible fluids) the author thinks that a rational theory of one-dimensional flow with shocks should be based on the following principles: the equation of continuity, Newton's equations for inviscid flow and the specifying equation assumed to be valid at all points of the x-t plane with the exception of certain 'shock lines'; across these lines the state variables are discontinuous, *the sudden changes being governed by rules derived from the theory of viscous and/or heat-conducting fluids.*

Chapters IV and V give a thorough discussion on hodograph transformation, limit lines and branch lines. The conjectures about the relation between these lines and shocks are avoided. The discussion on transonic flow problems is interesting and many problems, which are still open and undecided, are visualized.

The book is strongly recommended to workers in the field of fluid dynamics.

S. D. NIGAM

GAS TURBINES FOR AIRCRAFT by A. W. Judge (Chapman & Hall Ltd, London; *Distributors in India*: Asia Publishing House, Bombay), 1958. Pp. vii + 439. Price 60*s*. net

Several books have been written on the subject of 'Gas Turbines for Aircraft' but in most cases the scope is so vast that sufficient information is lacking on any of the several aspects of the subject. In contrast to this practice, the present author has limited the scope of this book to "an attempt to bridge the gap between the mostly descriptive and elementary type of text-book and the more academic kind". By and large, the author has succeeded in his attempt.

The first two chapters of the book give a historical account of the origin and development of gas turbines in general and aircraft gas turbines in particular up to the end of the last world war. The next two chapters deal with the working principles of an aircraft gas turbine.

The fifth chapter presents in detail the performance features expected of an aircraft gas turbine, how these are realized in practice and the development work that is in progress to improve the performance further. This chapter is of considerable interest to the research and development engineer.

The next three chapters deal with the design and operational aspects, the relative merits and demerits, and the field of application of the turbojet and turboprop engines currently in use both for military and civil purposes. This information is very useful to those engaged in air transport work.

The subsequent four chapters pertain to fuels, fuel systems, combustion systems, lubrication, power augmentation and starting aids. Lubrication, which is generally a neglected subject, is given the necessary importance and space in this book. More information on fuel systems of American gas turbine and rocket-assisted take-off is desirable.

The last four chapters deal with maintenance, materials, special types of aero-engines, and simple thermodynamics of gas turbines. Detailed and up-to-date information given on silencing of jet noise is welcome, particularly in view of the fact that gas turbine powered civilian aircraft are becoming popular and they must adhere to certain minimum standards of engine silencing in keeping with the comfort of passengers and the people living in the vicinity of airports. The chapter on thermodynamics could have been omitted since this book is not meant for those having no elementary knowledge of thermodynamics.

There is a certain amount of repetition of matter in almost all chapters, the elimination of which would have made the book less bulky and still as informative as it is now. Notwithstanding some of these criticisms, the book is well written and will be useful to the advanced student of aircraft gas turbines. The author should be complimented on the exhaustive list of references and bibliography.

M. R. K. RAO

ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY: First Supplement Volume, edited by Raymond E. Kirk & Donald F. Othmer (Interscience Publishers Inc., New York), 1957. Pp. xviii + 974. Price $ 25.00

The *Encyclopedia of Chemical Technology*, a monumental work in 15 volumes, took a span of nine years for completion; the first volume appeared in 1947. This is indeed a short period by any standard for a work of this calibre and dimensions: yet it is not short enough for the rapidly expanding horizons of chemical technology. Recognizing this, the editors, Drs Kirk

and Othmer, and the publishers rightly decided to bring out the First Supplement to the Encyclopedia. This has been done very expeditiously as it was published just a year after the fifteenth volume appeared in print.

The present volume is not a mere supplement to the 15 volumes as it has new and major additions. Articles have been included in the Supplement volume which were not represented in the original volumes. Some individual substances that have come on the market in the last few years are thus described, as also are some reactions (as Cyanoethylation) and unit operations (as Fluidization) that were considered of lesser importance several years ago. The original volumes contained a series of articles on dyes and dyeing, and synthetic fibres; the dyeing of synthetic fibres is treated for the first time in this volume. In selecting the subjects for the fifty-one articles included in the Supplement, it is stated that " the boundaries of chemical technology have been drawn *somewhat* widely " (italics ours). However wide the scope may be, the subjects like automation, computers, etc., need not have been dealt with in such detail in an encyclopedia of chemical technology.

Few errors of a minor character have been noticed: maximum attained efficiency of conversion of solar energy to electricity in the photo-voltaic process has been mentioned on page 805 as 10 per cent while on page 669 it is 11 per cent; the units on the *y*-axis in the figure on page 371 have been omitted; the abbreviation CPS denoted in the figure on page 697 is not explained in the preliminary pages while more elementary abbreviations are elaborated; according to the recently agreed international nomenclature, *Rauvolfia* is the official spelling but in the article on Psychopharmacological Agents it is spelt differently; *Rauwolfia serpentina* is referred to as native to *Dihar*, which should be *Bihar*. In the list of periodicals cited, the *J. sci. industr. Res.* is not included though the bibliography to certain articles refers to this *Journal*.

Excellently produced and reasonably priced, the supplement contains a wealth of information. The volume should be a valuable asset to all institutions of higher learning and research.

In conclusion, the reviewers would like to add that the death of Dr Raymond Eller Kirk, on 6 February 1957, has been a grievous loss to the world of science and his outstanding services to his fellow chemists in their search for comprehensive, accurate and up-to-date information on chemical technology, in the form of the *Encyclopedia of Chemical Technology*, will always be remembered with gratitude.

S. Ranga Raja Rao
A. Krishnamurthi

Bibliography of Publications Dealing with Polarographic Methods in 1955 by J. Heyrovsky

Collection of Czechoslovak Chemical Communications, Vol. XXI (Czechoslovak Academy of Science, Praha), 1956. Pp. 76

Tabulky Pulvlnoych. Potencialu Anorganickych Depolarisatoru (Tables of Half-wave Potentials of Inorganic Depolarizers) by Dr A. A. Vlcek (Nakladatelstve Ceskoslovenske Akademie Ved, Praha), 1956. Pp. 96

Selected Values of Polarographic Data by Giovanni Semerano & Luciana Griggio — Supplement a la Ricerca Scientifica (Research Centre of Polarography of the Italian Research Council, Padua, Italy), 1957. Pp. 327

Since the epoch-making work of Prof. Heyrovsky in 1921, polarography, along with the associated techniques like amperometry, has come to occupy an important position in the repertoire of analytical chemist today. Now is the time for a stock-taking of the past achievements and critical evaluation of the data collected so far. The above-mentioned publications meet the requirements very admirably. Prof. Heyrovsky's Bibliography is a continuation of the earlier manuals published as Part II of the Proceedings of International Polarographic Congress held in Prague in 1951. This was supplemented by later publications which appeared as special issues of Collection of Czechoslovak Chemical Communications. These bibliographies contain references to original papers in which some aspects of e.m.f. developed on a dropping or streaming electrode have been discussed.

As these publications have been compiled by Prof. Heyrovsky, who is the founder of and mainly instrumental for the development to the present stage of this very important subject, and through whose efforts the Polarographic Institute of the Czechoslovak Academy of Sciences has been established, it may safely be surmised that nothing of importance has escaped the careful eyes of the compilers. It would, however, have been helpful to the users of these bibliographies, if in addition to the present arrangement of listing the entries in an alphabetical order authorwise, the entries were also listed and classified subjectwise.

Prof. Vlcek's book outlines polarographic data of elements, e.g. half-wave potentials, valency changes involved in electrode reactions, effect of various complexing agents and other supporting electrolytes, etc., along with full references. In the beginning of the text, an expanded form of periodic table is appended in which are indicated several of the electron reduction steps undergone by elements as interpreted by polarographic measurements.

Due to a fortunate amity among the chemists as regards their common language of chemical formulations, etc., this publication can be useful even to those not conversant with the Czech language.

Realizing the need for a critical evaluation of electrochemical data of analytical interest, the International Union of Pure and Applied Chemistry appointed, in 1953, Commissions to collect materials covering the following three categories: (1) Polarographic data; (2) Oxidation-reduction potentials; and (3) Potentiometric data. The Commission responsible for compiling the polarographic data was composed of Profs. Semerano, Laitinen and Heyrovsky.

The Italian Research Centre had earlier presented a more detailed publication on the subject, but following the pattern set by the National Bureau of Standards, the publication under reference has been brought out in its present form. The substances whose data are listed in the tables are all organic compounds and have been arranged in well-defined groups. These tables present a quick comparison among the compounds of the same series and, therefore, it becomes easy to locate the gaps, if any. Prof. Kolthoff has expressed great satisfaction on the completion of the present volume and these tables have been approved by the Section Committee of I.U.P.A.C. for Union sponsorship. These tables will be able to meet the needs of a wide range of scientists including those who have to employ polarographic techniques in analytical chemistry.

M. R. VERMA

TECHNICAL DRAWING by Fredericke Giesecke, Alva Mitchell & Henry Cecil Spencer (The Macmillan Company, New York), 1958. Pp. vii + 844. Price $ 10.00

This is one of the most comprehensive books published on Technical Drawing. It covers practically the entire field drawing and drafting for engineering institutions, viz. Geometrical drawing, Machine drawing, Shop processes, Topographic drawing and mapping, Perspective, Engineering graphics, Structural and aeronautical drafting, etc. The drawings and illustrations included are excellent and the subjects are well explained. The examples of drawing exercises are carefully selected from current engineering practice. Many of the older books on drawing have stereotyped copies of obsolete items, like steam engine, details which are no longer of use or of interest to engineering students. This book thus serves as a very good text-book for engineering students.

The book, however, suffers from its bulk and encyclopaedic coverage. It would be preferable if its 844 pages are divided into, say, three volumes or parts: Part I, dealing with Geometrical Drawing; Part II dealing with Machine Drawing and Shop Processes, and Part III dealing with Engineering Graphics, Structural and Aeronautical Drafting, Perspective, Topographic Drawing and Mapping. These parts will be more beneficial to students of different classes and subjects, and will be within the reach of their pockets. The relevant sections can be dealt with in a more exhaustive and explanatory manner. The geometrical drawing part dealing with solids, sections and projections requires more adequate treatment and examples.

No book, particularly in engineering, can satisfy all requirements. This publication is one of the best books published so far on the subject and is strongly recommended as a text-book for use in all engineering institutions.

LAKSHMINARAYANAN

AVIATION MEDICINE: Selected Reviews—AGARDograph 25, edited by Clayton S. White, W. Randolph Lovelace II & Frederic G. Hirsch (Pergamon Press Ltd, London), 1958. Pp. vii + 305. Price 70s. net

The selected reviews on 'Aviation Medicine' edited by White, Lovelace II and Hirsch, under the auspices of the NATO, is an expensive volume consisting of twelve essays on different topics which have a bearing on biology in relation to medicine, and on physiology of measurement of human respiration, etc., as related to aviation. Papers 1, 3, 7, 8, 11 and 12 are important essays and deal with: the methods of finding the composition of the respiratory gases and of residual air, the changes under stress, electrolyte imbalances, etc., possible poisoning by ozone in pressurized cabins or under partial pressure, as a function of the altitude. Each essay is well worth careful study. Attention is drawn to the new techniques of measurements of instantaneous changes of respiratory gases by Dr White in paper No. 8.

Paper No. 9 on Aerosols by Dr Reif is on the stabilization and other properties of aerosols, which are now coming to be used in the new industrial concerns (dust production and settlement are problems in factories, mines, etc.) where production and/or settling of aerosols, under different conditions, is the problem of study. The essay (No. 6) by Dr Chiffelle describes technical developments in anatomy and pathology of obtaining casts of specimens of viscera, etc., by the use of plastics. This paper is well worth concentrated study by workers in that field. Papers No. 10 and 11 bear on problems on biophysics and can be recommended to anyone interested in such problems.

Paper No. 2 on High-speed Photography is quite technical and can be recommended for study by

scientists who have to deal with high-speed photography in relation to biological problems such as movements (instantaneous or otherwise), growth, changes in density, etc.

Dosimetry of Ionizing Radiations, the fifth paper by Dr Howarth, is topical wherein nuclear energy is treated from the angle of detection and measurement.

This book produced by the Pergamon Press is beautiful in design and the format is expensive (cost, nearly Rs 50.00 in Indian money); it is worth purchasing by libraries as a reference book. One wishes that such detailed information can be made available much cheaper to Indian students working in relevant fields. A summary of each paper has been introduced in the beginning by the editors to provide a preliminary acquaintance of each essay published in the book. One has a pleasing satisfaction while studying this book as the information on each concerned topic is recent and complete.

C. V. NATARAJAN

MATHEMATICS FOR ENGINEERS: (Part II) by W. N. Rose (Chapman & Hall Ltd, London; *Distributors in India*: Asia Publishing House, Bomay), Fifth Revised Edition, 1958. Pp. xii + 403. Price 25*s*. net

The book covers the usual course for technical and engineering students in calculus along with a few formulae in spherical trigonometry and mathematical probability. It contains a large number of illustrative examples and each concept is introduced by giving a number of examples from elementary mechanics and geometry.

The first ten chapters deal with calculus. There is a chapter on harmonic analysis, one on spherical trigonometry with reference to the solution of triangles and the method of least squares.

Rigour is of course a luxury in an introductory course for engineers. But it is important to take care that nothing is required to be accepted without explanation. Such shortcomings are found here and there in the book. For example, the choice of the sign of the square root in the differentiation of inverse trigonometric functions and the expression for the total differential of a function of two variables appear without any explanation. Even though it is noted that the process of integration is just the converse of differentiation, no proof is given to show how the rules of integration follow from those of differentiation. When speaking of even and odd functions in dealing with Fourier series, a graphical elucidation of how a function such as x is defined as an even function and x^2 as an odd one, is necessary. If such points are not clearly and precisely explained, the student starts looking at mathematics as a mystery rather than as a science. The introduction of differential equations as a natural expression of the laws of mechanics and of the properties in geometry would be more in keeping with the spirit of the book.

The printing of the book does not facilitate easy and smooth reading.

B. R. SETH

ACCELERATORS OF IONS AND ELECTRONS by Cestmir Simane: English translation from the Czech edition by C. Mayor & A. G. Evans (Constable & Co. Ltd, London), 1958. Pp. 191. Price 16*s*. net

Particle accelerators are important tools in nuclear research. The study of the internal structure of nuclei requires their penetration by external particles, whereby their stable state is disturbed. The introduction of the additional particle having kinetic energy produces interference inside the nucleus. The various manifestations that come up with this interference may be utilized for inferring the stable state structure. The impinging particle may be a proton, a deuteron, an alpha-particle or any heavier nuclear particle. It may also be a neutron, an electron, or even a photon. These particles with kinetic energy may be found in emissions from naturally occurring radioactive substances and in cosmic radiation. But the artificial acceleration of ions can only supply these particles with sufficient kinetic energy in sufficient quantities.

The book gives the principle of action and constructional details of almost all the different types of accelerators that are in use. It also describes the principles and operations of the various auxiliary equipment that are used with the accelerators.

The book opens with a brief survey of the scope of the ion and electron accelerators in research and medicine, and a short description of the construction materials for the vacuum systems employed in the accelerators. It is then divided into two major parts dealing separately with linear and circular accelerators. The principles and the constructional details of these accelerators are described at sufficient length. A very useful appendix is provided giving the basic calculations met with in the design of the accelerators.

The book is intended for designers of ion and electron accelerators as well as research workers in the field. It will also be helpful as a text-book for postgraduate students in nuclear physics.

ARUN K. SAHA

Recent Publications

Mathematics and related subjects

ASTRONOMY by R. H. Baker (D. Van Nostrand Co. Ltd, London), Seventh Edition, 1959. Pp. viii + 547. Price 52*s*. 6*d*.

APPLICATIONS OF THE THEORY OF MATRICES by F. R. Gantmakher. Translated from the Russian & revised by J. L. Brenner (Interscience Publishers Inc., New York), 1959. Pp. *c*. 325. Price *c*. $ 9.50

THE ALGEBRA OF ELECTRONICS by C. H. Page (D. Van Nostrand Co. Ltd, London), 1959. Pp. 268. Price 66*s*.

Physics

HEAT TRANSMISSION by William H. McAdams — Asian Students' Edition (McGraw-Hill Book Co. Inc., New York), 1959. Pp. 517. Price $ 2.39

INTRODUCTION TO THE THEORY OF QUANTIZED FIELDS (Revised & Enlarged) by N. N. Bogoliubov & D. F. Shirkov. Translated from the Russian by G. M. Volkoff (Interscience Publishers Inc., New York), 1959. Pp. *c*. 740. Price *c*. $ 15.00

CRYSTAL STRUCTURES — Supplement IV by Ralph W. G. Wyckoff (Interscience Publishers Inc., New York), 1959. Pp. *c*. 790. Price *c*. $ 21.00

THE CLASSICAL THEORY OF FIELDS by L. Landau & E. Lifshitz. Translated by M. Hamermesh (Pergamon Press Ltd, London), Second Edition, 1959. Pp. 354. Price *c*. 70*s*. net

PRINCIPLES OF OPTICS — ELECTROMAGNETIC THEORY OF PROPAGATION, INTERFERENCE AND DIFFRACTION OF LIGHT by MaxBorn & Emil Wolf (Pergamon Press Ltd, London), 1959. Pp. *c*. 900. Price *c*. £ 5 10*s*. ($ 15.00)

THERMAL REACTOR THEORY by A. D. Galanin. Translated from the Russian by J. B. Sykes (Pergamon Press Ltd, London), Second Edition, 1959. Pp. 300. Price £ 4 ($ 15.00)

TOPICS IN ELECTROMAGNETIC THEORY by Dean Watkins (John Wiley & Sons Inc., New York; *Distributors in India*: Asia Publishing House, Bombay), 1959. Pp. 118. Price $ 6.50

MATHEMATICAL ASPECTS OF SUBSONIC AND TRANSONIC GAS DYNAMICS by Lipman Bers (John Wiley & Sons Inc., New York; *Distributors in India*: Asia Publishing House, Bombay), 1959. Price $ 7.75

TECHNICAL ASPECTS OF RADIOACTIVITY by Broda & Schonfeld (D. Van Nostrand Co. Ltd, London), 1959

INTRODUCTION TO NEUTRON PHYSICS by L. F. Curtiss — V. N. Nuclear Science Series (D. Van Nostrand Co. Ltd, London), 1959. Pp. xi + 380. Price 73*s*.

THE METHOD OF ISOTOPIC TRACERS APPLIED TO THE STUDY OF ACTIVE ION TRANSPORT by J. Coursaget (Pergamon Press Ltd, London), 1959. Pp. *c*. 160. Price *c*. 60*s*. or 3000 French Fr.

Engineering

TELEVISION RECEIVER SERVICING by M. S. Kiver (D. Van Nostrand Co. Ltd, London), Fourth Edition, 1959. Pp. vi + 312. Price 36*s*.

INTRODUCTION TO NUCLEAR ENGINEERING by Richard Stephenson — Asian Students' Edition (McGraw-Hill Book Co. Inc., New York), 1959. Pp. 387. Price $ 1.89

INTRODUCTION TO CHEMICAL ENGINEERING by Walter L. Badger & Julius T. Banchero — Asian Students' Edition (McGraw-Hill Book Co. Inc., New York), 1959. Pp. 739. Price $ 3.06

SYMPOSIUM ON ELECTRONIC WAVEGUIDES, NEW YORK, APRIL 8-10, 1958, edited by Jerome Fox (Symposia Series: Microwave Research Institute Proceedings: Vol. 8) (Interscience Publishers Inc., New York), 1959. Pp. 439. Price $ 5.00

UNIT OPERATIONS by George Granger Brown *et al.* (Asia Publishing House, Bombay), 1959. Price Rs 22.00

COMBUSTION & PROPULSION: NOISE-SHOCK TUBES — MAGNETIC EFFECTS — INSTABILITY & MIXING by J. Fabri *et al.* (Pergamon Press Ltd, London), 1959. Pp. 614. Price *c*. £ 7 or $ 20.00

AUTOMATION IN THE MANUFACTURING PROCESS by George F. Hawley (Reinhold Publishing Corporation, New York), 1959

APPLIED MECHANICS — the Proceedings of the Third U.S. National Congress, 1958 (Pergamon Press Ltd, London), 1959. Pp. 904. Price *c*. £ 7 or $ 20.00

MATERIALS FOR NUCLEAR REACTORS by Bernard Kopelman (McGraw-Hill Book Co. Inc., New York), 1959. Pp. 411. Price $ 12.00 or 93*s*.

HANDBOOK OF NATURAL GAS ENGINEERING by Donald L. Katz — McGraw-Hill Chemical Engineering Series (McGraw-Hill Book Co. Inc., New York), 1959. Pp. 802. Price $ 37.50 or £ 14 11*s*.

HANDBOOK OF INDUSTRIAL LOSS PREVENTION by Factory Mutual Engineering Division (McGraw-Hill Book Co. Inc., New York), 1959. Pp. 864. Price $ 20.00 or £ 7 15*s*.

FUNDAMENTALS OF DIGITAL COMPUTORS by Mathew Mandl (Prentice-Hall Inc., New Jersey; *Distributors in India*: Asia Publishing House, Bombay), 1959. Pp. 297. Price $ 7.65

THE INDUSTRIAL COOLING TOWER by K. K. Mckelvey & Maxey Brooke (D. Van Nostrand Co. Ltd, London), 1959. Pp. 448. Price 90*s*.

Chemistry

CHROMATOGRAPHIC REVIEWS: Vol. 1, edited by M. Lederer (D. Van Nostrand Co. Ltd, London), 1959. Pp. ix + 276. Price 45*s*.

NON-BENZENOID AROMATIC COMPOUNDS, edited by David Ginsburg (Interscience Publishers Inc., New York), 1959. Pp. *c*. 450. Price *c*. $ 12.50

TREATISE ON ANALYTICAL CHEMISTRY: Part I, Vol. I, edited by I. M. Kolthoff (Interscience Publishers Inc., New York), 1959. Pp. 750. Price *c.* $ 16.00

THE HIGHER TERPENOIDS by P. De Mayo (Interscience Publishers Inc., New York), 1959. Pp. 248. Price $ 6.00

MONO- AND SESQUITERPENOIDS by P. De Mayo (Interscience Publishers Inc., New York), 1959. Pp. 328. Price $ 7.50

SIX-MEMBERED HETEROCYCLIC NITROGEN COMPOUNDS WITH THREE CONDENSED RINGS by C. F. H. Allen *et al.* (Interscience Publishers Inc., New York), 1959. Pp. 646. Price *c.* $ 22.00

BORON FLUORIDE AND ITS COMPOUNDS AS CATALYSTS IN ORGANIC CHEMISTRY by A. V. Topchiev, S. V. Zavgorodnii & Ya. M. Paushkin. Translated by J. T. Greaves (Pergamon Press Ltd, London), 1959. Pp. 450. Price *c.* 80*s.* or $ 12.00

CATALYSIS: Vol. 7, edited by Paul H. Emmett (Reinhold Publishing Corporation, New York), 1959

FATTY ACIDS, edited by E. Scott Pattison (Reinhold Publishing Corporation, New York), 1959

COMPREHENSIVE ANALYTICAL CHEMISTRY, edited by Cecil L. Wilson — in Five Volumes (Elsevier Publishing Co., London; *Distributors*: D. Van Nostrand Co. Ltd, London), 1959. Pp. 5000

EDTA TITRATIONS — AN INTRODUCTION TO THE THEORY AND PRACTICE by H. Flaschka (Pergamon Press Ltd, London), 1959. Pp. 140. Price 42*s.* or $ 6.50

THE QUANTITATIVE ANALYSIS OF DRUGS by D. C. Garratt (Chapman & Hall Ltd, London; *Distributors in India*: Asia Publishing House, Bombay), 1959. Price 75*s.* net

AN INTRODUCTION TO THE CHEMISTRY OF FATS AND FATTY ACIDS by F. D. Gunstone (Chapman & Hall Ltd, London; *Distributors in India*: Asia Publishing House, Bombay), 1958. Pp. x + 161. Price 32*s.*

THE STRUCTURE & PROPERTIES OF POROUS MATERIALS: Vol. 10 of the Colston Papers — Proceedings of the Tenth Symposium of the Colston Research Society held in the University of Bristol, 24-27 March 1958. Edited by D. H. Everett & F. S. Stone (Butterworths Publications Ltd, London), 1958. Pp. 397. Price 60*s.*

THE CHEMISTRY OF THE ACTINIDE ELEMENTS by Joseph J. Katz & Glenn T. Seaborg (John Wiley & Sons Inc., New York; *Distributors in India*: Asia Publishing House, Bombay), 1958. Pp. 508. Price $ 14.00

ADVANCES IN INORGANIC CHEMISTRY AND RADIOCHEMISTRY: Vol. I, edited by H. J. Emeleus & Alan G. Sharpe (Academic Press Inc., New York), 1959. Pp. *c.* 560. Price *c.* $ 15.00

INORGANIC CHEMISTRY by Therald Moeller (Asia Publishing House, Bombay), 1959. Pp. 966. Price Rs 25.00

ORGANIC CHEMISTRY by Fieser & Fieser (Asia Publishing House, Bombay), Third Edition, 1959. Pp. 1118. Price Rs 27.50

PHYSICAL CHEMISTRY by Farrington Daniels & Robert A. Alberty (Asia Publishing House, Bombay), 1959. Pp. 671. Price Rs 16.50

Technology

THE CHEMICAL PROCESS INDUSTRIES by R. Norris Shreve — Asian Students' Edition (McGraw-Hill Book Co. Inc., New York), 1959. Pp. 1000. Price Rs 20.00

CHEMICAL ANALYSIS OF RESIN BASED COATING MATERIALS, edited by C. P. A. Kappelmeier (Interscience Publishers Inc., New York), 1959. Pp. *c.* 400. Price *c.* $ 11.00

LINEAR AND STEREOSPECIFIC ADDITION POLYMERS: POLYMERIZATION WITH CONTROLLED PROPAGATION by N. G. Gaylord (Interscience Publishers Inc., New York), 1959. Pp. *c.* 520. Price *c.* $ 15.00

PROCESSING OF THERMOPLASTIC MATERIALS, edited by Ernest C. Bernhardt (Reinhold Publishing Corporation, New York), 1959. Pp. 720. Price $ 18.00

WELDING OF PLASTICS by J. A. Neumann & F. J. Bockhoff (Reinhold Publishing Corporation, New York), 1959. Pp. 288. Price $ 7.25

SILICONES by Rober N. Meals & Frederick M. Lewis (Reinhold Publishing Corporation, New York), 1959. Pp. 304. Price $ 5.95

EPOXY RESINS by Irving Skeist (Reinhold Publishing Corporation, New York), 1958. Pp. 308. Price $ 5.50

FILLER METALS FOR JOINING by Orville T. Barnett (Reinhold Publishing Corporation, New York), 1959. Pp. 252. Price $ 7.00

MATERIALS AND TECHNIQUES FOR ELECTRON TUBES by Walter H. Kohl (Reinhold Publishing Corporation, New York), 1959

SOURCE BOOK OF INDUSTRIAL SOLVENTS: Vol. III — MONOHYDRIC ALCOHOLS by Ibert Mellan (Reinhold Publishing Corporation, New York), 1959

HOT ORGANIC COATINGS by Raymond B. Seymour (Reinhold Publishing Corporation, New York), 1959

CONFERENCE ON EXTREMELY HIGH TEMPERATURES, edited by Hienz Fischer & Lawrence C. Mansur (John Wiley & Sons Inc., New York; *Distributors in India*: Asia Publishing House, Bombay), 1958. Pp. 258. Price $ 9.75

SYNTHETIC ION-EXCHANGERS by G. H. Osborn (Chapman & Hall Ltd, London; *Distributors in India*: Asia Publishing House, Bombay), 1959. Price 30*s.* net

FUNDAMENTAL ASPECTS OF REACTOR SHIELDING by Herbert Goldstein (Pergamon Press Ltd, London), 1959. Pp. 300. Price *c.* 66*s.* 6*d.*

MATHEMATICAL METHODS OF OPERATION RESEARCH by Thomas Saaty (McGraw-Hill Book Co. Inc., New York), 1959. Pp. 411. Price $ 10.00 or 77*s.* 6*d.*

URANIUM PRODUCTION TECHNOLOGY by C. D. Harrington & A. E. Ruehle (D. Van Nostrand Co. Ltd, London), 1959. Price *c.* 131*s.* 6*d.*

PRINCIPLES OF SUGAR TECHNOLOGY: Vol. 2 — CRYSTALLIZATION, edited by P. Honig (D. Van Nostrand Co. Ltd, London), 1959. Pp. 584. Price 95*s.*

SEMICONDUCTORS, edited by Norman B. Hannay (Reinhold Publishing Corporation, New York), 1959

Biology

ADVANCES IN PEST CONTROL RESEARCH: Vol. 2, edited by R. L. Metcalf (Interscience Publishers Inc., New York), 1959. Pp. 434. Price $ 12.50

BACTERIOPHAGES by Mark H. Adams *et al.* (Interscience Publishers Inc., New York), 1959. Pp. 610. Price $ 15.00

ELECTRONIC APPARATUS FOR BIOLOGICAL RESEARCH by P. E. K. Donaldson (Butterworths Scientific Publications, London), 1959. Pp. 730. Price 120*s*.

PHYSIOLOGY OF FUNGI by Vincent Cochrane (John Wiley & Sons Inc., New York; *Distributors in India*: Asia Publishing House, Bombay), 1959. Pp. 524. Price $ 9.75

QUANTITATIVE METHODS IN HUMAN PHARMACOLOGY AND THERAPEUTICS—The Proceedings of a London Symposium, 1958 — by D. R. Laurence (Pergamon Press Ltd, London), 1959. Pp. 272. Price *c.* 45*s*. or $ 7.50

Biochemistry

PROTIDES OF THE BIOLOGICAL FLUIDS: 6th Colloquium 1958 — by H. Peeters (D. Van Nostrand Co. Ltd, London), 1959. Pp. ix + 330. Price 45*s*.

ANTIBIOTICS ANNUAL 1958-1959 — Proceedings of the Sixth Annual Symposium on Antibiotics held on 15-17 October 1958, Washington, edited by Henry Welch & Felix Marti-Ibanez (Interscience Publishers Inc., New York), 1959. Pp. *c.* 1200. Price *c.* $ 12.00

COMPLETE PROCEEDINGS OF THE IVTH INTERNATIONAL CONGRESS OF BIOCHEMISTRY, VIENNA, 1958, edited by O. Hoffmann-Ostenhof (Pergamon Press Ltd, London), 1959. To be published in 15 volumes

THE COMPARATIVE BIOCHEMISTRY OF THE CAROTENOIDS by T. W. Goodwin (Chapman & Hall Ltd, London; *Distributors in India*: Asia Publishing House, Bombay), 1959. Price 56*s*. net

CHEMICAL TRANSFORMATIONS BY MICROORGANISMS by Frank Stodola (John Wiley & Sons Inc., New York; *Distributors in India*: Asia Publishing House, Bombay), 1959. Pp. 134. Price $ 4.25

ANTIBIOTICS: THEIR CHEMISTRY AND NON-MEDICAL USES by H. S. Goldberg (D. Van Nostrand Co. Ltd, London), 1959. Price *c.* £ 11

Miscellaneous

PLANETARY AND SPACE SCIENCE (An International Bimonthly Journal), edited by Milton Greenberg *et al.* (Pergamon Press Ltd, London), 1959. Pp. *c.* 350. Price per volume £ 7 or $ 20.00

THE DESIGN OF PHYSICS RESEARCH LABORATORIES — A Symposium held by the Institute of Physics, 1959 (Reinhold Publishing Corporation, New York), 1959. Price $ 4.50

DISINFECTANTS: THEIR VALUES AND USES by W. E. Finch (Chapman & Hall Ltd, London; *Distributors in India*: Asia Publishing House, Bombay), 1959. Price 30*s*. net

FLAVOUR RESEARCH & FOOD ACCEPTANCE, edited by the staff of Arthur D. Little Inc. (Reinhold Publishing Corporation, New York), 1959. Pp. 400. Price 80*s*.

BRIEFING AND CONFERENCE TECHNIQUES by Glenn M. Loney — McGraw-Hill Series in Speech (McGraw-Hill Book Co. Inc., New York), 1959. Pp. 194. Price $ 3.95 or 31*s*.

ROCKETRY AND SPACE EXPLORATION — THE INTERNATIONAL STORY — by A. G. Haley (D. Van Nostrand Co. Ltd, London), 1959. Pp. 350. Price 51*s*.

OVERVOLTAGE RESEARCH AND GEOPHYSICAL APPLICATIONS by James R. Wait (Pergamon Press Ltd, London), 1959. Pp. 120. Price *c.* 60*s*. or $ 9.00

PUBLICATIONS RECEIVED

THE TECHNICAL WRITER — An Aid to the Presentation and Production of Technical Literature by J. W. Godfrey & G. Parr (Chapman & Hall Ltd, London; *Distributors in India:* Asia Publishing House, Bombay), 1959. Pp. 340. Price 45*s*. net

BIOCHEMICAL ENGINEERING (UNIT PROCESSES IN FERMENTATION), edited by R. Steel (Heywood & Co. Ltd, London), 1958. Pp. 328. Price 50*s*.

PRINCIPLES OF MODERN PHYSICS by Robert B. Leighton (McGraw-Hill Book Co. Inc., New York, Toronto, London), 1959. Pp. xii + 795. Price $ 12.50

PLASTIC ANALYSIS OF STRUCTURES by Philip G. Hodge, Jr — McGraw Hill Series in Engineering Sciences (McGraw-Hill Book Co. Inc., New York, Toronto, London), 1959. Pp. xiv + 364. Price $ 10.50

INTRODUCTION TO METEOROLOGY by Sverre Petterssen (McGraw-Hill Book Co. Inc., New York, Toronto, London), Second Edition, 1958. Pp. ix + 327. Price $ 6.75

INTRODUCTION TO NEUTRON PHYSICS by L. F. Curtiss — Van Nostrand Nuclear Science Series (D. Van Nostrand Co. Inc., New York, Toronto, London), 1959. Pp. xi + 380. Price 73*s*.

TUBE & SEMICONDUCTOR SELECTION GUIDE, 1958-59, compiled by Th. J. Kroes (N. V. Philips Gloeilampenfabrieken, Eindhoven), Second Revised Edition, 1958. Pp. 158. Price Rs 5.00

PROTEINS IN FOODS — I.C.M.R. Special Report Series No. 33 — by S. Kuppuswamy, M. Srinivasan & V. Subrahmanyan (Indian Council of Medical Research, New Delhi), 1958. Pp. vi + 290. Price Rs 12.00

NUCLEAR REACTOR PHYSICS by Raymond L. Murray (Macmillan & Co. Ltd, London), 1959. Pp. xi + 317. Price 30*s*. net

RADIOISOTOPES IN THE SERVICE OF MAN by Fernand Lot (Unesco, Paris), 1959. Pp. 84. Price $ 1.00 or 5/- (stg.) or 300 Fr.

NOTES & NEWS

Future standard of time

DR L. ESSEN, SENIOR PRINCIPAL Scientific Officer, National Physical Laboratory, Teddington, has been named for the Wolfe Award for his outstanding work on the establishment of an atomic frequency standard as a basis for the future standard of time.

The caesium frequency standard developed at the National Physical Laboratory, Teddington, has given valuable information on the performance of quartz clocks, the propagation of radio signals, the periodic and irregular variations of the rate of rotation of the earth, and the value of the present international standard of time in terms of a particular frequency of the caesium atom. The unit of time provided by the present atomic frequency standard can be determined in a few minutes to an accuracy of 2 parts in 10,000 millions, which is ten times better than that recently announced from measurements, extending over three years, of the astronomical unit based on the period of the earth's revolution round the sun. The standard has, in effect, been the time standard of the world for the past three years.

The comparison of different caesium standards carried out in 1958, both directly and by radio transmissions, has established that the standard is adequate to meet the demands of improved aerial navigational systems and also that times and frequencies can be compared over very long distances with the accuracies required by these systems [*Press Release, dated* 18 *March* 1959, *of the Department of Scientific & Industrial Research, London*].

Ion rocket engine

THE FEASIBILITY OF AN ION rocket, powered by a nuclear reactor for interplanetary travel, has been put forward by the scientists of the Radiation Laboratory, University of California, at the American Nuclear Society meeting in Detroit. The ions could, however, only give a thrust of about thousandth of a '*g*' which is far less to enable the rocket to climb through the earth's atmosphere and so the rocket would have to start its interplanetary trip from an orbit far above the planet's surface. Still such milli-'*g*' systems could be successfully used. If a frictionless railroad could be constructed on a great circle of a planet with no atmosphere, a milli-'*g*' rocket mounted on a car on that path could, in due course, build up the velocity to surface satellite velocity. From that time onwards an ever-increasing adiabatic expansion of the orbit would occur. Thus the rocket could go any distance provided energy is supplied. Major technical problems to be solved before such an engine can be translated into actual practice are the development of materials that can withstand high thermal stresses (temperature of over 3600°F.) and the attainment of high heat fluxes. An answer to these problems may be found by the work being done on the Los Alamos Kiwi-A reactor.

The method of working of the engine to create the ions and harness them for propulsion work can be understood from the following: It will employ a chemical propellant whose molecules offer the highest possible weight. Among 'ideal' propellants are uranium tetrachloride, thorium, mercury and the alkali metals, cesium and rubidium. Vaporized, the propellant will be fed into an electrically charged chamber, where an electric arc or a metallic plate generating 100 times the heat of a large electric stove will knock loose an electron from each molecule of vaporized propellant thus ionizing it. The newly created ions will be pulled out of the ionizing chamber by the attraction of an electrostatic field and then jolted by 12,000 V. to effective velocities of 300-400 thousand miles an hour. The current of speeding ions will be harnessed for propulsion by being directed through a cylindrical thrust chamber *c.* 2 ft long and 9 in. diameter. Propulsive force comes from the vehicle's reaction to the escape of ions from the chamber.

Electrons left over from the ionization process will also be directed through a thrust chamber to add a tiny increment of additional thrust [*J. Franklin Inst.*, **267** (1959), 166; and *Sci. Newslett. Wash.*, **75** (1959), 38].

Solar turbine

THE DEVELOPMENT OF THE CONcept of a magnetic engine, originally visualized by A. Presnyakov, a Russian scientist, has led to the practical achievement of a device known as the 'solar turbine', which avoids the chief intermediate process — steam raising — in the conventional method of converting thermal energy into mechanical energy. The solar turbine is a highly economic proposition since it requires no other kinds of energy except the heat of the sun to run the turbine. Presnyakov's 'magnetic engine' produces mechanical energy by the repulsion of the like poles of two permanent magnets. The efficiency of such an engine not being high, attempts have been made to develop a magnetic-thermal engine which produces mechanical energy as a result of the action of the fields of the permanent magnets and the solar heat.

The solar turbine is simple in design. The rotor is made of special alloy capable of easily losing its magnetic property when heated. Each blade, drawing to the magnet, is heated by solar rays, loses its magnetism and shoots past without any delay, thus producing continuous rotation of the rotor. The limitation is the amount of power that can be harnessed but recent advances in physical sciences have made it possible to design and fabricate permanent magnets whose force of attraction exceeds by tens of times their weight. Such magnets do not also demagnetize for many years. The use of such magnets in this type of engines promises a bright prospect for the increasing use and progressive enhancement of power potential obtainable from them. Usual mirror reflectors can be used for concentrating solar energy [*News & Views from the Soviet Union*, **18** (No. 85) (1959), 8].

Synthetic quartz crystals

THE WESTERN ELECTRIC CO. AND the Bell Telephone Laboratories, New York, have jointly succeeded in growing large (up to 5-6 in. long and 2-3 in. cross-section) crystals of artificial quartz by a new method. In this method, a vertical autoclave is filled with an alkaline solution, usually of sodium hydroxide. Small pieces of natural quartz placed at the bottom serve as the material (it is expected that in future, high quality sand may be used in place of natural quartz). Seed plates cut from natural or artificial quartz crystals are hung from a rack in the upper part of the vessel. After sealing, the autoclave is heated to the required temperature and maintained, during the processing time extending from one to several weeks, with a constant temperature differential from bottom to top. Flat plates are used and growth occurs primarily in one dimension, the thickness. The nutrient material dissolves in the hotter lower region and is carried by convection currents to the cooler upper region, where the solution becomes supersaturated and the dissolved silica is deposited in the form of a single crystal. The crystals produced are free from foreign inclusions, can be obtained without optical or electrical twinning and can be sawn in the most efficient manner [*Nature, Lond.*, **183** (1959), 294].

Foamed metals

A PROCESS FOR PRODUCING FOAMS of nickel, copper and cast iron has been developed by the General Electric Co., U.S.A. The method used is similar to that used for making thermosetting foamed plastics. An organic resin is mixed with a standard foaming agent that releases nitrogen or carbon dioxide. Metallic powder is added and the mixture is baked in an oven. Heat releases the gas, which foams the metal to a point that depends on predetermined amounts of materials. Density can also be controlled by the amounts of materials used. The foams can be moulded during the baking stage into almost any shape desired and conventional tools can be used to machine them.

Foamed metal has potential applications for labyrinth seals and high temperature filters. The high surface area and cell construction of foamed metal would enable it to be used for cooling and insulating. Large electrical installations can use foamed copper since this material has been found to have the same capacity for electrical conductivity per unit weight as solid copper. The natural cooling action of foamed copper, plus small amounts of cooling air appear to increase the capacity of foamed copper to carry electricity [*Chem. Age*, **81** (1959), 408].

New radiation-resistant glasses

THE CHANCE-PILKINGTON OPTICAL Works, U.K., has developed radiation-absorbing glasses of larger dimensions than have been available hitherto. At extremely short wavelengths, the attenuation offered by protective walling is proportional to the density of the material employed. The newly developed Pilkington glasses range in density from 2·5 to 6·1 g./ml. and allow the design of windows, in many cases, of thickness equal to that of the surrounding wall, thus reducing the complexity of additive shielding and secure maximum optical advantage from the window in cases of remote control operations. In these glasses, the tendency for discolouration after exposure to large doses of radiation is stabilized by suitably amending the compositions, which have the effect of only slightly decreasing the transmission in the unirradiated state. Shielding glasses of density 2·5 or 4·3 g./ml. are manufactured in polished plate or in block form up to $4\frac{1}{2}$ by 3 ft. in area and 10 in. in thickness (weighing up to 2000 lb.) [*Nature, Lond.*, **183** (1959), 292].

Ultrasonic brazing

A NEW EQUIPMENT FOR FLUXLESS brazing of aluminium and other materials with melting temperatures below 1250°F. has been developed by the Aeroprojects Incorporated, West Chester, Pa. Known as Sonobraze equipment, it is particularly suitable for applications where flux joining is difficult or undesirable, and when corrosion is to be avoided. Both gas-fired and electrically heated types of the equipment are available in several models — hand, floor and large industrial type. The units are easily operated and are designed to operate on 115 or 230 V., 60 c/s. a.c. and are made in different sizes requiring power outputs ranging from 25 to 2000 r.f. watts.

In the Sonobraze process, the generator supplies high-frequency current to a brazing head which converts the current to acoustical energy in the range of 15,000 to 60,000 c/s. and then transmits this energy to the brazing tip. This tip removes the oxide coating on the material to be brazed and also helps the material to alloy with the base metal. Brazing heads utilize transducer couplings which are cooled either by air or by water (or by both, in special cases).

Although the process is particularly useful to join two insulated aluminium (or copper) wires without removal of the insulation, it is equally effective on aluminium sheet, sand and die castings, extrusions, tubing and busbars. The units require from 1 to 10 sec. for the brazing process [*J. Franklin Inst.*, **267** (1959), 183].

Thermocompression bonding

RECENT DEVELOPMENTS IN THERmocompression bonding have made it possible to form large area contacts between metallic leads and semiconductor devices. The new technique enables greater reliability of finished semiconductor devices to be achieved. It is also now possible to attach leads to opposite sides of a semiconductor wafer simultaneously, thus making both base and emitter contacts at once.

In thermocompression bonding, soldering and alloying techniques are eliminated along with undesirable low melting materials and fluxes. In this process a soft metal lead is pressed against the gold-plated surface of a semiconductor, and moderate heat is applied. Adhesion generally takes place in a few seconds. Pressures in the range 12,000-20,000 p.s.i. are normally used; temperatures required are in the range 300-325°C. These temperatures are well below the melting points of either the lead or the semiconductor, and the pressures are below the deformation point of the semiconductor.

For large area contacts, gold or silver leads from 6 to 15 mils in diameter are 'headed' like nails.

Heads are commonly 30 mils in diameter. These headed leads are fitted into a hollow jig in a ram, and pressed against the surface of the heated semiconductor. Wires with flattened ends can also be used in this manner, when the diameter of the lead is too small to make heading practical.

Thermocompression bonding is being used to attach leads to diffused silicon diodes at the Bell Telephone Laboratories, New York. The 30 mils contact head covers almost the entire active area of the mesa-type diode. This configuration allows the passage of a high forward current.

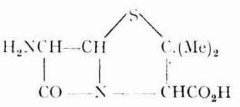
The method allows the use of higher bake-out temperatures, and is an inherently cleaner procedure than present methods of attachment in the commercial preparation of diodes and transistors [*J. Franklin Inst.*, **266** (1959), 97].

6-Amino-penicillanic acid

THE ISOLATION OF THE 'CORE' OF penicillin — 6-amino-penicillanic acid — reported, opens the way to 'tailor-make' any number of new penicillins by chemical means. Also, with suitable substituents on the basic radical of 6-amino-penicillanic acid, there is every possibility that effective penicillins can be produced which will not lead to untoward reactions in penicillin-sensitive persons. Of even greater importance is the hope now offered of overcoming the problem of micro-organisms that become resistant to the action of penicillin.

The presence of 6-amino-penicillanic acid was first indicated when a fermentation liquor (the culture used was an isolate from *P. chrysogenum* W. 5120), after removal of natural penicillins by solvent extraction at low *p*H, was treated with an excess of phenyl acetyl chloride in the presence of a weak base such as sodium bicarbonate. This resulted in the formation of a benzyl penicillin-like substance on paper chromatogram. Reaction with phenoxyacetyl chloride resulted in the formation of an antibiotic resembling penicillin V in its stability in acid solution as well as its behaviour on paper chromatograms. The unknown substance was identified as 6-aminopenicillanic acid, m.p. 208-9°C.

6-Amino-penicillanic acid itself has been found to possess definite antibacterial properties. It is destroyed, as is benzyl penicillin, by penicillinase but at a much slower rate. It is rapidly decomposed by strong alkali but is relatively stable to acids. The compound has been found to be surprisingly strong acid, the isoelectric point being about 4·3.



I

In support of structure (I) for 6-amino-penicillanic acid is the evidence obtained by treating the substance with ethyl chloroformate to give a crude N-carbethoxy derivative which has been degraded to N-carbethoxy-aminoacetaldehyde-2:4-dinitrophenylhydrazone [*Chem. Age*, **81** (1959), 453].

Mode of action of biotin

AN EXAMINATION OF THE MOLECular structure of biotin, as determined by X-ray crystallographic analysis, has indicated that biotin may be capable of forming an intramolecular hydrogen bond in solution between oxygen of the carbonyl and one of the carboxyl oxygen atoms. Supporting evidence for this type of hydrogen bonding in the biological function of the vitamin is provided by studies of the biotin-like properties of several chemical analogues of the vitamin. These studies have indicated a high degree of biological specificity for the structure of biotin, not only with regard to the steric configuration and the length of the aliphatic chain, but also with regard to the ureido ring system and the presence of an oxygen atom at the position of the carboxyl group. Further, none of the three stereoisomers of biotin, or molecules with different chain lengths, appear to be capable of forming an intramolecular hydrogen bond, the possibility of which depends critically on both the steric configuration and the chain length.

It is not quite clear how the formation of an intramolecular hydrogen bond would affect the chemical reactivity of the molecule. In aqueous solution, such a hydrogen bond will be presumably unstable, allowing the biotin molecule to alternate between two different states [*Science*, **129** (1959), 210].

New sedative and soporific drug

A NEW SEDATIVE DRUG, TRIMETHoxybenzoyl-glycinediethylamide (trimeglamide), which induces normal sleep in dogs and cats without preceding ataxia has been developed at the Riker Laboratories, California. The sleep induced is neither preceded nor followed by skeletal muscle movements. In man, oral doses of 500-1500 mg. causes sedation or drowsiness or both. The lack of hypnosis or anaesthesia and of undesirable side effects or artifacts is a distinct advantage of this drug.

In dogs and cats, the oral soporific dose of trimeglamide was 50 mg./kg.; this dose had a latency of 30-90 min. and a duration of 2-6 hr. When asleep, the animals could be aroused easily by sound or touch, and they would respond in a normal manner to external stimuli. If left alone, the animals would fall asleep again within a few minutes. There were no indications of skeletal muscle involvement, and no gross abnormalities were detected in neurological examinations. Adverse effects on blood pressure and heart rate were also absent. Rate and depth of respiration remained unchanged.

Larger doses (100 mg./kg.) only prolonged the soporific action in cats. In dogs, the soporific effects were also longer lasting and, in addition, some side effects appeared: emesis in about 10 per cent of the animals and some muscle twitching and occasional slight ataxia [*Science*, **128** (1958), 1570].

Electromagnetophoresis: a new method of separating cells

BIOPHYSICISTS AT THE UNIVERSITY of California have evolved an improved method for breaking down a mixture of different kinds of cells in suspension by electromagnetic means. With this technique, called electromagnetophoresis, red blood cells, plant spores and sea urchin eggs have been separated within *c.* 2 min. into three distinct layers.

Current centrifugation methods of separating cells and cell debris suspended in fluids are limited by the fact that the densities of these biological materials differ but little from each other and from the density of the suspension fluid. The effective electrical conductivities of cells vary widely, sometimes by two or three orders of magnitude. In the new method, an electromagnetic field is substituted for a gravitational or centrifugal field and the separation of particles is effected due to differences in electrical conductivity instead of density.

The cells are suspended in an electrically conducting fluid through which a current is passed. Simultaneously a magnetic field is maintained throughout the fluid at right angles to the current. The different types of cells then migrate at different speeds in the same or opposite directions and are thus separated [*Sci. Newslett. Wash.*, **75** (1959), 119].

Sterile culture of roots

A TECHNIQUE FOR PREPARING THE sterile culture of roots, which provides an easy method for control of cell nutrition, has been developed at the Johns Hopkins University, Maryland, U.S.A. An additional advantage offered by the technique is that it makes it possible to use clonal lines of tissue for cytological studies, since many lateral roots can be obtained from a single bean of *Vicia faba*, and these roots can be maintained in the culture.

The medium used is a modification of that developed by Bonner and Addicott. Each component of the medium is made up as a concentrated stock solution which can be kept refrigerated or frozen, and is diluted into the final volume of medium; each time fresh medium is prepared.

The vitamin solution is prepared by dissolving 10 mg. each of biotin, choline chloride, folic acid, nicotinamide, calcium pantothenate, pyridoxal hydrochloride, thiamin, B_{12} and riboflavin (1 mg.) in 100 ml. water. This solution is made alkaline with 1*N* sodium hydroxide until the vitamins are completely dissolved. The vitamin solution is kept frozen in small aliquots which are added to the medium after the latter has been autoclaved. The medium is placed in milk dilution bottles which can be fitted with a Cornwall syringe apparatus, and the bottles are sterilized at 20 lb. pressure at 121°F. for 20 min. Following sterilization, the medium can be stored under refrigeration until needed, at which time the sterile vitamin solution is added. Seeds of *Vicia faba* are chosen for their high percentage of germination and low frequency of spontaneous chromosomal aberrations. The seeds are sterilized by immersion for 30 min. in a saturated solution of calcium hypochlorite in which 3 g. of wetting agent (for example, ' Dreft ') per litre have been dissolved. Storage dishes containing pure silica sand (coarse grade, American graded sand) and distilled water are autoclaved, and the beans partially embedded in the sand. Vermiculite should be used in place of the sand if the beans are not to be grown deficient in metallic ions. The beans are allowed to grow at 20-5°C. for 7-10 days. The sand is kept moist, but with little or no excess water. When lateral roots appear to be at least 2 cm. in length they are ready for excision and transfer to culture plates.

A thin layer of ' Pyrex ' glass wool is placed in a 5 cm. petri dish and the plates are autoclaved. Filter paper or fine graded, pure silica sand can be used in place of the glass wool if deficiencies are not required. Sterile medium is dispensed into the petri dishes by a Cornwall syringe in amounts of 2-2·5 ml./plate. The medium used at the beginning of culturing contains gibberellic acid. The amount of medium used is enough to wet the glass wool, sand, or filter paper thoroughly. Tips of the lateral roots of *Vicia faba* are cut to a length of 0·5-1·0 cm., and 4-5 tips are placed in each petri dish. The roots are incubated at 20-5°C., and are kept moist, but not covered with the medium, as required during growth. Two days following root excision they are transferred to fresh medium in fresh dishes, the medium now lacking gibberellic acid. The latter is done since gibberellic acid tends to slow down growth following the initial elongation of the roots. The roots are kept moist as described, and transferred every 4-5 days to fresh medium. The standard Feulgen method is used for preparation of root tip smears [*Nature, Lond.*, **183** (1959), 412].

Estimation of magnesium

A NEW COLORIMETRIC REAGENT, magon [1-azo-2-hydroxy-3-(2:4-dimethylcarboxanilido)-naphthalene-1′-(2-hydroxybenzene)], has been successfully used for determining microgramme amounts of magnesium by direct titration in the presence of large amounts of calcium. The indicator forms a coloured complex with small amounts of magnesium but not with calcium. Magnesium in the complex is removed by titrating with EDTA, resulting in a sharp colour change of yellow red to blue-violet to blue. The blue end-point is slower than the blue-violet one but either colour change can be used. Magon, essentially insoluble in water, is soluble in ethanol and methanol. Therefore, the compound is dissolved in methanol and more methanol is added to the solution to be titrated, the concentration of methanol being in the range 30-80 per cent. For titration a *p*H range of 9·0-11·0 is necessary. Under the above conditions the titration can be used for determining the combined amounts of calcium and magnesium, since calcium is titrated before magnesium.

Metals such as copper and iron interfere by affecting the sharpness of the end-point. This difficulty is overcome by adding a small amount of solid potassium cyanide to the solution before adding the magon. A small amount of cyanide should be added to the solution since large amounts of potassium cyanide decrease the sensitivity of the colour change. Preliminary results show magon to be very sensitive for the determination of total hardness of water [*Nature, Lond.*, **183** (1959), 461].

Determination of halogens in polymers and oils

A RAPID, INEXPENSIVE TECHNIQUE for determining the chlorine and bromine contents of polymers, gas oils and heavy residual oils is described. The method gives reproducible results. A single unit of equipment can process three samples an hour.

The apparatus consists of two furnaces, one operating at about 950°F., its temperature depending on the nature of the sample, and the other kept at 1800°F. A

96 per cent silica glass tube allows the sample's combustion to be observed and, at the same time, enables the exact position of the sample boat to be checked. The boat with the sample is placed in the first section of the combustion tube and a push rod places it in the first furnace (950°F.). When burning is complete (5-10 min.) the boat is pushed to the second furnace (1800 F.) where it remains for about 10 min. Oxygen is passed through the chamber at the rate of 3 litres/min. to ensure that combustion products are completely swept away from the chamber. With light oils or other volatile materials, 96 per cent silica glass chips and a glass wool plug may be used in the second combustion chamber to provide a greater heating surface and minimize incomplete combustion. Halogens are washed from the other combustion products in a scrubber with an aqueous solution containing 2 per cent sodium hydroxide and 0·5 per cent hydrazine sulphate. Other scrubbing solutions are sodium arsenite and sodium disulphate. Washings are collected in a beaker and the halogens estimated by titration [*Chem. Age*, **81** (1959), 404].

Low-temperature production of ozone

A LABORATORY METHOD FOR THE efficient conversion of oxygen to ozone has resulted from studies of the low temperature reactions of atomic oxygen. The process, which gives nearly 100 per cent conversion under certain operating conditions, involves the electrical dissociation of oxygen in a microwave discharge near a surface cooled with liquid nitrogen. In this method, oxygen is passed through a high frequency electric discharge into a Pyrex U tube immersed in liquid nitrogen. The arrangement is such that a glow discharge occurs in the oxygen stream just above the liquid nitrogen level. Ozone, produced as the dissociation product in this discharge, condenses on contact with a liquid nitrogen cooled surface. The liquid ozone, which forms in a narrow band on the wall of the U tube a few millimeters below the glow discharge, drains slowly down the tube.

The conversion efficiency with this arrangement depends upon flow rates, maximum conversion being attained at 5·7 ml./min. and lower. At such low flow rates, all oxygen in the system is converted to ozone so that pumping becomes unnecessary [*Tech. News Bull. U.S. Bur. Stand.*, **43** (1959), 29].

Apparatus for production of monatomic hydrogen

A NEW APPARATUS HAS BEEN DEveloped at the U.S. National Bureau of Standards for preparing a stable form of monatomic hydrogen. The apparatus spatially resolves a beam of hydrogen atoms by means of an inhomogeneous magnetic field, into its two electron spin states and deposits the beam on a surface cooled to about 1°K. When spins of the hydrogen atoms are aligned recombination of hydrogen atoms may be delayed appreciably resulting in a more stable form of monatomic hydrogen.

Hydrogen atoms from a microwave discharge source squirt through a narrow slit (0·1 × 4 mm.) into a large chamber, pressure in the chamber being kept at 10^{-4} mm. Hg with a high speed diffusion pump. At this pressure, the mean free path of the hydrogen atoms is long enough so that the atoms can cross the chamber without undergoing collisions with the gaseous atmosphere and thus recombining.

This beam of atoms is then passed through more slits and chambers, and passes finally through an inhomogeneous magnetic field (10^4 to 10^5 gauss per cm.). This field splits the beam into its two components. In each component, all atoms have their spins aligned in the same direction. One or both of the beams then impinge on a metal surface kept at 1°K. Calorimetric methods determine the presence of these atoms by measuring the heat released when they recombine. The method has one disadvantage: Not too many atoms are obtained. The method is capable of being extended to produce stable forms of atoms of other elements [*Chem. Engng News*, **37** (No. 2) (1959), 38].

Purification of folic acid

A NEW METHOD FOR PRODUCING pure folic acid, developed at Cleveland's Western Reserve University School of Medicine, U.S.A., employs cellulose chromatography and filtration through charcoal. The cellulose column is prepared in the following manner. Whatman standard-grade cellulose powder (200 g.) is mixed with 0·1*M* phosphate buffer (*p*H 7) saturated with isoamyl alcohol. After the mixture has stood for half an hour, it is poured into a tube (7·5 × 55 cm.) plugged with cotton. Cellulose is packed to a height of 40 cm. by suction, covered with a circle of heavy filter paper (Eaton-Dikeman No. 627-030), and compressed with a plunger to a final height of 37 cm. The column is then washed with 500 ml. of buffer and placed in a dark room. The remaining operations are carried out under dim illumination.

Commercial folic acid (550 mg.) is suspended in 30 ml. of water, and sufficient normal sodium hydroxide is added to dissolve folic acid. The solution (*p*H 7) is introduced into the column, and sodium foliate is moved down from the top with three 2 ml. portions of the isoamyl-alcohol saturated buffer. The column is then eluted with buffer at the rate of about 75 ml./hr. The yellow foliate band, which is clearly visible, is collected between approximately 550 and 730 ml. of effluent. Since *p*-aminobenzoylglutamic acid is eluted just before folic acid, collection of the folic acid fraction should not be started until the effluent is distinctly yellow. If the folic acid band is so uneven that the folic acid fraction exceeds 200 ml., it probably will be contaminated with *p*-aminobenzoylglutamic acid.

Cellulose chromatography reduces the content of *p*-aminobenzoylglutamic acid (from 1 to 2 per cent in commercial folic acid) to less than 0·02 per cent. It also removes most, but not all, of the fluorescent material present in the folic acid. To remove the remaining traces of fluorescent material the folic acid is filtered through charcoal in specially made columns [*Science*, **129** (1959), 274].

New periodicals

THE CENTRAL PUBLIC HEALTH Engineering Research Institute (CPHERI), Nagpur, recently set up by the Council of Scientific & Industrial Research, New Delhi, has commenced the publication of a quarterly *Bulletin* from January

1959. The bulletin will contain technical articles and information not only on the current activities of the Institute, but also on the progress of public health engineering in its varied aspects. Books, periodicals and other technical literature of interest to public health will be noticed in the bulletin.

In the first number are presented, besides the features referred to, the proceedings of the symposium on 'Water Purification and Stream Pollution' held at New Delhi on 30 October 1958, under the joint auspices of the Institute and the Central Public Health Engineering Organization of the Government of India.

NML Technical Journal, is a new quarterly from the National Metallurgical Laboratory, Jamshedpur. The first number of the journal (Vol. 1, No. 1, February 1959) is exclusively devoted to the proceedings of the recent symposium on the 'Iron and Steel Industry in India" (organized by the NML during 4-7 February 1959). Besides giving the abstracts of all the thirty-seven papers presented, nine selected papers of the symposium are reproduced in full.

The publication of the *International Atomic Energy Agency Bulletin* (Vol. 1, No. 1, April 1959) by the International Atomic Energy Agency (IAEA), Vienna, will be widely welcomed by workers in the field of atomic energy. Intended presumably to record the work and activities of the Agency, this issue of the bulletin contains a good deal of useful information. The progress made in atomic energy projects in some of the member countries and the assistance rendered by the Agency are reviewed. New techniques in the use of radioisotopes in medicine discussed at the recent Vienna conference are described in an article. The purpose and scope of research contracts sponsored by the Agency are well brought out by two articles, one on biological effects of small radiation doses and the other on distribution of fission products in the biosphere. The bulletin also provides information on exchange and fellowship programmes of the Agency, training centres in atomic energy in Latin America, and a list of conferences, exhibitions and training courses relating to atomic energy.

Journal of Mines, Metals & Fuels — The *Indian Mining Journal*, which is running its seventh volume, is now being issued under the new title *Journal of Mines, Metals & Fuel*. In addition to the usual features — research and review articles of topical interest in the field of mining, metallurgy and fuel technology, notes and news — a new feature on machinery and techniques has been introduced which focusses attention on the recent developments in India and elsewhere pertaining to these subjects.

Russian-English Glossary of Optics and Spectroscopy

A 78-PAGE MODERN *Russian-English Optics and Spectroscopy Glossary* has been published by Interlanguage Dictionaries Publishing Corporation, New York. The glossary contains more than 4000 terms culled from several thousand pages of the most recent issues of pertinent Soviet journals, especially *Optics and Spectroscopy, Journal of Technical Physics, Journal of Experimental and Theoretical Physics* and the physics sections of *Doklady*. Many terms found in original Russian texts, and in English texts which have been translated into Russian, are also included. Glossary text is clearly reproduced by multilith process from 'cold' type and staple bound in durable paper covers: the glossary is priced $10.00.

New Division of ASTM on Materials Sciences

A NEW DIVISION OF MATERIALS Sciences will be organized by the American Society for Testing Materials (ASTM) to co-ordinate and intensify the development of knowledge of the fundamentals of materials. The new division, the first to be established by ASTM on the recommendation of its Planning Committee, will augment the scope of the Society's long-time objectives of promoting knowledge of engineering materials and tapping new sources of knowledge for the Society's extensive standardization activities. The division will concern itself with the collection, establishment and publication of basic information essential in creating a better understanding of materials and their properties. The division will also assist in co-ordination of the Society's 80 operating technical committees and promote team work.

The ASTM is in a unique position to provide a forum for materials scientists and engineers as its interests and long-time activities are primarily in the entire materials field. It is expected that members of this new ASTM division will include many now active in ASTM committee work, as well as other members of the Society; other leaders in science who are concerned with the basic problems involved will also be invited to participate.

Marine Biological Association of India

THE MARINE BIOLOGICAL SOCIETY of India, devoted to the furtherance of marine biology and related sciences, was formed in January 1959. The entrance fee for those becoming members of the Association during the first year of the inception of the Association is $0.50 or 3*s.* 6*d.*, and $1.0 or 7*s.* 6*d.* during subsequent years. The first number of the *Journal* of the Association is expected to be issued by June 1959. Annual subscription for the journal for members outside India is $2.50 or 17*s.* 6*d.*

Further enquiries may be addressed to the Secretary, Marine Biological Association of India, Marine Fisheries P.O., Ramnad District, South India.

I/EC — International Edition

BEGINNING FROM JULY 1959, THE American Chemical Society will start publishing an international edition of *Industrial and Engineering Chemistry*. The domestic and international editions of *Industrial and Engineering Chemistry* will continue to serve the same fields of design, development, research, plant operations and marketing and will be identical in contents. However, certain features of particular interest to foreign subscribers will be added to the international edition.

Announcements

▪ *The Symposium on Algology*, sponsored by the Unesco, in collaboration with the Indian Council

of Agricultural Research, will be held in New Delhi in early December 1959. A number of eminent foreign specialists from England, Germany, Japan, Afghanistan, Burma, Ceylon, India and Pakistan are expected to participate in the symposium.

▪ *The First All-India Congress of Zoology* (which was proposed to be held during 1958 but was postponed), sponsored by the Zoological Society of India, will be held at Jabalpur, Madhya Pradesh, from 24 to 29 October 1959. Further information regarding the Congress may be had from the General Secretary, Dr B. S. Chauhan, Zoological Survey of India, 34 Chittaranjan Avenue, Calcutta 12 (India).

▪ *Award of Doctorate Degrees* — The following have been awarded the Ph.D. degree of the Poona University for the respective theses noted in parentheses against their names: Shrimati Mandakini Vishvanath Natekar (*Alcoholysis of oils and fats*); and Shri Mohan Chandra Tewari (*Problems connected with the preservation of timber*).

The following have been awarded the Ph.D. degree of the Delhi University for the theses noted in parentheses against their names: Shri Govind Rai Chaudhry (*Chemical examination of some Indian medicinal plants and studies in the chemical constitution of their physiologically active constituents*); Shri S. Ramanujam (*Synthesis of some naturally occurring flavone and isoflavone derivatives*); Shri Rajindra Aneja (*Synthesis of benzofuran derivatives following a possible path of biogenesis*); and Shri B. Venkataramani (*Chemical components of certain vegetable dyes and tans: Synthesis of related compounds*).

INSTRUMENTS AND APPLIANCES

New infrared spectrometer

A VERSATILE INFRARED SPECTROmeter with extremely high resolution in the region 3-6 μ has been designed by the U.S. National Bureau of Standards. The instrument enables detailed studies of molecular spectra to be made, and yields data for calculating previously undetermined parameters such as bond distances and angles for large molecules, e.g. those found in fuels.

High resolution of the instrument is obtained by employing detectors and gratings in conjunction with two special optical systems for double passing the radiation to the grating. Total resolution obtained is 0·05 cm.$^{-1}$ and partial resolution is 0·025 cm.$^{-1}$ — three times that of the best available instruments. By means of a special arrangement of gears the spectrometer can be used either to scan a small rotational-vibrational band slowly, or larger regions quickly. Scanning is effected by rotating the grating at a variable rate ranging from 800 to 2·5 min. per degree of rotation. Narrow band scanning allows detection of the fine structure splitting of individual lines as well as rotational lines. Components of overlapping bands, e.g. those of atmospheric water vapour and ammonia, can be separated and thus more accurate classification of spectra is possible. Highest resolution, *c.* 320 cm.$^{-1}$ at 3·3 μ, is obtained at slow rotation speeds.

The instrument can be used as an emission as well as an absorption device. Using the instrument, the Bureau's scientists resolved the spectrum of carbon dioxide and detected l-type doubling using emission spectrometry (this doubling cannot be detected using absorption spectra) [*Chem. Engng News*, **37** (1) (1959), 68].

New manometer

A VERSATILE, LOW-PRICED MANOmeter, which can be simply and quickly set up for laboratory bench work, has been developed. The instrument is intended for measurement of pressure, differential pressures, and levels at system pressures up to 100 p.s.i.g. The instrument is tested to 200 p.s.i.g.

Special features of the equipment include the provision of two line isolating valves and one equalizing valve, fully shock-proof construction and a simple, foolproof system for filling and venting the measuring fluid used.

Three standard instruments are available with scales of 6, 12 and 24 in. respectively; alternative scales 15, 30 and 60 cm. and 0-100 square root can be provided. A free travel of 1 in. on each scale permits easy zero adjustment. The cast aluminium case of the manometer is provided with two built-in safety features, a transparent, plastic front and an adequate drainage and vent hole [*Industr. Chem.*, **34** (1958), 627].

Nuclear emulsion scanner

MICHIGAN UNIVERSITY PHYSICISTS have combined a powerful microscope, a television camera and a special electronic computer to form a machine that can recognize certain situations as well as humans can, and 15 times faster. The device, known as ' a nuclear emulsion scanner ' or ' Terry ', detects and counts the thousands of faint tracks left by atomic particles traversing thick sheets of special photographic film in atom smasher experiments. It represents the first successful attempt in the U.S.A. and Europe to solve this recognition problem instrumentally.

Terry holds promise of relieving humans of the slow, tedious task of examining hundreds of strips of film with microscopes. The device can automatically scan as much film in 90 min. as a human being can in four days, and it does so with 100 per cent efficiency in all areas of the film, while a human observer's efficiency drops rapidly in areas of many tracks.

Terry's ' eye ' is the television camera. It looks through a 200-power microscope at a different tiny square of the film every sixtieth of a second. A specialized electronic computer, which is the ' brain ', remembers dots within the squares that are dark enough and wide enough to be parts of a track; if it detects 15 consecutive dots within a square, it records them as one track. An electronic printer keeps a running count of the tracks, and a plotter draws a graph showing the frequency of the tracks.

As many as 30 film strips, representing more than six months of counting by a human being, are used in just one experiment with a modern huge cyclotron. The new scanner can process them in 4-5 days.

Terry looks for a millionth of a second at each of 130 squares which extend across the width of the film. After one band of squares is examined, the carriage holding the

film shifts to the next band, and the process is repeated.

Attempts are being made to adapt Terry to the 'much more complicated' recognition problems in the study of 'strange particles' and of cosmic radiation from outer space [*J. Franklin Inst.*, **266** (1958), 543].

Rubidium vapour magnetometer

A SIMPLE COMPACT MAGNETOMETER, which can measure extremely small magnetic fields, developed by scientists at the U.S. Coast and Geodetic Survey and the National Bureau of Standards, has significant advantages over previous instruments of the kind.

The instrument makes use of the fact that the absorption of polarized light in rubidium depends on the orientation of the rubidium atoms. When circularly polarized light of a particular wavelength is passed through rubidium vapour, atoms are "optically pumped out from high-absorption to low-absorption orientation as atoms returning from the excited state tend to accumulate in the lower absorption orientations".

In a radio frequency field, rubidium vapour displays absorption lines at its Zeeman transition frequencies. As the Zeeman transitions correspond to changes in atomic orientation, their frequencies can be determined by observing changes in the absorption, in the vapour, of polarized beam of light parallel to the magnetic field. Since the magnetic field is related to the transition frequencies by accurately known constants, an accurate measurement of field can be conveniently made in this way.

The rubidium vapour magnetometer consists of an absorption cell containing rubidium vapour and an inert buffer gas, and a rubidium lamp whose output is circularly polarized by a polaroid sheet and a quarter-wave plate. Light from the lamp is filtered so that only the strong optical line at 7947 A. enters the vapour. The amount of light transmitted is monitored by a photocell.

At the transition frequencies light is absorbed in greater amounts than when the atoms were aligned. Thus, the transition frequencies are observed as dips in the photocell output.

The high sensitivity, stability and potentially small size of the magnetometer make it particularly suitable for use in rockets and satellites. It is much more accurate in measuring very weak fields than the proton precession magnetometer and other instruments whose action depends on moving magnets. Its absolute accuracy in the measurement of magnetic fields is *c.* 2 γ (1 $\gamma = 10^{-5}$). The values of the earth's magnetic field obtained with this instrument differs by about 6 γ from the value in terms of the international magnetic standard [*Tech. News Bull. Nat. Bur. Stand.*, **42** (1958), 234].

ERRATA

This *Journal*, article entitled "The Corrosion of Metals in Synthetic Atmospheres Containing Sulphur Dioxide", **18A** (1959), 69-74: Page 69, R.H. col., line 22, the word "brass" should be *deleted*; page 70, R.H. col., lines 17 to 19 should *read* as "The comparative rates of corrosion of mild steel, aluminium, copper and zinc show that mild steel is the most corrodible metal, followed by"; page 71, R.H. col., line 1, "Fig. 3" should be *read* as "Fig. 4"; page 72, L.H. col., line 10, the word "aluminium" should be *deleted*; page 72, Fig. 4, on the Y-axis, *for* "Corrosion (Gain/Loss)" *read* "Corrosion (Gain)", and in the legend *for* "weight loss" *read* "sulphate metal ratio"; page 72, R.H. col., line 9, the following sentence should be *inserted* at the end of the paragraph: "On the other hand when panels of zinc and mild steel or zinc and nickel are exposed together, mild steel and nickel showed less corrosion with corresponding increase in the corrosion of zinc".

This *Journal*, article entitled "Studies in the Enzyme Make-up of *Vibrio cholerae*: Part XIII—Tryptophanase Activity of Vibrios", **18C** (1959), page 68, L.H. col., the title for Table 5 should *read* as "Effect of Inhibitors on Tryptophanase Activity" and *not* as printed. In col. 2, under A, the unit for the concentration of inhibitor should *read* as 3×10^{-3} *M*X and *not* as 3×10^{-3} M_x. The explanatory note for inhibitor concentration B at the bottom of the table should *read* as "B, final concentration of inhibitor during enzyme-substrate reaction" and *not* as printed.

The title for Table 6 should *read* as "Effect of inorganic salts on tryptophanase activity" and *not* as printed. In col. 2, under A the unit for the concentration of inhibitor should *read* as 3×10^{-3} *M*X and *not* as 3×10^{-3} M_x. The explanatory notes for inhibitor concentrations B and C at the bottom of the table should *read* as: "B, final concentration of inhibitor during enzyme-substrate reaction and C, final concentration of Cu, Hg, As, Mn, Fe, Mo and Mg during enzyme-substrate reaction", and *not* as printed. Page 68, R.H. col., in Fig. 3, under the X-axis, the caption should *read* as "Time of contact, min." and *not* as printed.

This *Journal*, article entitled "Respiratory Metabolism of *P. chrysogenum* during Commercial Penicillin Fermentation", **18C** (1959), page 74, in Figs. 1-4 the correct co-ordinates for Lactose, QO_2 and QO_2 (ml.) on the Y-axis should *read* as Lactose % (●—●); $QO_2 \times 10^{-1}$ (■—■); QO_2 (ml.) $\times 10^{-2}$ (□—□) and *not* as printed.

Progress Reports

COAL RESEARCH IN BRITAIN, 1957

THE WORK OF THE BRITISH COAL UTILIZATION Research Association during 1957 was concerned with devising methods for meeting the demand for suitable coal supplies for steam raising and other purposes and for solving the technical problems connected with the implementation of the Clean Air Act. In order to remove the shortage of large-size coal by using smaller size and inferior coals to a greater extent, work on improving the performance of mechanical firing equipment for industrial steam raising and for domestic heating was taken up. Among the programmes which have been completed, mention may be made of the development of small-pipe central heating, the measurement of dust and grit emission in industrial boilers, operation of stationary locomotive boiler using a ' difficult ' coal. A noteworthy feature of the year's activity was a conference which discussed many aspects of Gas Producer Practice.

A brief review of the Association's research activities is given below:

Domestic heating — The performance of small-pipe systems for central heating has been studied. A controller, designed for regulating the temperature of the heating circuits in sympathy with the prevailing outside temperature, has proved satisfactory. A laboratory apparatus has been developed for investigating the smoke tendencies of solid fuels by optical and gravimetric means. Investigations into the effectiveness of alkali addition to domestic fuel in reducing the amount of sulphur released from the open fire has shown that one of the more successful methods is the impregnation of hot (150-250°C.) coke with a solution of sodium carbonate. Full-scale tests of the alkali-treated coke have not shown any significant deterioration in the performance of the fuel, while the sulphur release is reduced by more than half, provided the fuel bed temperature does not exceed *c.* 1000°C.; the use of sodium carbonate may, however, lead to difficulties in handling and storage of the treated coke.

Boiler firing — From the studies on build-up of deposits on the rear tube plate and in the smoke tubes of coal-fired boilers, it has been concluded that the presence of a deposit usually, but not always, coincides with the use of a coal with a chlorine content in excess of 0·4 per cent; the trouble is not associated with any particular design of boiler or grate. A study of the effect of gas velocity on the quantity and strength of alkali-bonded deposits using pulverized coal has shown that with increase in gas velocity the quantity of bonded materials increases apparently to a maximum; thereafter both the strength of the bonding and the amount of the deposit are reduced. By measuring the rate of acid build-up on a dew point meter, determining SO_3 chemically and carrying out corrosion probe tests, it has been found that potential maximum corrosion in water-tube boilers occurs at 45 per cent excess air. Reduction of dust burden of the flue gases increases their corrosion tendency.

Gasification — With a view to evolving efficient and reliable means of producing fuel or synthesis gas from low rank coal, investigations are being carried out in gasifiers operating at high pressures and at temperatures at which the ash is in the form of liquid slag. Investigations into arrangements for ensuring a continuous flow of slag from the gasifier and for obtaining good quenching and break-up of slag stream have resulted in a design for the slag outlet of a larger gasifier. A slag viscometer having a furnace with low thermal inertia, thus permitting speedy operation, has been constructed to study the behaviour of slag in the molten state.

Basic research — The reaction between chlorine trifluoride and a low rank coal at 350°C. has been investigated, and it has been found that operating conditions affect the nature of the oils formed. These oils, which are extremely hydrophobic, have been found effective as promoters of dropwise condensation on condenser tubes. The fluorinated coal ash residue is in a very fine state and might find application as a polishing powder.

A large part of the oxygen in bituminous coals has now been accounted for as hydroxyl and quinone groupings. From a study of the reduction of the aromatic part of coal by lithium in ethylamine at 17°C. and in solvent extract by electrolysis at a controlled potential of −2·2 V., it appears that low rank coals undergo little reduction, suggesting that aromatic systems in the coals to be rigidly linked to each other by a number of aliphatic chains or by alicyclic rings, and these linkages resist deformation from planarity due to hydrogenation. Studies on the products of chemical reactions of coals and coal extracts containing modified edge groupings have shown that concentrations of free radicals in them are not significantly different from the untreated materials. The presence of low concentration of free radicals in coals has established that the number present is probably a function of the size of the aromatic ring clusters in the coal molecule rather than of the reactive and non-aromatic groups. Measurements of electron paramagnetic resonance carried out on bright coals have shown that unpaired electrons associated with free radical structures are present, and the free radical concentration has been correlated with other physical and chemical measurements on the coals.

General — A total heat meter has been devised for the investigation of furnace performance. Continuous records of the total heat of preheat and waste gases in open-hearth furnaces have been obtained at temperatures up to 1700°C. The results have been found to agree with values estimated from temperature readings with suction pyrometer. It has been successfully used at higher temperatures on the waste gases of open hearth, where almost all other instruments fail.

Improvements in coal handling methods have been effected by a study of the matrix method of representing coal breakage processes; these are of help in overcoming operational difficulties in a gas producer plant due to coal breakage.

Investigation on the usefulness of reflectance measurements in coal prospecting has shown that no significant change in reflectance or in petrological composition results from the exposure of finely ground coals to heated air at 150°C. and oxygen at 110°C. for periods up to 90 hr and 418 days respectively. From this it appears that the natural weathering of coal is unlikely to change its optical properties. During prospecting, therefore, the reflectance of coal specimen taken from outcrops should provide a useful guide to the nature of underlying seams.

Fossilized remains of fungi have been observed in lignites for the first time. Detailed study of sclerotinites in lignite, by examining polished sections by reflected light, has led to the recognition of various types of fungal spores, reproductive bodies and sclerotia. An automatic photoelectric scanning device for counting and sizing microscopic particles has been devised. The method involves scanning a field with a light beam or beams and detecting the occurrence of particles with a photoelectric device, high speed counting circuits being used to record these occurrences. An accurate, rapid method for the analysis of the inorganic coal residues has been developed; the procedure enables eleven constituents to be determined in ten samples in about a week by one analyst.

TEA RESEARCH

THE ANNUAL REPORT OF THE TOCKLAI EXPERIMENTAL Station of the Indian Tea Association in Assam for the year 1957 records interesting results obtained in connection with shading and manuring trials, the study of parasites of tea and their control, identification of different varieties of tea and suitability of mechanical harvesting and pruning methods. The following is a brief review of the more important achievements of the station in different fields of study.

Physico-chemical studies — The effect of growing tea in shaded areas on the nitrogen status of the top soil has been investigated. It has been found that in the case of unmanured and unshaded tea, and when no infilling is done, the nitrogen status of the top soil may ultimately drop by as much as 41 per cent of its original value. The use of fertilizer in tea plantations in divided doses has been found to be more economical than application in a single dose.

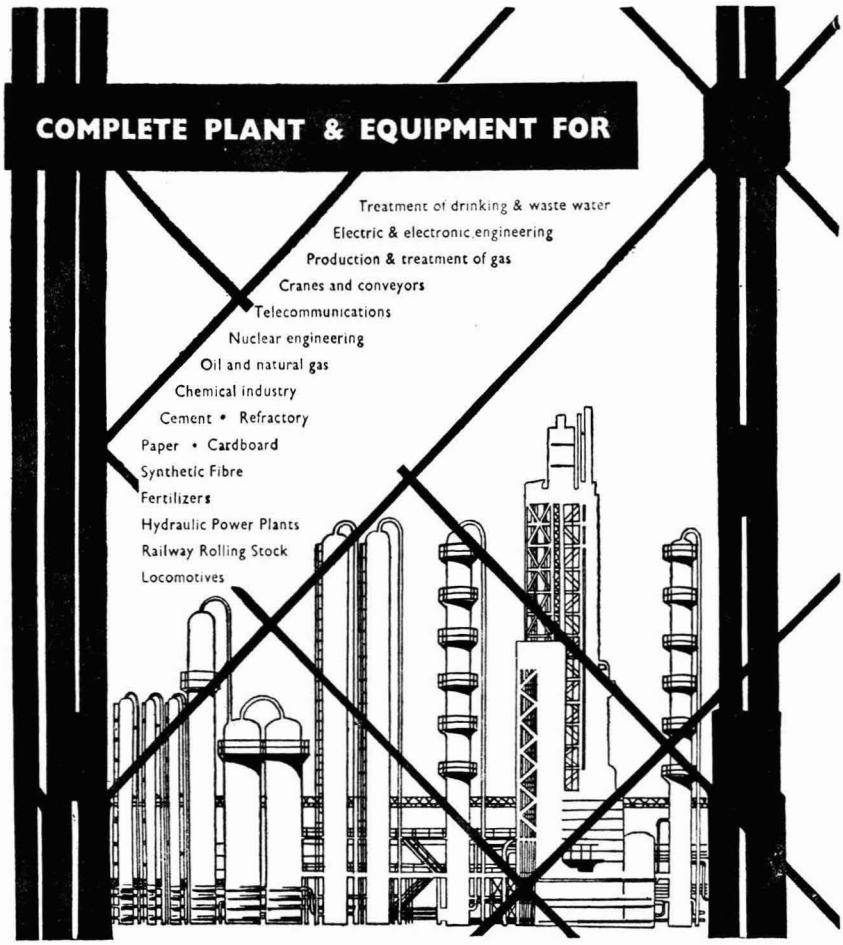
An attempt was made to assess the percentage recovery of applied superphosphate in the case of acid tea soil (*p*H 4·7). Manuring was done at two levels (40 and 30 lb. per acre) of P_2O_5 and K_2O applied in the form of superphosphate and potassium sulphate respectively and one level (4 mg./acre) of slaked lime. The uptake of phosphate with the dose of phosphate applied is linear in both cases, the regression coefficients being statistically significant at $P < 5$ per cent. The percentage recovery is calculated to be approximately 10 and 14 per cent at the end of 3 and 7 months respectively.

Agriculture — The overall yield of tea has been found to increase by nitrogen application to mature tea. With increase in the amount of nitrogen applied (40-80 lb.) a proportionate increase in yield was obtained every year. As regards the overall effects of increase of phosphate and potash, no significant differences were observed. Green crop manuring trials have established the value of phosphate for *Crotolaria anagyroides*.

Plant pathology — A hymenopterous parasite (Drynidae) has been recorded for the first time; this pest attacks later nymphal instars. Another root-knot nematode parasite of tea seedlings, *Pratylenchus* sp., has been noted in the roots of tea seedlings for the first time in North-east India. In a trial conducted on the control of the root-knot nematode, *Meloidogyne incognita*, Hexamar (30 gal./acre) and Shell DD (400 lb./acre) were found to destroy more than 50 per cent of the parasites. The effectiveness of a number of pesticides such as Melathion, DDT, Endrin and Toxaphene were tested against Looper caterpillar, using 80 gal. of spray per acre, applied by means of low volume sprayers. Endrin proved to be the most effective pesticide and in spite of 3·9 cm. of rainfall within 24 hr its activity was maintained. The fungicidal properties of a number of fungicides were tested. Perenox and Coppesan alone or in admixture were found effective against black rot at 0·25 per cent concentrations.

Biochemistry — A method has been developed for chemical differentiation of tea varieties and other *Camellia* species, employing two-dimensional paper chromatography of leaf extracts. Tea gives a characteristic chromatogram which can be distinguished from chromatograms obtained from hybrids of tea with *Camellia*. Parallel botanical examination has confirmed the results obtained by chromatography.

Miscellaneous investigations — Field trials were conducted on mechanical harvesting of tea. The mechanical harvester employed reasonably fulfils the following three functions: (i) it removes all mature growth above the predetermined harvesting level, (ii) it rejects as far as practicable all immature shoots and (iii) does not subject harvested leaf to much damage. Mechanical pruning trials showed that it is more suited to hedge-planted tea. Apart from the increase in the number of bushes dealt with for a given ground speed, which is constant regardless of the spacing of bushes, the additional firmness inherent in the closer spacing improves the quality and efficiency of the machine. This results in less bruising of the freshly cut shoots due to the more solid nature of the tops of the bushes as distinct from the branch springiness obtaining in bushes of wider spacing.



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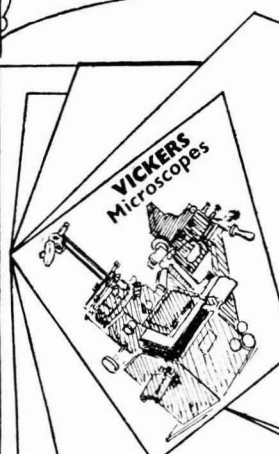

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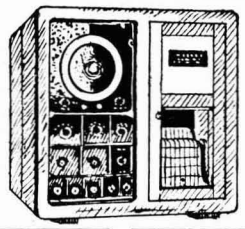

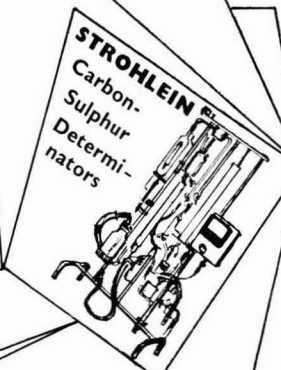

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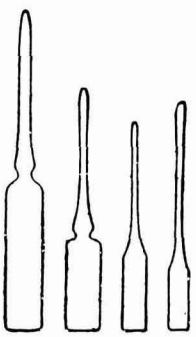

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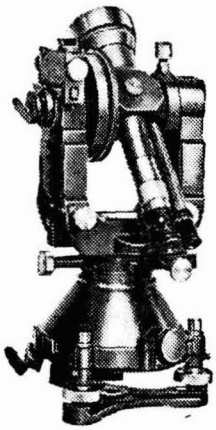

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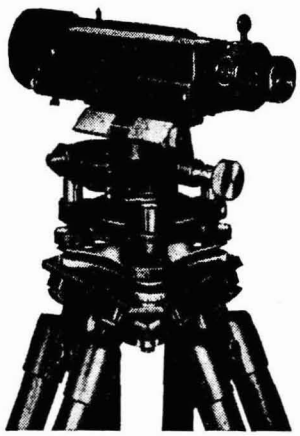

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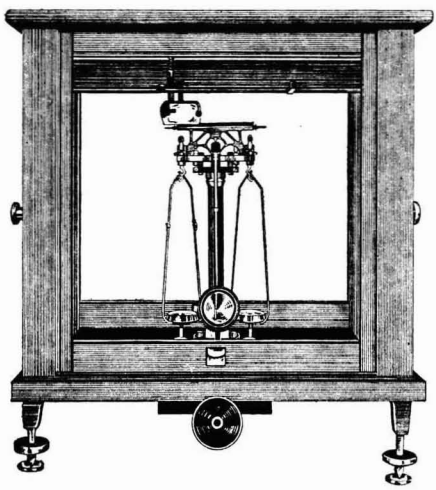

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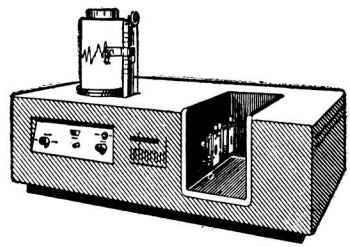

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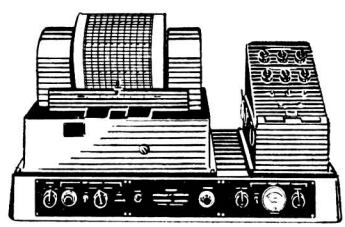

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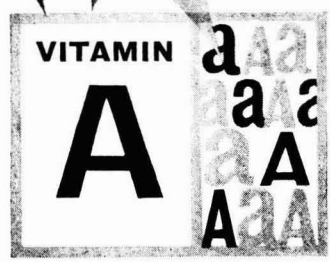

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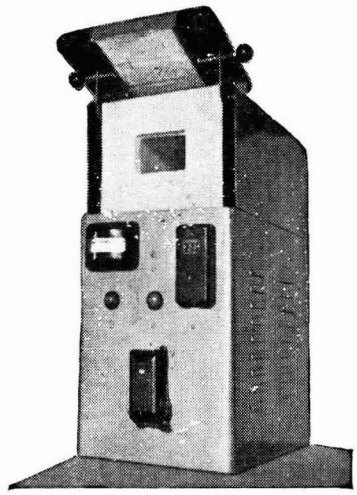

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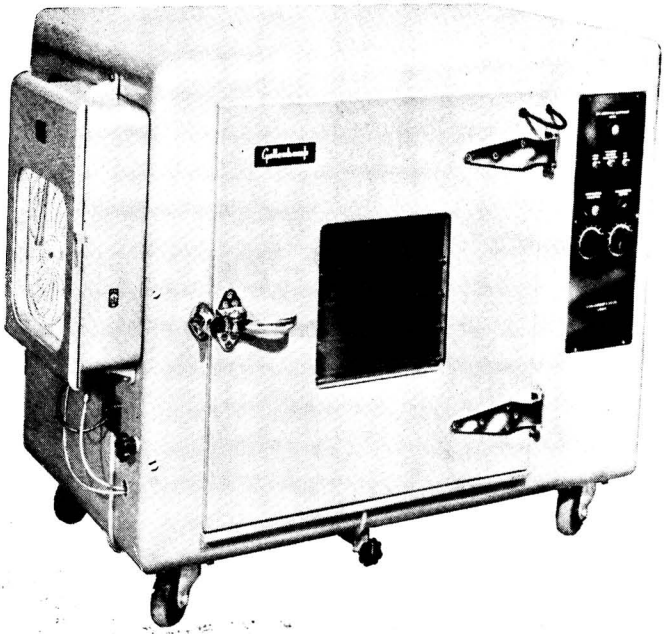

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