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APRIL 1964

COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH, NEW DELHI

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CONTENTS

For Index to Advertisers, see page A21

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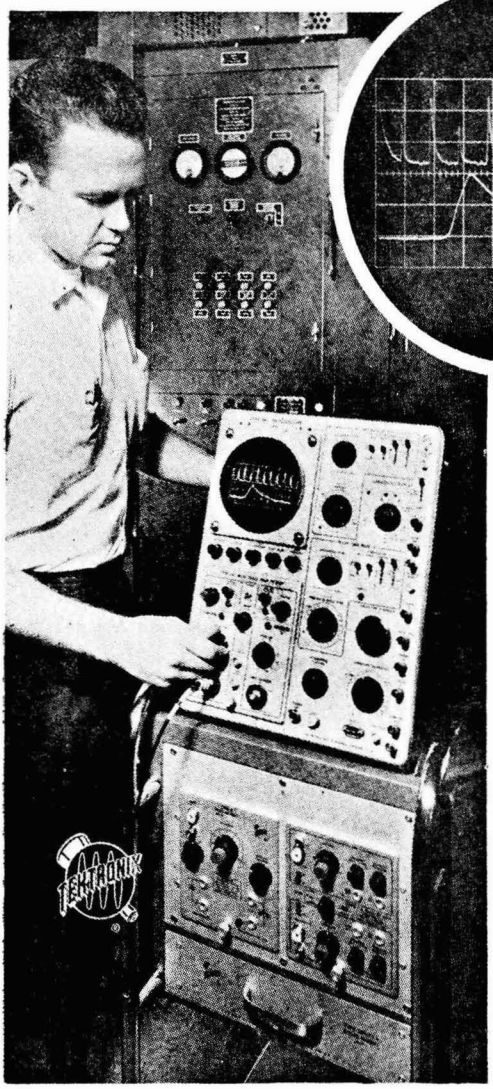

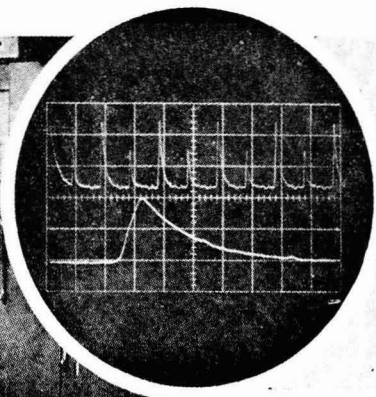

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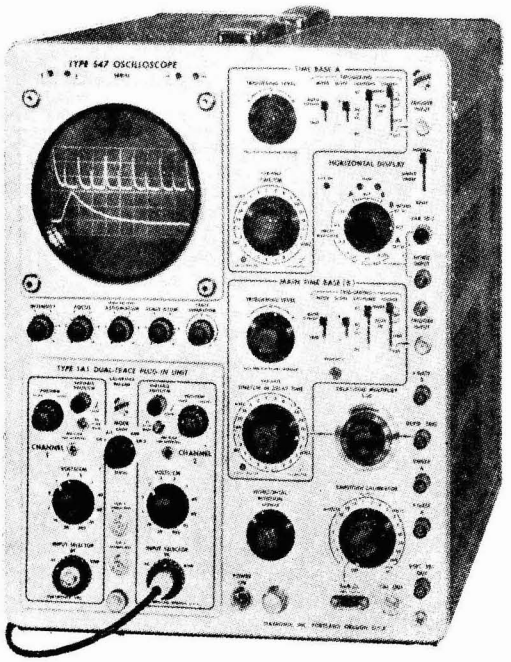

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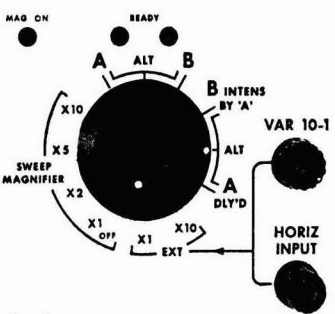

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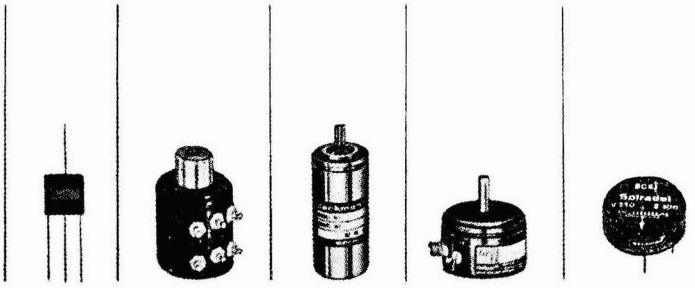

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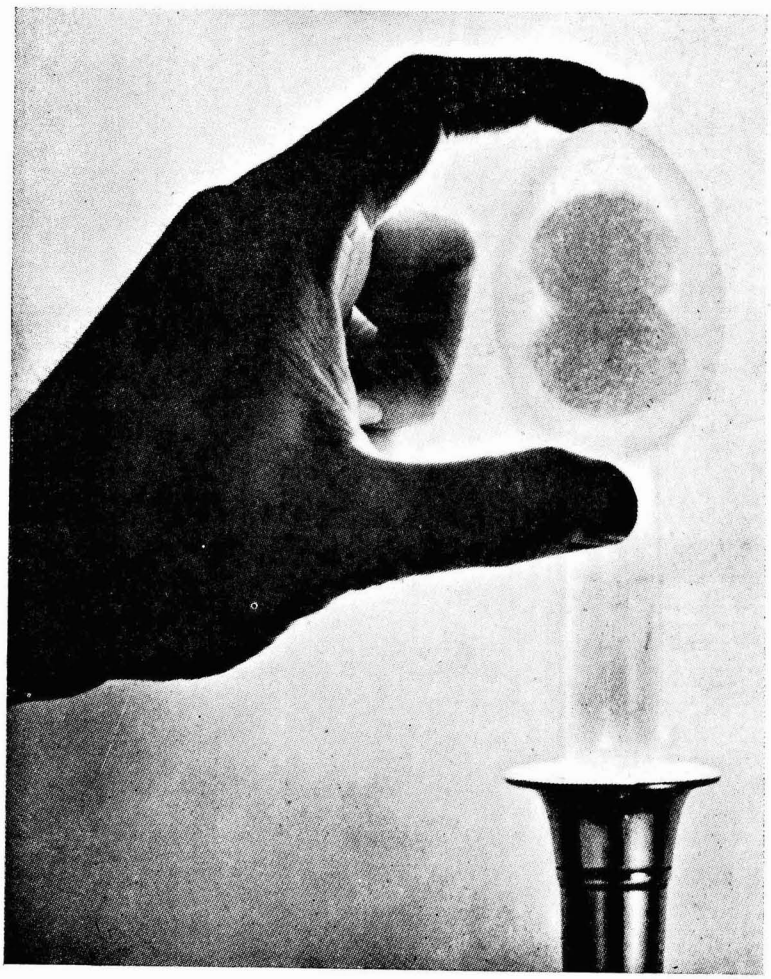

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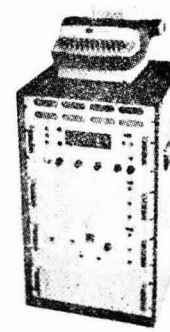

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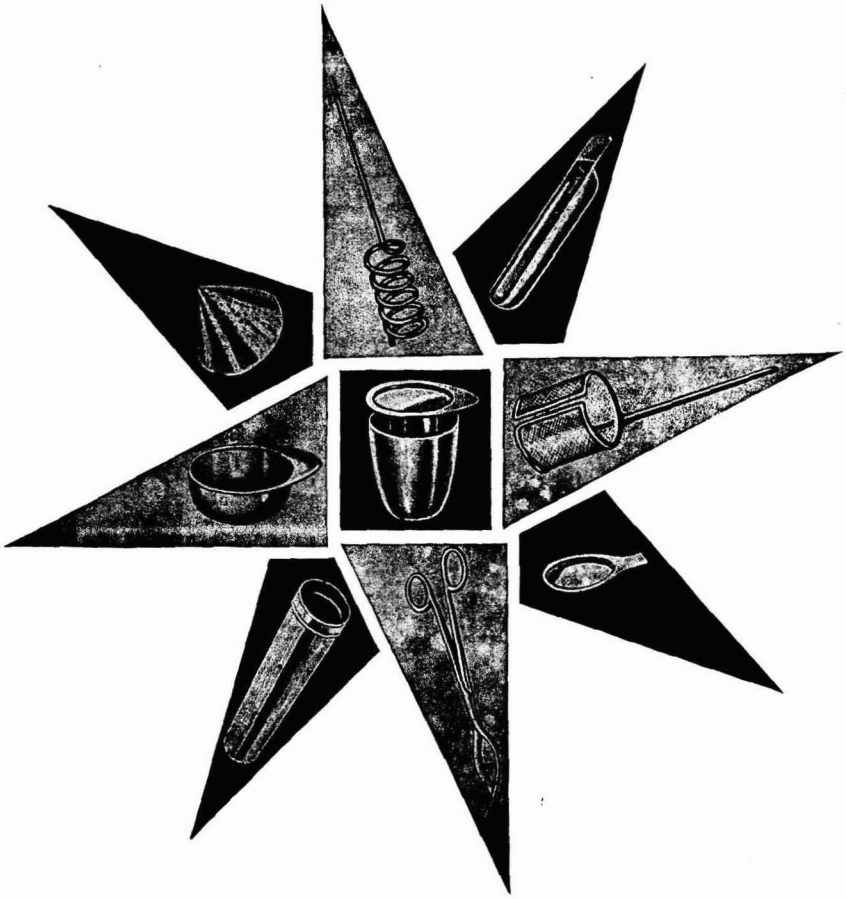

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Current Topics

Radio Frequency Allocation for Scientific Uses

IN the past decade increasing demands were being made on the radio frequency (r.f.) spectrum for a number of purposes other than regular service communications. The advent of space vehicles and the progress made in radio astronomy, along with the increasing needs of rapidly developing geophysical sciences like meteorology and oceanography, have made additional radio frequency allocations on an exclusive basis imperative and urgent. The new users are faced with the problem of the natural limitations of the r.f. spectrum. The problem has been further accentuated by the continual expansion of many established services, e.g. broadcasting, radio location services, etc.

The needs of radio astronomy deserve special attention. In the first place, there should be access to a few specific frequencies associated with matter that emits or absorbs these frequencies, e.g. 1420·4 Mc/s. spectral line of neutral atomic hydrogen. To derive maximum scientific use, access to the continuous spectrum — extending up to one octave — emitted by discrete radio sources and by the general cosmic background is equally essential. Further, the interference noise levels for radio astronomy, particularly for the ' B category ' stations, are very critical, and even the feeblest interfering signals from other services operating on these frequencies anywhere in the world cannot be tolerated.

Communication services in space research represent another important new user and merit equal consideration. Rocket tracking, satellite telemetry and remote control television play a vital role in space research. The radio link equipment on spacecraft, which should be compact and of low power, are susceptible to interference. Any research data lost due to interference is irretrievable. Thus, unless exclusive frequency bands are allocated for the ' space research service ', the full growth of space research may be hampered. The increasing complexity of space research programmes reduces the practicability of shared use of these bands with other services now operating on these bands.

The International Geophysical Year programme called for considerable expansion in oceanographic activities. Oceanographic research assumed a new practical importance in the context of the search for additional mineral and food resources, and further development of water-borne transportation. Better observational coverage of the oceans by automatic recording or telemetering data from remote areas requires suitable communication channels for transmitting data. Thus oceanography is the latest competitor for additional exclusive frequency bands.

First practical steps towards the recognition for exclusive frequency allocation for some of the abovementioned emerging disciplines were taken as early as 1959 at Geneva by the Plenipotentiary and Radio Conference of the International Telecommunications Union (ITU). The Extraordinary Administrative Radio Conference of the ITU at its meeting on 7 October 1963 recognized four new services, viz. Radio Astronomy Service, Meteorological Aids Service, Space Service and Earth-Space Service, and made allocations for space research and radio astronomy.

Regarding the allocations for radio astronomy the 1959 ITU conference allocated an exclusive single frequency band at 1400-1427 Mc/s. on a worldwide basis. A stocktaking in 1963 of the frequency requirements of radio astronomy services revealed that the continuum requirements for frequencies below 73 Mc/s. are satisfactory and that the needs above 73 Mc/s. can be met by bands beginning at 73·0, 404, 1400, 2690, 4990, 10680, 15350, 19300 and 31300 Mc/s. The spectral band, now allotted to Television Channel No. 37 in USA (608-614 Mc/s.), is of particular interest and importance in investigations on major problems concerning the origin of cosmic rays and the nature of magnetic fields in the solar system, intra- and intergalactic magnetic fields. The adoption by the ITU in 1959 of a substantial measure of protection for the 606-614 Mc/s. band (European TV Channel 38) was a progressive step in reserving this band for radio astronomy service.

A difficulty is encountered, particularly in the allocation of frequencies for space research, because the range of frequency bands used for this purpose overlaps considerably the bands used by the other existing services. The problem should be solved only by a cautious approach and a planned ' phased out ' programme in a reasonable period of time (say 3-5 years). A more detailed slicing of the 5925-8400 Mc/s. band, assigned to the Fixed and Mobile Services, has been suggested to include portions of this part of the spectrum for communication satellites and seven different bands of the spectrum from 136-137 to 31·5-37·8 Mc/s. to be exclusively assigned to space research.

No specific allocations have yet been made exclusively for oceanographic research and the claim for the urgent need for r.f. spectrum space for oceanographic research is being sponsored by a number of scientific bodies interested in oceanographic research. These organizations proposed the recognition of an additional service, known as ' Ocean Data Service ', and the allocation of frequency bands 3·5 kc/s. wide in those portions of the spectrum between 4 and 27·5 Mc/s. exclusively to Maritime Mobile Services. The need for a medium frequency for use in the

Arctic and Antarctic regions where higher frequencies are useless owing to auroral disturbances and for a VHF/UHF frequency for buoy-satellite links has also been recognized.

India is keenly interested in these developments. It has a modest programme in radio astronomy and a few scientific institutions like the National Physical Laboratory, New Delhi, the Institute of Radio Physics & Electronics, Calcutta, and the Kodaikanal Observatory are engaged in research on the solar, galactic and extragalactic activity; the Tata Institute of Fundamental Research, Bombay, is shortly initiating a comprehensive project in radio astronomy envisaging the setting up of a few ' B category ' stations for the first time in India. The International Indian Ocean Expedition is in full swing now. The task of adopting new radio frequency allocation rules for the growing needs of new disciplines is not an easy one. Patient and continuous study of the situation through constructive international cooperation alone can solve the problems posed by these new needs. In this task, India has a role to play.

Total Gasification of Coal

WITH the inauguration on 15 March 1964 of the high pressure gasification pilot plant at the Central Fuel Research Institute (CFRI), Jealgora, the Institute added an important facility to its battery of pilot plants set up for undertaking long-range investigations on the efficient utilization of India's coal resources. The primary object of the new pilot plant and two other units already in operation, viz. the powdered coal gasifier and the slagging ash gas generator, is to investigate the gasification characteristics of Indian coals. The pressure gasification pilot plant, with a designed capacity of producing 1400 $Nm.^3$ of raw gas per hour, will be used for studies on complete gasification of coal under pressure with steam and oxygen resulting in the production of town gas and synthesis gas.

A problem peculiar to India in respect of her coal deposits is that though the reserves are abundant (of the order of 120,000 million tons), a major portion of the reserves comprises low grade (non-coking) coals, unsuitable for metallurgical use. Therefore, for maximum conservation of metallurgical coals, India has to depend upon inferior grade coals for non-metallurgical uses. With the increased tempo of coal production, mechanization of mines and coal washing, large amounts of fines and washery middlings are accumulating, and their disposal and economic utilization becomes no less important than that of utilizing low grade coals as such. From both theoretical and practical considerations, complete or total gasification affords the most efficient means of utilizing the low grade coals, fines and middlings.

The technologies of production and distribution of gas for domestic and industrial consumption have been developed to a high level in the advanced countries. However, most of the technological advances are closely guarded secrets. Also, India has specific problems to contend with both in respect of production of gas (arising from the varied nature of coal deposits in different parts of the country) and its distribution over vast distances. Therefore, before embarking upon a programme of switch-over from the conventional fuels to gas, considerable amount of spade-work is necessary. While the pilot plant investigations in hand at CFRI will no doubt provide answers for most of the technological problems as far as the production of gas at economic rates from different coals is concerned, it is the distribution aspect that is complicated by a host of problems. The problems range from the fundamental question of deciding which of the two system, viz. national grid or regional grid, would be more convenient and economical to operate, to those concerning the details of construction and diameter size of the pipeline, gas pressure and other factors influencing the maintenance of a steady and constant supply of gas over long distances. Problems such as outlets and uses of gas, pattern of demand, cost of production and supply, size of economic units of gasifiers, etc., have to be gone into carefully.

Both the planners and CFRI have been alive to these complex issues. A blue print of an integrated plan based on the establishment of gas grids in different regions of India, keeping in view the location of existing or proposed industries, the population density in different regions and other factors has been finalized. In fact, the Durgapur Gas Grid Project in Eastern India, now in the early stage of implementation, was born out of the plans prepared by CFRI as far back as 1952. More recently, CFRI has been devoting a great deal of attention to investigations on the methods of production of gas in different types of pilot plants and the supply of gaseous fuels to urban and industrial areas.

Replacement of conventional fuels by gas is intimately interwoven with several socio-economic factors. It is hoped that in long-range planning these will not be lost sight of. The economics of large-scale production and supply of fuel gas are interconnected with a variety of problems and among these the problem of utilizing the vast surpluses of naphtha available from the expanding petroleum refining industry is of considerable importance. Therefore, in planning regional gas grids the possibility of employing naphtha as a supplementary raw material for fuel gas production in regions where oil refineries are located needs consideration. Of equal importance is the question of planning a network of subsidiary fuel and synthesis gas-based industries for the production of carbochemicals, fertilizers, etc. The successful implementation of these plans will depend largely on the coordinated efforts of various establishments concerned with research in coal, petroleum and chemical technology, corrosion, fluid dynamics and other related fields.

Recent Developments in Chemical Industries Relating to Ethyl Alcohol, Its Byproducts & Wastes

THE Symposium on New Developments in Chemical Industries Relating to Ethyl Alcohol, Its Byproducts and Wastes, held in New Delhi during 14-16 October 1963 and organized jointly by the All India Distillers' Association and the Unesco South Asia Science Cooperation Office, was concerned with different aspects of the ethyl alcohol industry and the organic chemicals based on alcohol as raw material. Since the use of alcohol as motor spirit has lost much of its significance, emphasis has shifted to its use as an industrial raw material.

The results of studies conducted at various institutions which were presented in a number of papers to the symposium by different participants were classified into the following broad groups for convenience of discussion: (i) Economy of energy means; (ii) Equipment for production of ethyl alcohol and its byproducts; (iii) Automation and instrumentation; and (iv) Industrial utilization of alcohol, its byproducts and wastes.

Economy of Energy Means

Discussions at this session (President, Shri L. Kumar) mainly dealt with steam economy in the alcohol industry and the use of alcohol as a supplementary fuel in diesel engines. Although it has been recognized in industry for a long time that heat recirculation could be effected to an appreciable degree from the reflux streams and the effluent flow, the papers presented gave a well-coordinated plan for the recovery of reflux heat for preheating the feed wash and also for the subsequent heating by the waste in the spent wash. The aim is to get the maximum amount of heat back into the feed stream from the two outgoing streams, namely reflux and the stillage, and also to raise the temperature of the feed almost to its boiling point. It was reported that the latter objective could be achieved by further preheating the wash with the help of vapour from the analyser column, the vapours themselves being partially condensed. This partial condensation has been claimed to result in saving in reflux heat and also an overall reduction in the consumption of condenser water.

Another interesting scheme for minimizing heat consumption is based on flashing the spent wash or lees in a flash chamber with a thermocompressor and using the flash vapour as additional steam for the boiling column. This process has been successfully coupled with simultaneous extraction of heat from analyser vapour. This system is estimated to reduce steam consumption for the vapour by effecting partial condensation in a calandria. This calandria on the liquid side acts as a flash chamber for the thermocompression system and on the vapour side as a partial condenser for the analyser vapour. Steam consumption for distillation of rectified spirit is 22-26 lb./gal. of product. It was stressed that analyser vapour carrying surplus heat could be used for heating the dehydration column with the help of a thermosyphon reboiler. A saving of 2·5-3 lb. of steam/gal. of absolute alcohol has been claimed.

In one of the papers, standards of heat consumption in the different stages of distillation process were presented. These standards are useful for ready reference in judging the various methods and innovations for the heat saving devices.

It was brought out during the discussion that the adoption of the flash recovery system needs careful study of the economics of heat saving in flash as against the price which has to be paid for the power which will no longer be available if high pressure steam is fully utilized for thermocompression.

Results of studies on the use of alcohol as a supplementary fuel for diesel engines were presented in a paper. These studies have demonstrated the material benefits of alcohol induction into the diesel engine for reducing smoke density, increasing overload capacity and air utilization, and improving overall thermal efficiency. This also reduces the carbon deposits while the wear of the engine remains normal. During the discussion, it was, however, recognized that there is no prospect of alcohol being utilized in this manner for a long time, as the demand of the organo-chemical industries for alcohol produced in the country is already exceeding the possible production. However, this research work will remain a valuable achievement which can be used when there is a necessity.

Equipment for Production of Ethyl Alcohol and Its Byproducts

The second session (President, Shri G. Gundu Rao) was concerned with the design and construction of plant and efficient operation of the manufacturing process, control by instrumentation and alternative raw materials for the production of alcohol. In one of the papers, a new design for dilution of molasses was described, which will rank among the other continuous devices for diluters already in use.

The discussions on papers on efficiency of operation in the ethyl alcohol industry brought out several points of interest. It was suggested that for the sake of convenience and ready comparison, the efficiencies should be based on the total sugar content of molasses. The difference in efficiency from plant to plant was generally attributed to the characteristics of the raw material which varied from region to region. For achieving a certain normal level of working in the plants it is necessary to concentrate efforts towards increasing the fermentation efficiency as, generally, the distillation efficiency is already fairly satisfactory. Allowing for the variations in the quality of coal received by the different units, it is possible to achieve maximum fuel efficiency by adopting various steam saving schemes discussed at the first session.

The process of continuous fermentation of cane molasses as well as the yeast reuse system were discussed at length and the advantages of this new

development were pointed out. Rapid strides made in the continuous fermentation of carbohydrates for the production of alcohol and other products were discussed. The need for an immediate beginning to be made by the Indian distillery industry in sponsoring experimental studies on the continuous fermentation of indigenous cane molasses was stressed.

The problem of scaling in wash columns received considerable attention. Removal of calcium from molasses by adequate treatment wherever possible, maximum preheating of wash, maintenance of high velocity of movement in pipeline and across the heating surfaces, judicious dilution of wash on the boiling plate, specially of fermented washes of high alcohol concentration by pure water, spent lees or even the lees from the rectification column and prevention as far as possible of sub-cooling of feed wash were some of the means suggested for eliminating scaling nuisance. Preservation of molasses in good condition was also considered an important factor.

The difference in the quality of molasses obtained from carbonation and sulphitation was suggested as one of the factors responsible for scaling, but no definite conclusion could be arrived at in the absence of precise data. For preserving the quality of molasses use of an oil layer was suggested.

In the fermentation of molasses worts, urea was reported to show better performance as a nutrient and accelerator compared to the traditional nutrient, ammonium sulphate. During the discussion it was pointed out that before arriving at a final conclusion it is necessary to obtain comparative data on equivalent nitrogen basis at indentical *p*H ranges. Further study is also necessary to determine the optimum dosage of urea as well as its effect on the yeast cell contents and note its effect on fusel oil production. The need for studies on the possibility of using hydrolysed distillery slop as a nitrogen nutrient was stressed.

The development of a yeast strain with high alcohol tolerance and the production of molasses washes containing up to 14 per cent of alcohol were reported in a paper. These developments have been claimed to give increased capacity of the plant and reduction in steam consumption. During the discussion it was felt that the problem should be subjected to further investigations in the light of the known fact that steam requirement for distillation remains steady for alcohol concentration of 8·7 per cent (vol.) and above in the feed wash. The necessity for suitable modifications in the existing plant designs to handle such highly concentrated wash was also stressed ; because of the losses in the spent wash, reduction in the ultimate strength of the product in the present plants will be pronounced.

Reeds and kail sawdust have been investigated as alternate sources of alcohol. The results of investigation on this raw materials, however, have not led to any definite conclusions. The economics of the raw materials have to be carefully considered in view of the fact that sources other than sugarcane molasses tried in other countries have not resulted in the production of cheaper alcohol. It may be that these alternate sources will become important in case of an acute demand for fermentation alcohol. The need for continuing research on these and other alternate raw materials was stressed.

In a report on the equipment for synthetic ethyl alcohol presented by the USSR delegate, various aspects of synthesis of ethanol were presented in a very interesting manner. Since this subject is totally new to India the paper evoked considerable interest.

The suggestion put forward by D. Dass Gupta in his paper for the adoption of proof spirit as the basis for alcoholometry was received with interest. The author has completed the work of compiling precise tables for volumetric estimation of alcoholic strengths based on the French system. The adoption of this system both by the revenue authorities and the industry immediately was recommended. The advantages of the new system are: (i) the accuracy of determination at high concentrations and temperatures, and (ii) its conformation to the metric system.

Automation and Instrumentation

The discussions on this subject were held in two sessions. The first session (President, Shri G. Gundu Rao) was concerned with instrumentation and automation. The success and benefits of automation have been practically demonstrated in plants producing acetic acid. It was hoped that for alcohol industry a careful selection of instruments would be made so that fluctuation in the operational conditions could be avoided and efficiency of operation could be improved. It is nevertheless necessary to keep the instrumentation to a minimum as alcohol manufacture is basically not very complicated. Temperature control by indicating instruments, steam meters and rotameters at suitable points, continuous brix indicator and recorder and, if possible, a control device for molasses dilution and a control device for steam admission into the boiling column are perhaps all that is needed by way of instrumentation.

The second session (President, Prof. T. K. Ghose) was concerned with the treatment, disposal and utilization of distillery wastes. Several papers dealing with various aspects of the treatment and disposal of distillery wastes were presented, all of which were followed by lively discussions. Studies on biological disposal of distillery wastes by anaerobic digestion carried out at two institutions in the country were reported. While anaerobic fermentation of spent distillery slop yielding valuable by-products like methane gas and potash is well known, recent investigations carried out in India have shown definite possibilities of biochemical utilization of molasses distillery wash. Two methods of disposal and utilization, viz. (i) direct methane fermentation over 8-10 days' retention yielding 25-30 volumes of fuel gas (containing 60-65 per cent methane) per volume of the raw molasses distillery slop and a resulting fluid carrying approximately 2 per cent of the initial b.o.d. load, and (ii) neutralization concentration by evaporation of the raw slop followed by incineration of the concentrate and water extraction of potash salts from the fused

mass, were discussed at length from the point of view of economic utilization.

The results of recent studies on anaerobic fermentation of spent distillery washes by sulphate reducing bacteria presented in a paper stimulated interesting discussion. In this study, a reduction of 98 per cent of initial carbon content and about 80 per cent in the c.o.d. has been claimed with a recovery of 11,000-13,000 p.p.m. of sulphide in the gas phase.

Studies carried out so far on the disposal of distillery waste have given promising results as far as recovery of valuable byproducts is concerned. Continuation of these studies on pilot scale was recommended.

The discussion also centred round the problem of making protein digests from distillery sludge. The importance of the work in developing a supplementary diet rich in essential amino acids was stressed and the need for further research on the economics of the production of protein digests was indicated.

Industrial Utilization of Alcohol, Its Byproducts and Wastes

Shri C. J. Dadachanji presided over the deliberations of this session. The possibilities of using acetaldehyde as a building block for several important organic chemicals were dealt with in one of the papers, while another attempted the relative evaluation of alcohol and petroleum sources as alternative raw materials for the organic chemical industry in India. A number of alcohol-based chemical plants, including a large SB rubber factory, have been established recently as fermentation alcohol has hitherto been readily available, while raw materials of petro-chemical origin are not yet available in sufficient quantities in the country. With the rapid growth of organic chemical industry, the demand for alcohol has outstripped the availability and a shortage has already been experienced.

Although the controlled ex-distillery price of alcohol is Rs 240 per ton, in practice the delivered cost at the point of use runs as high as Rs 450 per ton, due to various additional cost surcharges combined with high transport cost and governmental levies. It was mentioned that, with alcohol at Rs 450 per ton, the cost of acetaldehyde was likely to be of the order of Rs 700 per ton. On the other hand, a primary producer of petro-ethylene using naphtha and employing the direct oxidation process may be able to produce acetaldehyde at 15-20 per cent less cost. Therefore, in order that the existing alcohol-based chemical industries may be placed in a favourable position in relation to the projected naphtha-based units, alcohol must be available at a lower cost.

During the discussion it was brought out that while petro-chemical raw materials will be highly economical for chemical industries situated in the vicinity of the sources, alcohol will still be important at locations distant from petro-chemical raw material sources and also for use in the industries located at the distilleries. It was also emphasized that the price of industrial alcohol, delivered at the chemical factories, is still much below the price levels in other countries. Therefore, further lowering of price of alcohol by a reduction in the ex-distillery price may not be desirable, as it will make the alcohol industry unremunerative.

The discussion also highlighted the fact that in future the petro-chemical raw materials will have to supplement ethyl alcohol, which has, so far, played a key role as a raw material for the organic chemical industry and will continue to be used to the full extent of its availability in the years to come. It was also emphasized that the fermentation alcohol industry need not entertain any fear that the industrial usage of petro-chemical raw materials will render alcohol surplus or obsolete as a raw material, as it is intended to utilize all the 290,000 tons of alcohol expected to be available by the end of the Fourth Plan.

Other papers presented at the concluding session dealt with the production of acetic acid from alcohol, the activity of alumina catalysts during dehydration of alcohol to ethylene, the use of alcohol in the production of pesticides and alcohol as a source of various organic chemicals.

Seminar on Bleaching Earths & Active Carbons

A seminar on Bleaching Earths and Active Carbons will be held at the Regional Research Laboratory, Hyderabad, during 11-13 August 1964. The discussions at the seminar will relate to: (i) Fundamental and applied studies on bleaching earths and active carbons; (ii) Production and economics of the processes involved; (iii) Utilization aspects; (iv) Standards and specifications; and (v) Geology and mineralogical aspects.

Besides scientists and technologists working in the field, representatives of the industry processing these materials are expected to participate. Further particulars may be obtained from the Director, Regional Research Laboratory, Hyderabad 9.

Pekar's Theory of the F-Centre*

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THE theory of colour-centres has been receiving increasing attention of the physicists in recent years. This is evident from the emergence of more elaborate techniques, such as semi-continuum methods, MO-LCAO (Molecular Orbital-Linear Combination of Atomic Orbitals) techniques and calculations involving detailed interactions of the F-electron with the nearest neighbours and the next nearest neighbours, in which the effects due to exchange and finite ion sizes are also considered.

Pekar[1,2] and Buimistrov and Pekar[3,4] have described the F-centre by a quantum mechanical treatment, using the continuum approximation. In this treatment the polarizable crystalline medium is replaced by a continuum which can be described by a macroscopic property, such as the dielectric constant. Pekar visualized a 'smoothed out' picture in which the long-range electrostatic forces are effective and the local forces on the immediate neighbours of the centre are neglected. The continuum picture does not allow localized modes to arise, and it is for just this reason that Pekar's treatment is outstanding in its simplicity and one is rewarded with fairly good results. Hence, an attempt is made in this review to consider Pekar's theory in detail and the method for the calculation of the ground state energy of the F-centre is presented.

The Hamiltonian of the System

Pekar considers the system described by the Hamiltonian

$$H=-\sum_{i=1}^{N}\frac{\hbar^2}{2m_i}\nabla_i^2+\sum_K \tfrac{1}{2}\hbar\omega_K\left(q_K^2-\frac{\partial^2}{\partial q_K^2}\right)+\sum_{K,i}C_K^i q_K \chi_{-K}(\vec{r}_i)+V(\vec{r}) \quad \ldots\ldots (1)$$

where $\vec{r}_i$ is the radius vector of the ith particle, m_i the effective mass which takes into account the periodic potential of the lattice, ω_K the vibration frequency of the continuum corresponding to a wave vector $\vec{K}$, q_K the normal coordinate of the same vibration, C_K^i the coupling constant between this vibration and the ith particle, $V(\vec{r}_1 \ldots \vec{r}_N)$ the potential of the interaction of the particles with each other and with external fields, and

$$\vec{P}(\vec{r}_i)=\sum_K \vec{P}_K \chi_K(\vec{r}_i) \quad \ldots\ldots (2)$$

$$\chi_K(\vec{r}_i)=\sqrt{\frac{2}{V}}\sin\left(\vec{K}.\vec{r}_i+\frac{\pi}{4}\right) \quad \ldots\ldots (3)$$

$$\nabla\chi_K(\vec{r}_i)=\vec{K}\chi_{-K}(\vec{r}_i) \quad \ldots\ldots (4)$$

$$K_j=\frac{2\pi}{L}\nu_j, \quad j=1,2,3$$

$$\nu_j=0,\pm1,\pm2,\ldots\ldots;\ V=L^3$$

Hence, the χ_K's are a complete system of functions normalized in a volume V, comprising a cube of side L. The above Hamiltonian [expression (1)] has been written for a particular branch number of the energy surface.

The Hamiltonian function of any system which executes small harmonic oscillations consists of purely quadratic forms of the normal coordinates and velocities (in this form appear only the squares of these quantities and not their mixed products). In particular, the Hamiltonian of the longitudinal (infrared) vibrations can be represented as

$$H_{\text{opt}_{\parallel}}=\sum_K\frac{2\pi}{c}\left(P_K^2+\frac{1}{\omega_K^2}\dot{P}_K^2\right) \quad \ldots\ldots (5)$$

Here $\vec{P}_K$'s are the normal coordinates describing the longitudinal polarization vibrations and ω_K's the eigen frequencies. The term $\frac{2\pi}{c}P_K^2$ represents the potential energy density and gives the net energy density which has to be expended in setting up an infrared polarization corresponding to a displacement of the ions with the electronic shells adjusted to the new positions of the ions. The parameter c is given by

$$c=\frac{1}{\varepsilon_0}-\frac{1}{\varepsilon} \quad \ldots\ldots (6)$$

where ε_0 represents the polarization of core electrons when nuclei are fixed and ε accounts for the composite polarization behaviour of core electrons and movable nuclei and c describes polarization due to the displacement of ions when core electrons have adjusted themselves to the instantaneous positions of nuclei.

It is advantageous to use the canonically conjugate coordinates

$$q_K=\sqrt{\frac{4\pi}{\hbar\omega_K c}}P_K, \quad p_K=\sqrt{\frac{4\pi}{\hbar\omega_K^3 c}}\dot{P}_K \quad \ldots (7)$$

With these substitutions, Eq. (5) takes the form

$$H_{\text{opt}_{\parallel}}=\tfrac{1}{2}\sum_K\hbar\omega_K(q_K^2+p_K^2) \quad \ldots\ldots (8)$$

The classical equations of motion for ions (in the absence of conduction electrons) have the form of

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

the canonical equations

$$\hbar\dot{q}_K = \frac{\partial H_{\text{opt}_\parallel}}{\partial p_K}, \quad \hbar\dot{p}_K = -\frac{\partial H_{\text{opt}_\parallel}}{\partial q_K}$$

The energy operator is obtained by replacing p_K by $-i\frac{\partial}{\partial q_K}$ in Eq. (8) to obtain the second term in Eq. (1).

By means of a well-known formula in electrostatics, the potential of the interaction between an electron of charge e and the polarization field due to lattice vibrations can be expressed as

$$V'(\vec{r}) = e\int \frac{(\vec{r}-\vec{r}_1).\vec{P}(\vec{r}_1)}{|\vec{r}-\vec{r}_1|^3}\, d\tau_1 \qquad \ldots (9)$$

where $\vec{r}_1$ is the point where the charges are situated and we have to find the potential energy at the point whose radius vector is $\vec{r}$. The total polarization can be written as

$$\vec{P}(\vec{r}) = \vec{P}_\parallel(\vec{r}) + \vec{P}_\perp(\vec{r})$$

where $P_\parallel$ and $P_\perp$ represent the polarizations set up due to longitudinal and transverse infrared vibrations respectively of the lattice.

If we substitute this in Eq. (9) for $V'(\vec{r})$ and put $\operatorname{div}\vec{P}_\perp = 0$ then the term with $\vec{P}_\perp$ vanishes on integration. Hence

$$V'(\vec{r}) = e\int \frac{(\vec{r}-\vec{r}_1).\vec{P}_\parallel(\vec{r}_1)}{|\vec{r}-\vec{r}_1|^3}\, d\tau_1 \qquad \ldots (10)$$

The potential $V'(\vec{r})$ thus does not depend on the normal coordinates of the transverse polarization waves. Substituting Eqs. (2), (3), (4) and (7) in Eq. (10) and using the relation

$$\frac{1}{|\vec{r}-\vec{r}_1|} = \frac{1}{2\pi^2}\int \frac{\exp[-i\vec{l}.(\vec{r}-\vec{r}_1)]}{l^2}\, d^3l$$

we obtain

$$V'(\vec{r}) = A\int \frac{d^3l}{l^2}\int \cos\left(\vec{K}.\vec{r}_1+\frac{\pi}{4}\right)\exp[-i\vec{l}.(\vec{r}-\vec{r}_1)]\, d^3r_1$$

where $$A = -\sum_{\vec{K}} \frac{e}{2\pi^2}\sqrt{\frac{\hbar\omega c}{4\pi}}\sqrt{\frac{2}{V}}\, q_K K$$

$$V'(\vec{r}) = A(2\pi)^3\left[\int\frac{d^3l}{l^2}\delta(\vec{K}+\vec{l})\,\frac{\exp\left(-i\vec{l}.\vec{r}+i\frac{\pi}{4}\right)}{2} + \int\frac{d^3l}{l^2}\delta(\vec{K}-\vec{l})\,\frac{\exp\left(-i\vec{l}.\vec{r}-i\frac{\pi}{4}\right)}{2}\right]$$

$$= A(2\pi)^3\left[\frac{1}{K^2}\,\frac{\exp\left(i\vec{K}.\vec{r}+i\frac{\pi}{4}\right)}{2} + \frac{1}{K^2}\,\frac{\exp\left(-i\vec{K}.\vec{r}-i\frac{\pi}{4}\right)}{2}\right]$$

$$= A(2\pi)^3.\frac{1}{K^2}\cos(\vec{K}.\vec{r}+\pi/4)$$

$$= \sum_K C_K q_K \chi_{-K}(\vec{r})$$

where $$C_K = -\frac{e\sqrt{4\pi\hbar\omega c}}{|\vec{K}|} \qquad \ldots . (11)$$

Hence, we have all the terms in the Hamiltonian where the first term represents the kinetic energy of the particles, the second the energy of free vibration of the continuum and the third the interaction between the particle and continuum. The first three terms constitute the energy of the polaron. Pekar considers the problem of a polaron under the influence of an electrostatic potential $V(\vec{r}) = -\frac{Ze}{\varepsilon r}$ due to a vacancy.

The energy levels are calculated by a direct variational method which is valid for any strength of coupling.

Choice of Approximate Wave Function

This approximation, also known as Born-Oppenheimer approximation, represents in principle an extreme simplification. According to this approximation, the function of the electronic and nuclear coordinates $\Psi(\vec{r}, \vec{q})$ can be decomposed into a product of functions $\Psi(\vec{r}, \vec{q}) = \psi(\vec{r})\Phi(\vec{q})$. The electronic wave function depends parametrically on the instantaneous positions of the nuclei q_K. The nuclear wave function, however, depends upon the electronic state and not on the positions of the electron. This approximation apparently is equivalent to saying that electrons move so much more rapidly than nuclei that nuclei may be taken to be at rest at any particular moment. Consequently, as the coupling strength becomes greater and greater, the multiplicative approximation becomes more and more exact. This is explained by observing that the particle moves so fast in its potential well that the slowly moving continuum feels only the average field of the ψ-cloud of the particle.

The continuum moves as if it were subjected to a given external force. The field of the ψ-cloud produces a displacement in the equilibrium positions of the continuum coordinates q_K. The equilibrium values of these coordinates are the functionals of ψ. If the coupling is weakened, the particle motion becomes slower and the continuum begins to feel the instantaneous field of the particle. Then the equilibrium positions of the continuum coordinates

become the functions of the particle positions, and can be represented as

$$q_K^0 = q_K^0(\vec{r}_1 \ldots \vec{r}_N)$$

Thus, the approximate wave function of the system is written as

$$\Psi(\vec{r}, q_K) = \psi(\vec{r}) \prod_K \Phi_K(q'_K) \quad \ldots (12)$$

The functional

$$\bar{H} = \int \Psi^* \hat{H} \Psi \, d\vec{r} dq, \quad dq = \prod_K dq_K$$

is minimized with the supplementary conditions that Ψ be normalized. To do this, a transformation from the variables $\vec{r}_i \ldots q_K$ to the variables $\vec{r}_i \ldots q'_K$ is made. The Jacobian of the transformation is unity. The transformation is given by

$$q'_K = q_K - q_K^0(\vec{r}) \text{ and } \vec{r}'_i = \vec{r}_i$$

Writing the x-component

$$\frac{\partial}{\partial x_i} = \sum_j \frac{\partial x'_j}{\partial x_i} \cdot \frac{\partial}{\partial x'_j} + \sum_K \frac{\partial q'_K}{\partial x_i} \cdot \frac{\partial}{\partial q'_K}$$

$$= \frac{\partial}{\partial x'_i} - \sum_K \frac{\partial q_K^0}{\partial x_i} \cdot \frac{\partial}{\partial q'_K}$$

Therefore

$$\frac{\partial^2}{\partial x_i^2} = \frac{\partial^2}{\partial x_i'^2} - \sum_{K_1} \frac{\partial}{\partial x'_i}\left(\frac{\partial q_{K_1}^0}{\partial x_i} \cdot \frac{\partial}{\partial q'_{K_1}}\right) - \sum_K \left(\frac{\partial q_K^0}{\partial x_i} \cdot \frac{\partial}{\partial q'_K}\right)\frac{\partial}{\partial x'_i}$$

$$+ \sum_{KK_1}\left(\frac{\partial q_K^0}{\partial x_i} \cdot \frac{\partial}{\partial q'_K}\right)\left(\frac{\partial q_{K_1}^0}{\partial x_i} \cdot \frac{\partial}{\partial q'_{K_1}}\right)$$

Changing K to K_1, in the second term

$$= \frac{\partial^2}{\partial x_i'^2} - \sum_K \frac{\partial^2 q_K^0}{\partial x_i^2} \cdot \frac{\partial}{\partial q'_K} - 2\sum_K \frac{\partial q_K^0}{\partial x_i} \cdot \frac{\partial^2}{\partial x'_i \partial q'_K}$$

$$+ \sum_{KK_1} \frac{\partial q_K^0}{\partial x_i} \cdot \frac{\partial q_{K_1}^0}{\partial x_i} \cdot \frac{\partial^2}{\partial q'_K \partial q'_{K_1}}$$

generalizing

$$\nabla_i^2 = \nabla_i'^2 - \sum_K (\nabla_i^2 q_K^0) \frac{\partial}{\partial q'_K} - 2\sum_K (\nabla_i q_K^0) \cdot \nabla_i \frac{\partial}{\partial q'_K}$$

$$+ \sum_{KK_1} (\nabla_i q_K^0) \cdot (\nabla_i q_{K_1}^0) \frac{\partial^2}{\partial q'_K \partial q'_{K_1}} \quad \ldots . (13)$$

The energy operator in terms of the new variables is then given by

$$\hat{H} = -\sum_{i=1}^N \frac{\hbar^2}{2m_i}\left[\nabla_i^2 - 2\sum_K\left(\nabla_i q_K^0 \cdot \nabla_i \frac{\partial}{\partial q'_K}\right)\right.$$

$$\left. + \sum_{KK_1} (\nabla_i q_K^0 \cdot \nabla_i q_{K_1}^0) \frac{\partial^2}{\partial q'_K \partial q'_{K_1}} - \sum_K (\nabla_i^2 q_K^0) \frac{\partial}{\partial q'_K}\right]$$

$$+ \sum_K \frac{\hbar\omega_K}{2}\left[(q_K^0 + q'_K)^2 - \frac{\partial^2}{\partial q_K'^2}\right]$$

$$+ \sum_{K,i} C_K^i (q_K^0 + q'_K) \chi_{-K}(\vec{r}_i) + V(\vec{r}) \quad \ldots (14)$$

To obtain $\bar{H}$ the assumption is made that the functions ψ, Φ_K are normalized and real. Then using the identities

$$\int \Phi_K \frac{\partial \Phi_K}{\partial q'_K} dq'_K = 0$$

and writing

$$\overline{\varphi(\vec{r})} = \int \varphi(\vec{r}) \, |\psi(\vec{r})|^2 \, d\vec{r}$$

minimization of $\bar{H}[\Psi]$ with respect to Φ_K (which are exactly the displaced harmonic oscillator wave functions) is carried out, keeping ψ constant. In deriving the resulting $\bar{H}[\Psi] \equiv Q[\psi \ldots q_K^0]$ the quantization volume is allowed to become infinite. $Q[\psi \ldots q_K^0]$ is further minimized with respect to q_K^0 keeping ψ constant. The Euler equation that is obtained is complicated and has been solved by Pekar only in the cases of weak and strong coupling. In both these cases the solution is given by

$$q_K^0 = \sum_i a_K^i \chi_{-K}(\vec{r}_i)$$

where a_K^i are suitable constants. The above approximation for q_K^0 is utilized in the general case to give the final energy expression:

$$Q[\psi \ldots a_K^i] = J[\psi] + \sum_K \hbar\omega_K (n_K + \tfrac{1}{2}) + \sum_{K,i} \frac{\hbar^2}{2m_i} a_K^{i^2}$$

$$\times \overline{|\nabla_i \chi_{-K}(\vec{r}_i)|^2}(n_K + \tfrac{1}{2}) + \sum_{K,i,i_1}\left[\frac{\hbar\omega_K}{2} a_K^i a_K^{i_1} + C_K^i a_K^{i_1}\right]$$

$$\times \overline{[\chi_{-K}(\vec{r}_i)\chi_{-K}(\vec{r}_{i_1}) - \chi_{-K}(\vec{r}_i)\,\chi_{-K}(\vec{r}_{i_1})]}$$

and

$$J[\psi] = \sum_{i=1}^N \frac{\hbar^2}{2m_i} \int |\nabla_i \psi|^2 d\vec{r} - \sum_K \frac{1}{2\hbar\omega_K}$$

$$\times \overline{[\sum_i C_K^i \chi_{-K}(\vec{r}_i)]^2} + V(\vec{r}) \quad \ldots (15)$$

Ground State Energy

The ground state energy is the absolute minimum of the functional given by expression (15), in which all n_K's are set equal to zero. The minimum is then found by a direct variational method.

If $\psi = \text{constant} = V^{-1/2}$, which corresponds to the case $V(\vec{r}) = 0$ in the limit of weak coupling $C_K^i \to 0$, then

$$\overline{\chi_{-K}(\vec{r}_i)} = 0; \quad \overline{\chi_{-K}(\vec{r}_i)\chi_{-K}(\vec{r}_{i_1})} = \frac{\delta_{i,i_1}}{V};$$

$$\overline{|\nabla_i \chi_{-K}(\vec{r}_i)|^2} = \frac{K^2}{V}; \; J[\psi] = 0 \quad \ldots (16)$$

These relations are then substituted in Eq. (15) and the result is minimized with respect to the a^i_K, which gives

$$a^i_K = -\frac{C^i_K}{\frac{\hbar^2K^2}{2m_i} + \hbar\omega_K}$$

and the ground state energy becomes

$$E_0 = -\frac{1}{2V}\sum_{K,i=1}^{N}\frac{C^{i^2}_K}{\frac{\hbar^2K^2}{2m_i} + \hbar\omega_K} \quad \ldots (17)$$

In particular, in the polaron problem which has $N = 1$, $\omega_K = \omega$ independent of $\vec{K}$, and using relations (6) and (10) the ground state energy of the polaron becomes

$$E_{0P} = -\alpha\hbar\omega, \quad \alpha = e^2ch^{-3/2}\left(\frac{m}{2\omega}\right)^{1/2} \quad \ldots (18)$$

The above equation was obtained earlier by Gurari[5] and Lee *et al.*[6] by using variational methods, and by Frohlich *et al.*[7] who used the perturbation theory.

Pekar found that the approximation [Eq. (12)] also gave the correct ground state energy in the strong coupling limit. If use is made of the approximation

$$\psi(\vec{r}) = \prod_{i=1}^{N}\psi_i(\vec{r_i})$$
$$\psi^2_i(\vec{r_i}) = \psi^2_i(-\vec{r_i})$$

then

$$\overline{|\nabla_i\chi_{-K}(\vec{r_i})|^2} = \frac{K^2}{V}; \quad \overline{|\chi_{-K}(\vec{r_i})|^2} = \frac{1}{V};$$
$$\overline{\chi_K(\vec{r_i})} = V^{-1/2}\,\overline{\cos\vec{K}.\vec{r_i}} \quad \ldots (19)$$

When these values are substituted in Eq. (14) and the result minimized with respect to a^i_K, the energy becomes

$$Q = J[\psi] - \frac{1}{2V}\sum_{K,i}\frac{C^{i^2}_K(1-\overline{\cos\vec{K}.\vec{r_i}})^2}{\frac{\hbar^2K^2}{2m_i} + \hbar\omega_K(1-\overline{\cos\vec{K}.\vec{r_i}})} \quad \ldots (20)$$

Pekar next chose the trial wave function as

$$\psi(\vec{r_i}) = \left(\frac{2\beta_i}{\pi}\right)^{3/4}\exp(-\beta_i r_i^2) \quad \ldots\ldots (21)$$

In this case

$$\overline{\cos\vec{K}.\vec{r_i}} = \exp\left(-\frac{K^2}{8\beta_i}\right) \quad \ldots\ldots (22)$$

For an F-centre where $V = -\frac{Ze^2}{\varepsilon r}$ making use of Eqs. (11), (18) and (22), writing $\omega_K = \omega$ and further replacing sums by integrals according to the rule

$$\sum_K f(K) = (2\pi)^{-3}V\iint f(\vec{K})dK_1dK_2dK_3$$

Pekar obtains

$$Q_F = J[\beta] - \frac{2e^2c\sqrt{\beta}}{\pi}\int_0^\infty \frac{[1-\exp(-x^2)]^2dx}{bx^2+1-\exp(-x^2)} \quad \ldots (23)$$

where

$$x = \frac{K}{2\sqrt{\beta}}; \; b = \frac{2\beta\hbar}{m\omega}$$

and

$$J[\beta] = \frac{3\hbar^2\beta}{2m} - \frac{e^2\sqrt{\beta}}{\sqrt{\pi}}\left(c+2^{3/2}\frac{z}{\varepsilon}\right)$$

The ground state energy of the F-centre is given by the minimum value of Eq. (23) with respect to β.

In the strong coupling limit, β is large and only the terms of $J[\beta]$ of order β and $\sqrt{\beta}$ are utilized and the second term in Eq. (23) of order $1/\sqrt{\beta}$ is neglected. Then minimization with reference to β gives

$$\beta = \left(\frac{m^2e^4}{9\pi\hbar^4}\right)\left(c+2^{3/2}\frac{z}{\varepsilon}\right)^2 \quad \ldots\ldots (24)$$

and substitution of this value of β gives for the ground state energy

$$E_F = -\frac{me^4}{6\pi\hbar^4}\left(c+2^{3/2}\frac{z}{\varepsilon}\right)^2 - 1{\cdot}76\hbar\omega\Big/\left(1+2^{3/2}\frac{z}{\varepsilon c}\right) \quad \ldots. (25)$$

The polaron ground state energy (E_{0P}) can be obtained by setting $Z = 0$ in Eq. (25) for the strong coupling case as

$$E_{0P} = -(0{\cdot}106\alpha^2 + 1{\cdot}76)\hbar\omega \quad \ldots. (26)$$

Similarly, the following trial wave functions also give fairly good results:

$$\psi_{1S}(\vec{r}) = A\exp(-\beta|\vec{r}|), \; A = \frac{\beta^{3/2}}{\sqrt{\pi}} \quad \ldots (27)$$

$$\psi_{1S}(\vec{r}) = A(1+\beta|\vec{r}|)\exp(-\beta|\vec{r}|), \; A = \frac{\beta^{3/2}}{\sqrt{7\pi}} \quad \ldots (28)$$

In the case of the expression given by Eq. (27)

$$\overline{\cos\vec{K}.\vec{r_i}} = \frac{4\beta^2}{(4\beta^2+K^2)^2} \quad \ldots\ldots (29)$$

When the first wave function is substituted, the second term in Eq. (20) becomes

$$-\frac{2\beta e^2\hbar\omega c}{\pi\hbar\omega}\int_0^\infty \frac{\left[1-\frac{1}{[1+x^2]^4}\right]^2dx}{bx^2+\hbar\omega\left[1-\frac{1}{[1+x^2]^4}\right]}$$

where

$$x = \frac{K}{2\beta} \quad \text{and} \quad b = \frac{2\beta^2\hbar}{m\omega}$$

In the denominator, we neglect the second term with respect to the first (a good approximation if $b > 4$). Minimization of Eq. (20) yields for this wave function

$$\beta = \frac{me^2}{\hbar^2}\left(\frac{z}{\varepsilon}+\frac{5c}{16}\right) \quad \ldots\ldots (30)$$

and

$$E_F = -\frac{1}{2}\frac{me^4}{\hbar^2}\left(\frac{z}{\varepsilon}+\frac{5c}{16}\right)^2 - 1{\cdot}23\hbar\omega\left(\frac{2z}{\varepsilon c}+\frac{5}{8}\right)^{-1} \quad \ldots\ldots (31)$$

For the second wave function, i.e. that given by expression (28)

$$\overrightarrow{\cos K.r_i} = \frac{64\beta^6}{7}\cdot\frac{28\beta^2+K^2}{(4\beta^2+K^2)^4}$$

On substitution, the second term of Eq. (20) becomes

$$\frac{2e^2\hbar\omega c}{\pi}\beta\int_0^\infty \left[1-\frac{(7+x^2)^2}{49(1+x^2)^8}\right]^2 dx \Big/ bx^2+\left[1-\frac{(7+x^2)}{49(1+x^2)^8}\right]$$

where

$$x = \frac{K}{2\beta} \text{ and } b = \frac{2\beta^2\hbar}{m\omega}$$

The second term in the denominator can be neglected if $b > 8$. On minimization of Eq. (20) we have

$$\beta = \frac{me^2}{2\hbar^2}\left(\frac{3z}{\varepsilon}+c\right) \quad \ldots\ldots\ldots (32)$$

and

$$E_F = -\frac{27}{56}\frac{me^4}{\hbar^2}\left(\frac{z}{\varepsilon}+\frac{c}{3}\right)^2 - 1{\cdot}89\hbar\omega\left(\frac{3z}{\varepsilon c}+1\right)^{-1} \quad \ldots\ldots (33)$$

If one compares Eqs. (25), (31) and (33) for the F-centre ground state energy, with the corresponding results of the multiplicative approximation used by Pekar[1] in his earlier work, one finds that the second term in these equations is new and always negative.

Another series of states of this system can be obtained by putting the electron into the state

$$\psi_{2p} = 8(\alpha^5\beta^5/2\pi)^{1/2}\, r \exp(-2\alpha\beta r)\cos\theta$$

where β is given by Eqs. (24), (30) and (32) and α is the new variation parameter.

Buimistrov and Pekar[4] have also extended these calculations for the polaron, taking into account the translational symmetry of the system.

Conclusion

The foregoing review thus indicates that Pekar's treatment has a great methodological value. In this treatment, once the continuum approximation is made, one adheres to it faithfully in the subsequent development of the theory, unlike many other models where one has to rely on a series of approximations of doubtful validity.

Admittedly, the starting assumptions of the continuum model are rather stringent and it should not be applicable to centres like those in alkali halides. However, the calculations based on the model give results better than one would expect. This leads one to expect that the parametrization of this theory continues to be appropriate, at least in the lowest order of approximation, even for a more realistic theory.

The usual requirements for the validity of the effective mass approximation and for the usefulness of the concept of a dielectric constant are most probably not met in most of the better known F-centres. However, it appears that these parameters may still play a dominant role in the theory of F-centres with an altered interpretation of their physical significance. In other words, there exists promise in a more sophisticated theory of the F-centre as a superstructure on the continuum model of Pekar.

Summary

Pekar's quantum mechanical treatment of the theory of the F-centre using the continuum approximation is reviewed. The ground state energy of the F-centre is calculated by using three different types of trial wave functions for the electron trapped in a negative ion vacancy. Calculations show that the three trial wave functions give equally good values for the ground state energy of the F-centre. The approximations made in Pekar's theory are fulfilled most in the case of the hole trapped in a positive ion vacancy in cuprous oxide.

Acknowledgement

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Principles & Applications of Parametric Amplifiers

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PARAMETRIC amplifiers are comparatively a new class of solid state devices whose existence was completely unknown only a few years ago. The feasibility of such a device was first pointed out in a paper by Manley and Rowe[1] as late as 1956. They considered the energy relations in a non-linear reactor and from the mathematical analysis of the problem they showed that if certain frequency relations be maintained in three tuned circuits coupled to this non-linear reactor, this gives the possibility of amplification at two of these frequencies due to the appearance of negative resistance in their input. Since the appearance of Manley and Rowe's paper[1], considerable work has been done for the practical realization of such a device and, within a short space of only a few years, parametric amplifiers have been developed which can be used in systems satisfying the stringent requirements of stability and non-fallibility.

Though the basic principles involved are the same, these amplifiers have taken various physical configurations to suit the particular work for which they were developed. However, the basic ideas underlying each of them are the same. Therefore, in this review the fundamental principles on which the working of this amplifier is based are explained without attempting to describe all the different versions of these amplifiers which have been developed up to date. A few important applications and its improved performance over some other conventional types of amplifiers are also briefly considered.

The term parametric amplifier has been coined because of the fact that in the differential equation which governs its operation, one or more of the parameters vary with time as will be seen later. However, this class of amplifiers have three very distinctive features: (i) they draw energy from an r.f. source rather than from a d.c. source, (ii) they behave as the bilateral negative resistance at the amplifying frequency, and (iii) they are capable of very low-noise amplifications.

How these characteristics are obtained is discussed in detail in the following:

The basic principle of operation of the parametric amplifier rests on the fact that when two resonant circuits are suitably coupled to a non-linear reactor whose value or parameter is made to vary in a certain way, energy may be extracted from the source which drives the energy storage element and may be transferred to the resonant circuit of the either circuit.

For this energy transfer to take place the frequency of the driving source, usually called the pumping frequency, must be simply related to the frequencies of the two resonant circuits, called the idling and the signal frequencies. A schematic representation of this arrangement is shown in Fig. 1.

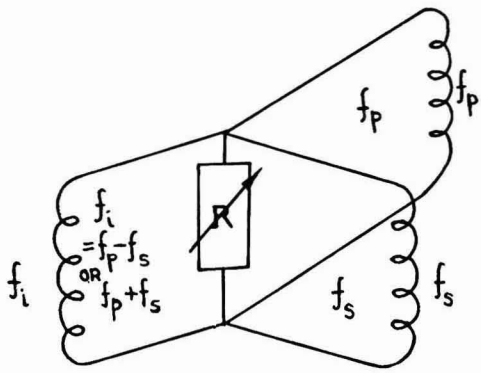

Fig. 1 — Schematic arrangement of the parametric amplifier [R, non-linear reactor; f_p, pumping frequency; f_s, signal frequency; and f_i, idler frequency]

Principle of Operation

For understanding the action of this circuit we may start from the Manley-Rowe relations[1] relating average powers at different frequencies in non-linear reactors. These equations are a consequence only of the assumption of a single valued characteristic (Lorc) of the non-linear element. They are independent of the particular shape of this characteristic, of the power levels at the different frequencies and of the external circuits in which the non-linear reactor is connected. In general, two generators with frequencies f_p and f_s applied to the non-linear reactor produce an infinite set of new frequencies, these being mf_p+nf_s where m and n may take any value from $+\infty$ to $-\infty$. If W_{mn} be the power into the reactor at the frequency mf_p+nf_s it has been shown that

$$\sum_{m=0}^{\infty}\sum_{n=-\infty}^{+\infty}\frac{mW_{mn}}{mf_p+nf_s}=0 \quad \ldots\ldots (1)$$

$$\sum_{n=0}^{\infty}\sum_{m=-\infty}^{+\infty}\frac{nW_{mn}}{mf_p+nf_s}=0 \quad \ldots\ldots (2)$$

where W_{mn} is the power corresponding to the frequency mf_p+nf_s.

These are the well-known Manley-Rowe relations in their most general form. However, if the signal at f_p be very much stronger as compared to f_s, then this will reduce the possible frequencies to a single infinite series in which the higher harmonics of f_s do not appear. For all practical purposes, n will have the values $+1$, 0, -1 so that the possible frequencies in this case will be f_s, f_p, $2f_p \ldots nf_p$, f_p-f_s, $2f_p-f_s \ldots nf_p-f_s$ and f_p+f_s, $2f_p+f_s \ldots nf_p+f_s$.

It is possible to connect a third circuit to the non-linear reactor resonant at a frequency other than f_p and f_s such that it presents a short circuit to any one of this set of frequencies and rejects all the others.

There are two cases of special interest corresponding to the value of $n = 1$ and -1, keeping for the sake of simplicity $m = 1$. For $n = 1$, the three circuits connected to the non-linear reactor have frequencies f_p, f_s and f_p+f_s.

In this particular case, Eqs. (1) and (2) simplify to

$$\frac{W_p}{f_p} + \frac{W_{ps}}{f_p+f_s} = 0 \quad \ldots\ldots\ldots (3)$$

$$\frac{W_s}{f_s} + \frac{W_{ps}}{f_p+f_s} = 0 \quad \ldots\ldots\ldots (4)$$

In Eqs. (3) and (4) it is of utmost importance to define the convention of signs. Any power going into the reactor is taken as positive, such that W_p and W_s, the powers entering into the reactor from the two generators at f_p and f_s, are taken as positive. Hence W_{p+s} with a negative sign is the useful power output of the device.

It is to be noted that power W_s is entering at the frequency and f_s due to the mixing action in the reactor is coming back amplified at the frequency f_p+f_s, the power amplification being given by

$$G = \frac{W_{ps}}{W_s} = (f_p+f_s)/f_s \quad \ldots\ldots\ldots (5)$$

i.e. the gain is directly proportional to the two frequencies. This is not the negative resistance amplifier but is called the ' upconverter ' where gain is obtained at a higher frequency than the signal frequency but at a very low-noise figure. The reasons for this will be discussed later. These modulating devices have been found to be pretty stable and also easily operable.

The second case for $n = -1$ presents features of special interest. Expanding Eqs. (1) and (2) and following the same notations for this case also we obtain

$$\frac{W_p}{f_p} + \frac{W_{p-s}}{f_p-f_s} = 0 \quad \ldots\ldots\ldots (6)$$

$$\frac{W_s}{f_s} - \frac{W_{p-s}}{f_p-f_s} = 0 \quad \ldots\ldots\ldots (7)$$

In this case it is seen that assuming W_p, the power at the frequency f_p to be positive, both W_s and W_{p-s} turn out to be negative, i.e. with only a single generator giving the power at W_p, powers W_{p-s} and W_s flow out in the passive resonant circuits at the frequencies f_s and f_p-f_s. Hence, it is seen that the flow of this difference frequency f_p-f_s introduces negative resistance in both the signal and the idling circuits. The value of this negative resistance has been shown to be proportional to the power W_p. This ability of the pump power to control the value of negative resistance gives the possibility of using this device as an amplifier, and the device when used in this manner is known as a ' parametric amplifier '.

The resonant circuits of f_s and f_p-f_s have a finite positive resistance due to losses. If the value of the negative resistance coupled into them exceeds the total positive resistance, these circuits become unstable and parasitic oscillations are started. However, if the value of this negative resistance is kept just below that of the positive resistance in the circuit, very high gains may be obtained of signals in either of the two circuits at the frequencies f_s and (f_p-f_s).

The equivalent circuit diagram of the signal circuit having this variable negative resistance is shown in Fig. 2.

The condition for oscillation of this circuit is

$$-G = G_T \quad \ldots\ldots\ldots (8)$$

where $G_T = G+G_1+G_L$.

As already mentioned above, for obtaining very high gains, the value of the negative conductance G must be very nearly equal to G_T.

From the above considerations it is clear that the following conditions must be fulfilled for obtaining a parametric amplifier device: (i) highly tuned circuits must be provided for all the three frequencies, namely f_p, f_s and f_i $(f_i = f_p-f_s)$; this condition

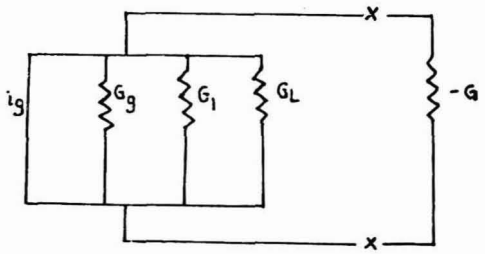

Fig. 2 — Equivalent diagram of the signal circuit [G_g, generator conductance; G_1, circuit loss; G_L, load conductance; $-G$, negative conductance coupled by the non-linear reactor; and i_g, generator current]

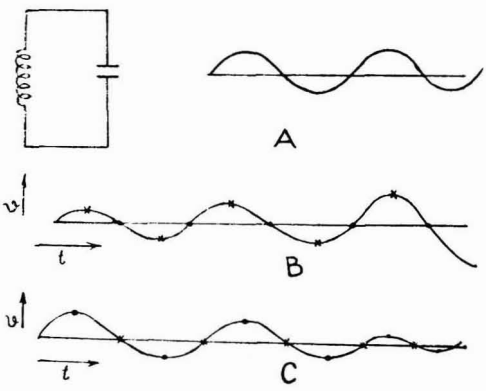

Fig. 3 — Parametric amplification and attenuation of an a.c. signal [A, an LC resonant circuit sustaining a voltage $v = v_0 \sin \omega t$; B, growth of the voltage v when the pushing and pulling of the plates are done in the correct phase; and C, decay of the voltage v when the pushing and pulling of the plates are done in the wrong phase. ×, points at which the plates are pulled apart and •, points at which the plates are pushed in]

necessarily makes the amplifier a narrow band device; (ii) the system must be pumped at a relatively large amplitude; and (iii) the pumping of energy must be done at a higher frequency than that of the signal to be amplified. This system is called a three-frequency amplifier.

However, if in the case considered above $f_i = f_s$, then the system acts as a two-frequency amplifier where the amplification of the signal takes place at half the pumping frequency. However, for such a system to be operable, specific phase relations must be maintained between the two frequencies. The meaning of this statement can be understood by the consideration of the following example.

Consider now the resonant circuit shown in Fig. 3A consisting of a lumped capacitance and inductance. This circuit is sustaining an a.c. voltage at a frequency ω. Imagine now that the condenser plates could be pulled apart or pushed closer at will at the frequency 2ω. Suppose that at the instants corresponding to the maxima or minima of the a.c. voltage in the resonant circuit the plates are suddenly pulled apart. Work is done in this act of pulling against the applied voltage and this energy goes into the tank circuit of the condenser and the inductor. When the value of the applied field is zero, the plates are pushed back so that no work is involved by or against the field in this process. The whole process is repeated with each cycle of pulling and pushing so that the voltage across the circuit will be progressively amplified as shown in Fig. 3B. Imagine now a reverse process, i.e. the plates are pushed in at the maxima of the voltage and pushed out at the zero of the voltage. In this case the work is done by the field, so that the field loses energy with each cycle and the voltage gets gradually attenuated as shown in Fig. 3C. Thus, accurate phase relations must be maintained between the signal and the pumping circuit.

Now if the frequency at which the parameters of the capacitance be varied be at a frequency not exactly equal to twice the frequency of the existing voltage in the circuit, the voltage of the tank circuit will be amplified and attenuated alternatively. Or, in other words, this voltage will be amplitude modulated at a frequency equal to the difference of these two frequencies. If a second circuit resonant at the difference frequency be also coupled to this capacitance, then the phases in both of them are automatically adjusted and the net energy flows in both these tank circuits at their respective resonant frequencies. It means that if a variable capacitor couples two-tank circuits having resonant frequencies f_1 and f_2 and if a signal voltage exists across one of these tank circuits, say at the frequency f_1, then on driving the variable capacitor at a frequency equal to (f_1+f_2), due to the mixing action in this reactor, a voltage is developed in the second circuit at the frequency f_2. The phases in both the circuits are automatically arranged in such a manner that there is a net flow of energy in either of the circuits and thereby amplification is possible at either of the frequencies f_1 and f_2.

This is the same result as that obtained by the more elegant mathematical analysis of Manley and Rowe mentioned earlier.

The Non-linear Reactor

From the generality of Manley-Rowe relations, this non-linear reactance may either be inductive or capacitive.

The first amplifier of this type as proposed by Suhl[2] was based on a non-linear reactance. This non-linear reactance is obtained by the application of a large amount of microwave power on a crystal of ferrite garnet placed inside a cavity. At these high microwave power levels, of the order of kilowatts, due to the spin wave[3] coupling, a non-linear inductance is obtained. However, due to the relatively large amounts of microwave powers involved, the complicated nature of the resonances involved in the ferrite garnets and the uncertainties of many other effects not fully understood, this particular form of amplifier did not become very popular and in recent years much more effort has been directed for the development of parametric amplifiers using non-linear capacitances as will be described below. However, studies are still in progress on ferrite garnets[4,5] and considering the fast strides that the ferrite technology is making it would not be surprising if a major break-through may occur overcoming most of the drawbacks inherent with the use of non-linear inductance in a parametric amplifier.

The use of non-linear capacitance with the parametric amplifier is much more common due to the relative simplicity with which such a device can be obtained and also the pump power required in this case is much less.

A point contact or junction diode when back-biased has an equivalent circuit as shown in Fig. 4A, consisting of a barrier capacitance C_D which is voltage sensitive in series with a constant series resistance R_s. The voltage sensitive barrier resistance which shunts the barrier capacitance is so large in the back-biased condition that it can be neglected. Typical variation of the barrier capacitance, which varies as the square root or the cube root of voltage, is shown in Fig. 4B.

The Q of the diode is given by $1/\omega_{C_D} R_s$ and it is this quantity which determines the noise characteristic of the amplifier as will be seen later. For satisfactory operation of the amplifier both C_D, the minimum capacitance, and R_s must be low, as shown in Fig. 4B. This diode will be inoperable above a

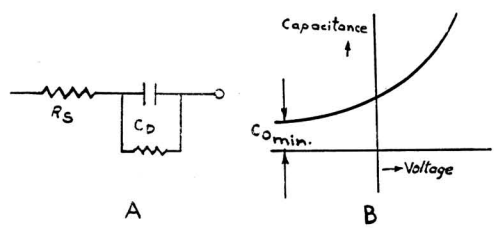

Fig. 4 — Equivalent circuit of a back-biased varactor diope [A, equivalent circuit; and B, variation of the barrier capacitance with voltage]

certain cutoff frequency f_c given by $\omega_c = 2\pi f_c = 1/C_D R_s$, above which the value of Q falls below unity. For normal operation in amplifiers the value of Q must be above 10. The highest frequency to which a diode has been operated is well above 10 kMc/s., and due to the very fast strides which semiconductor technology is making it would not be long before the diodes which can be operated in the millimetric range will be obtained.

Calculation of Noise Figure and Gain-bandwidth of the Amplifier

The expressions for the gain-bandwidth and the noise figure of the amplifier using a non-linear capacitance have been obtained by Heffener and Wade[6] using the equivalent circuit shown in Fig. 5. The two-tank circuits shown in Fig. 5 are coupled by means of a variable capacitor. Let ω_1 and ω_2 be the resonant frequencies of the two-tank circuits, then in this equivalent circuit

$$\omega_3 = \omega_1 + \omega_2 \quad \ldots\ldots\ldots (9)$$

The variable coupling capacitor is now given by

$$C_c = C_3 \sin(\omega_3 t + \phi_3) \quad \ldots\ldots (10)$$

By carrying out the analysis of the circuit for obtaining the expression for the gain-bandwidth, in the manner explained by Heffener and Wade, the equivalent circuit shown in Fig. 2 is obtained at resonance. G is the negative conductance coupled into the circuit at the amplifying frequency. Defining the gain as the ratio of power dissipated in the load conductance to the available generator power:

$$\text{Power gain at resonance} = \frac{4G_g.G_L}{(G_{T_1}-G)^2} \quad \ldots (11)$$

This is a typical expression for all the regenerative amplifiers and indicates that for large gains $G \simeq G_T$.

The expression for the general gain is very complicated using the equivalent circuit of Fig. 5:

$$\text{Power gain} = \frac{4G_g.G_L}{\left\{\frac{G_{T_1}-G}{[1+2\delta Q_2(\omega_1/\omega_2)]}\right\}^2 + 4\delta^2\left\{\frac{G_{T_1}Q_1+G\omega_1/\omega_2 Q_2}{[1+2\delta Q_2(\omega_1/\omega_2)]^2}\right\}^2} \quad \ldots (12)$$

In Eq. (12), δ is the fractional bandwidth of the amplifier, $(\Delta\omega/\omega)$, and Q_1, Q_2 are the quality factors of the signal and the idling circuits respectively.

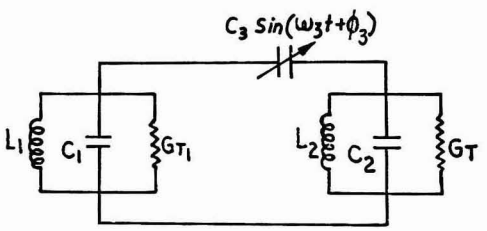

Fig. 5 — Equivalent lumped circuit for the two-tank variable parametric system

To determine the bandwidth we must investigate the general expression as given above and find the value of δ, corresponding to which the power gain is reduced to half the value at resonance.

From Eqs. (11) and (12), the half-power fractional bandwidth is given by

$$2\delta = \frac{G_{T_1}-G}{Q_1[G_{T_1}+G(\omega_1 Q_2/\omega_2 Q_1)]} \quad \ldots (13)$$

Since $(G_{T_1}-G)$ may be related to the square root of the power gain we can write a gain-bandwidth expression as

$$(\text{Power gain})^{\frac{1}{2}} \times \text{Fractional bandwidth} = \frac{2\omega_2(G_g.G_L)^{\frac{1}{2}}}{\omega_2 Q_1 G_{T_1}+\omega_1 Q_2 G} \quad \ldots\ldots (14)$$

Usually Q of the idling circuit is made much larger than that of the loaded amplifying tank circuit and

$$\omega_1 Q_2 G \gg \omega_2 Q_1 G_{T_1}$$

so that

$$(\text{Power gain})^{\frac{1}{2}} \times \text{Fractional bandwidth} = \frac{1}{Q_2}(\omega_2/\omega_1)(G_g/G.G_L/G)^{\frac{1}{2}} \quad \ldots\ldots (15)$$

for high gains $G \simeq G_{T_1}$, so that the quantity $2(G_g/G.G_L/G)^{\frac{1}{2}}$ is at most unity. Hence, the maximum value of the gain-bandwidth product that can be obtained is given by

$$[(\text{Power gain})^{\frac{1}{2}} \times \text{Fractional bandwidth}]_{\max.} = \frac{\omega_2}{\omega_1}\cdot\frac{1}{Q_2} \quad \ldots\ldots\ldots (16)$$

Noise Figure of the Amplifier

Assuming that the signal being amplified is precisely at the resonant frequency of the tank circuit, as from definition, the noise figure (F) is given by

$$F = \frac{S_i/N_i}{S_o/N_o} = (S_i/N_i)(N_o/S_o) = \frac{1}{\text{Power gain}}\cdot\frac{1}{kTB}\cdot N_o \quad \ldots\ldots (17)$$

where S_i/N_i and S_o/N_o are the ratios of signal to noise at the input and output respectively. For the case under consideration

$$F = \frac{1}{4kTB}\frac{(G_{T_1}-G)^2}{G_g.G_L}\cdot N_o \quad \ldots\ldots (18)$$

where k is the Boltzmann constant; B, the noise bandwidth; and T, the standard noise temperature.

The significant noise sources which contribute to N_o are: (i) thermal noise at ω_1 in tank circuit (1), and (ii) thermal noise at ω_2 in tank circuit (2). Taking these two sources into account, the noise figure of the amplifier turns out to be

$$F = 1 + G_1/G_g + G/G_g.\omega_1/\omega_2 \quad \ldots (19)$$

Calculations show that the second term on the right-hand side of Eq. (19), i.e. the term due to thermal noise from G_1, is very small. However, the third term, due to the thermal noise from the idling tank, can be significant.

As at high gains $G \simeq G_g$ the noise figure is given by the ratio of ω_1/ω_2. Comparing Eqs. (16) and

(18) it is seen that keeping a high ratio of ω_3/ω_1 is not only desirable from the point of view of large gain-bandwidth product but also from that of obtaining a low-noise figure. A very high value of the pump frequency is difficult to obtain due to the increase in the i^2R_s losses in the varactor. To avoid this, recourse in some special[7] cases (also Sinha, J. K., unpublished work) may be taken to the use of the second or third harmonic of the pump frequency, i.e. one must provide for the idler a tuned circuit at either $(2f_p - f_s)$ or $(3f_p - f_s)$. This also gives a possibility of amplification at a frequency higher than that of pump frequency.

Some Typical Circuits

One of the first parametric amplifiers to be reported in literature is due to Heffener and Kotzehur[8]. The system used here consists of a multi-resonance cavity being simultaneously resonant at frequencies 3500, 2300 and 1200 Mc/s. The pump power supplied was of the order of 70 mW. and the system could oscillate at either of the two frequencies giving an output of 2 mW. However, a stable gain of 20 db. for a bandwidth of 1 Mc/s. was obtained. The measured noise figure was less than 4·5 db., but this figure could be improved by an order of 2 db. by using the system as a two-port device with the use of a circulator. This system is shown in Fig. 6.

The basic arrangement of a two-frequency amplifier system as reported by Hermann *et al.*[9] is shown in Fig. 7. The pumping power is supplied at

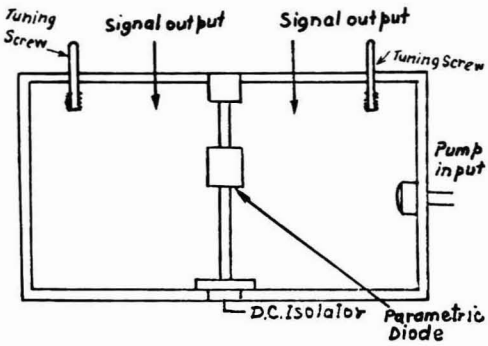

Fig. 6 – Schematic diagram of a multiresonant, cavity resonant at 1200, 2300 and 3500 Mc/s. [Gain, 20 db.; bandwidth, 1 Mc/s.; and noise figure, 4·5 db.]

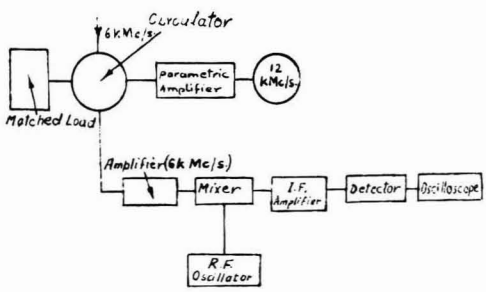

Fig. 7 — Basic circuit used for a two-frequency amplifier

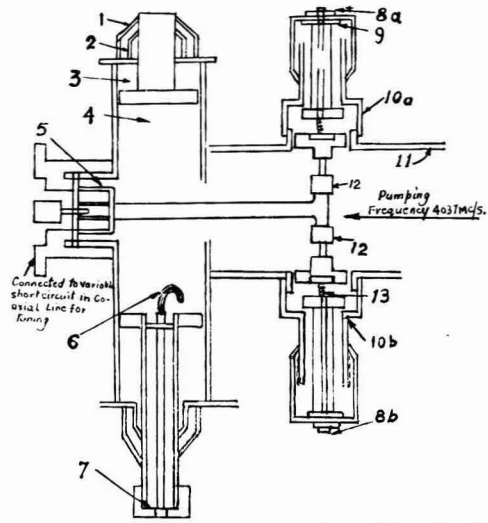

Fig. 8 — Arrangement of the parametric amplifier using the second harmonic of the pumping frequency [1, fixing ring; 2, slotted bush; 3, variable short circuit; 4, cavity sustaining the signal (3824 Mc/s.) and idling (4250 Mc/s.) frequencies; 5, quarter wave bucket at 4037 Mc/s.; 6, coupling loop; 7, input-output terminal of the amplifier; 8a and 8b, positive and negative d.c. terminals respectively; 9, insulating ring; 10a and 10b, provision for adding variable capacitance in series with the diodes; 11, dielectric spacer; 12, back-biased silicon diodes used in push-pull; 13, spring for applying current (d.c.) to crystals]

12 kMc/s. and a stable gain of 45 db. is obtained at the frequency of 6 kMc/s. A stable gain of 18 db. at a bandwidth of 8 Mc/s. has also been reported.

Another system developed by the author (Sinha, J. K., unpublished work) used a second harmonic of the pump. The basic system used is shown in Fig. 8. Here the diodes are used in a push-pull arrangement. The portions marked 10a and 10b are provided for varying the capacitance in series with the diodes and also for application of d.c. voltage. The value of the capacitance was found to be very critical for the operation of the amplifier. A quarter wave microwave choke is also provided for preventing leakage of microwave energy. The cavity (marked 4 in Fig. 8) is resonant at the signal frequency and also the idling frequency which is taken to be in this case as $(2f_p - f_s)$. The block diagram of the arrangement used for the experimental investigations is shown in Fig. 9. At a gain of about 18 db., bandwidths of the order of 3-4 Mc/s. were obtained and the noise figure measured was of the order of 3 db.

Modulator amplifiers have also been made and they turn out to be much simpler to operate. One of such systems at a relatively low frequency has been described by Salzberg and Sard[10] and is schematically shown in Fig. 10. Salzberg and Sard also used a balanced mixer with two crystals. The balanced configuration provides ease of tuning and eliminates the local oscillator noise. The available

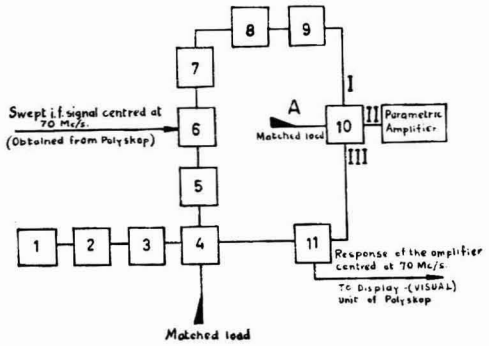

Fig. 9 — Block diagram of the experimental arrangement employed in the study of the parametric amplifier [1, klystron; 2, variable attenuator; 3, band pass filter (3754 Mc/s.); 4, magic-T; 5, 7 and 9, isolators; 6, high level mixer; 8, band pass filter (3824 Mc/s.); 10, circulator; 11, low level mixer; I, II and III represent the three arms of the circulator and A represents the parametric amplifier]

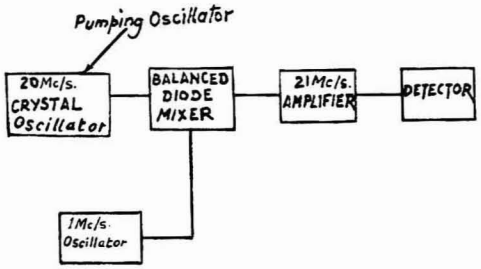

Fig. 10 — The upconverter arrangement of Salzberg and Sard[10] [Power gain, 10 db.; bandwidth, 10 per cent; and noise figure, 0·5 db.]

power gain has been reported to be 10 db. with a 10 per cent bandwidth and a noise figure of 0·5 db.

Recent Developments

All the systems discussed here have been developed four to five years ago. More recently parametric amplifiers have been developed based on the same principles as discussed above but which are much more stable in operation. This has been made possible chiefly due to the developments in the technology of the various components employed in the parametric amplifier system.

In the earlier versions the greatest problem was drift which made it necessary to periodically retune the amplifier to maintain optimum performance. Tuning a parametric amplifier was always a difficult and tedious operation and there was always the possibility of the amplifier going into oscillations, specially at high gain levels. The development of techniques has now progressed to the point that parametric amplifiers are capable of being stable reliable devices that are field operable. Several things have contributed to this accomplishment and probably the most important are the recent strides made in the field of ferrite devices.

As parametric amplifiers are basically one-port reflection devices, a ferrite circulator is used to separate the input and the output signals. Early versions of the circulator were imperfect in many ways. Many of the stability problems of the early parametric amplifiers were directly attributed to the circulator. The development of klystrons for use as pump power sources is another factor which has improved amplifier stability. Desirable characteristics of a pump klystron are a low temperature coefficient and a low modulation sensitivity. The tubes which are presently available provide excellent stability characteristics when placed in an oil filled container to minimize output variations with rapid changes of the ambient temperature.

The availability of better varactor diodes has also contributed to the practical realization of improved parametric amplifiers, principally by allowing development of parametric amplifiers at higher and higher frequencies. The reliability of finished diodes has improved, which is tending to make it possible to replace diodes in the field if necessary. In the past, diode characteristics have varied so much between different units that each amplifier had essentially to be tuned to its own diode.

All these developments have made it possible to take full advantage of the low-noise properties of the parametric amplifiers without having to put up with the associated problems that were connected with the early versions of these devices.

Applications of the Parametric Amplifier

One of the chief applications of parametric amplifiers is for extending the range of radar systems by using them in the receivers. This particular application will be discussed in detail in the following:

The other possible use of these amplifiers may be in the communication systems. However, the bandwidths of these amplifiers are not so large as to enable their use in the wideband communication systems. But this bandwidth problem may be overcome by using the travelling wave version of the amplifier, and considerable efforts are now being directed in this direction for the development of a travelling wave version[11,12] of the parametric amplifier. However, no such version has yet been made feasible at the microwave frequencies although some success has been reported at the lower frequencies[13].

Another possible application is with radio astronomy[14,15] for cases where the requirements of low-noise power are not such as to warrant the use of maser which has a lower noise figure than that of parametric amplifier but only at the expense of liquid helium and complicated external circuitry.

A concrete example of what can be done to improve an existing radar system using parametric amplifiers is available from the results of the testing programme carried out with the Melabs model X217[16] parametric amplifier on an American radar system in USA.

During the development of X217 the primary emphasis was placed on two characteristics: achievement of a noise figure less than 2 db. and establishing a stability specification which would allow the amplifier to be used with the radar system for extended periods without adjustment. The laboratory

tests revealed that the amplifier met requirements of noise figure, gain, bandwidth and stability. The operation for a period of 24 hr revealed that the gain remained within $\pm 0{\cdot}5$ db. of a nominal 20 db. gain.

Laboratory tests were revealing but the real proof lies in operational tests with the amplifier actually installed in a radar system. A comparison may be made between the normally operating system and the system with the parametric preamplifier installed. This was done at several installations in the US.

The electrical tests usually consisted of the following: (i) measurement of normal radar minimum detectable signal (MDS), (ii) the MDS with the amplifier in but inoperational, (iii) measurement of MDS with the amplifier operational, and (iv) monitoring of the MDS with the amplifier operating over several hours.

These tests established respectively: (i) the initial operational condition of the radar, (ii) the insertion loss of the amplifier when it is not operating, (iii) the degree of sensitivity improvement effected by the amplifier, and (iv) the long-term stability or the drift rate of the amplifier.

The results of three tests performed at three installations, summarized in Table 1, illustrate the advantage of using the parametric amplifier.

Some of the above-mentioned tests required a full 8 hr day for completion. The system was allowed in each case 15-20 min. to stabilize and then operated through the entire test period without adjustment or apparent degradation in performance.

From the results of the testing programme coupled with the results obtained from the preamplifier developed by the manufacturers, it can be said that the parametric amplifier has come to stay as a utility radar component.

The parametric amplifier has developed into a stable reliable device through the contributions of several advances in technique. By virtue of its proved capability to improve system performance with a minimum of installation problems and without contributing significantly to the complexity of the system, the parametric amplifier is ideally suited for incorporation in military radar systems as a means of extending their operational lifetime.

TABLE 1 — OPERATIONAL TEST DATA IN RADAR SYSTEMS WITH AND WITHOUT THE PARAMETRIC AMPLIFIER INSTALLED

	Minimum detectable signal, db. below 1 mW.		
	Radar only	Amplifier off	Amplifier on
Site No. 1	99·49	98·46	106·63
Site No. 2	91·30	89·90	103·40
Site No. 3	106·00	104·20	111·10

Summary

The basic principles of operation of the parametric amplifier are explained. Some of the actual parametric amplifier systems, developed in the early years of the growth of this branch of solid state technology, are described. The performance characteristics of a commercial parametric amplifier used in one of the radar systems are given in order to bring out the considerable advantage achieved by the use of this device over other conventional types of amplifiers.

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Development of Corrosion Resistant Alloys

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CORROSION is a global problem. The magnitude of the problem is clear from the fact that USA spends approximately 8 million dollars a year on measures for the control and prevention of corrosion. Similar estimates in UK, Australia and Canada put the annual figures at £ 600 million, £ 160 million and $ 300 million respectively. The exact figure for corrosion losses in India is not available, but it is estimated to be of the order of Rs 150 crores a year. These figures indicate that an important aspect of corrosion loss is that it increases with increase in the tempo of industrialization in a country. Only a decade back, the problems of corrosion did not draw much attention in India. However, with rapid industrialization of the country during successive five-year plans, corrosion with all its facets poses a real problem.

In this context, the Metals Committee of the Council of Scientific & Industrial Research constituted a Corrosion Advisory Bureau for studying corrosion problems in India and for framing a coordinated programme of research on national basis. The Bureau functions through several subcommittees so as to cover different aspects of corrosion research. Work on corrosion carried out at the National Metallurgical Laboratory (NML) can be classified under the following heads: (i) atmospheric corrosion, (ii) immersed corrosion, (iii) buried metal corrosion, (iv) power plant corrosion, and (v) conjoint mechanical and chemical corrosion. The problem of corrosion under various conditions of exposure is tackled by studying the factors controlling corrosion and prevention of corrosion by electrochemical or metallurgical adjustment of the composition of the materials used. This paper is concerned with the latter part of the problem, viz. metallurgical adjustment of the composition of materials or the development of corrosion resistant alloys.

The choice of materials of construction in industry is governed by several factors, the most important factor being the ability of the materials to stand the service conditions under the specific environment. With the growth of chemical, pharmaceutical, oil and fertilizer industries in India, the preparation of corrosion resistant materials for a variety of applications is of paramount importance. The present paper, besides reviewing the progress achieved in the development of different types of alloys based on indigenous resources, indicates the future lines of research and development.

High Tensile Low Alloy Steels

The strength of these steels as measured by the yield point is *c.* 50 per cent higher than that of structural carbon steels and their resistance to atmospheric corrosion is 4-6 times that of carbon steel. The chemical composition of these steels is specially adjusted to obtain improved mechanical properties and greater resistance to atmospheric corrosion as compared to conventional carbon structural steels. High strength low alloy steels are generally produced to mechanical property requirements rather than to chemical compositional limits, for they find application where saving in weight can be effected because of their superior strength and atmospheric corrosion resistance. These steels are normally furnished in as-rolled, as-annealed, as-normalized, or as-stress-relieved condition, and are intended for use without further heat treatment except for post-welding stress relieving treatments sometimes employed in conjunction with metal arc welding.

The development of low alloy high strength steels started with the introduction of silicon steels, which were soon replaced by steels with low additions of manganese, chromium and molybdenum to which part additions of copper were provided. Among several types of low alloy steels developed, two have generally established themselves; one in which, besides copper addition, a medium manganese content is coupled with a moderate chromium addition, and the other with higher manganese contents, without chromium addition. Manganese steels are considered to be better weldable. Attempts have been made to develop good welding steels to have still higher strengths (minimum, 38 tons/sq. in.) and yield strengths (> 25 tons/sq. in.) by a slight increase in silicon and manganese content together with additions of titanium or vanadium[1].

As compared to good welding straight manganese steels, manganese-copper steels offer, for lightweight welded constructions, the advantages of improved corrosion resistance and weldability, and are, therefore, specially suitable for lightweight coach construction. Structural steels produced at present (Tiscrom and Tiscor) by the Tata Iron & Steel Co. Ltd have a medium chromium and manganese content; Tiscrom has high yield ratio resulting from high phosphorus additions.

Tiscrom has a yield point of *c.* 22 tons/sq. in. (minimum), tensile strength of 37-43 tons/sq. in. and elongation of 18 per cent ($\frac{3}{8}$ in. and above, minimum), and satisfies the requirement of BSS No. 548 IRS, M-23/48. Tiscor has a yield point of *c.* 22 tons/sq. in. (minimum), tensile strength of 31 tons/sq. in. (minimum), and elongation of 20 per cent (minimum), in addition to superior corrosion resistance. These steels are claimed to have 50 per cent higher safe-working stress than mild steel, but, as far as it is known, their welding behaviour is not satisfactory.

Tiscrom steel was extensively used in the construction of the Howrah Bridge. Its distinctive characteristics are high yield point and ultimate tensile strength with good ductility, high resistance to corrosion and good workability in the as-rolled condition.

Atmospheric corrosion resistance of Tiscor is 4-6 times that of ordinary mild structural steel and 2-3 times that of corrosion resistant copper steels. Its high resistance to corrosion distinguishes Tiscor from other low alloy high strength structural steels.

Tiscor is used in the as-rolled condition without any heat treatment and can be readily fabricated employing the same methods and equipment as used for mild steel with minor changes in operating conditions.

Considerable work has been done on the development of low alloy high strength steel in other countries, but the main direction Indian investigations may profitably follow would be to find compositions readily weldable while possessing adequate strength resulting from suitable air-cooling transformation characteristics with adequate corrosion resistance under tropical conditions. Such compositions may be based on extended use of manganese than hitherto done. Their weldability and corrosion resistance under Indian conditions will have to be investigated thoroughly. A suggested combination may have the following compositions: C, 0·15-0·19; Si, 0·40-0·80; Mn, 1·4-1·6; P, 0·035 (maximum); S, 0·035; Cr, 0·30-0·60 per cent; and Cu, optional.

Low alloy molybdenum-boron steels have better weldability than Tiscrom, but are likely to have lower corrosion resistance. The use of molybdenum, however, is debatable under Indian conditions though it is worth serious consideration. Introduction of molybdenum to the extent of 0·20 per cent and of manganese to the extent of 1·6 per cent (maximum) will tend to depress the temperature of transformation of austenite on air cooling, and thus produce a structure in which the carbide phase is finely dispersed through the ferrite matrix. The properties of these steels depend largely on the rate at which they cool from the austenitic range and thus on the thickness of section. Addition of 0·10-0·15 per cent molybdenum produces a slight depression in the transformation temperature, resulting in increased yield stress of the order of 4-5 tons/sq. in. without appreciably affecting the shape of the stress-strain curve. The notch ductility of these manganese-molybdenum high tensile steels is much greater than that of ordinary mild steel. This steel can be made as a semi-killed or fully killed and grain-controlled steel employing various conditions of heat treatment depending on the degree of notch ductility required.

Important among the newly developed steels are those containing titanium, vanadium and boron. Boron has been found to bring about maximum improvement in the properties of steel, specially in the presence of titanium or zirconium. The effects of these alloying elements on the strength of the material depend on the way in which they modify the transformation of austenite during cooling and refine the grain size. The aggregates of carbide and ferrite and hardening of ferrite matrix determine the strength and toughness of the steel. A recent development in this field is an alloy of the following composition[2]: C, 0·14; Mn, 0·78; Si, 0·25; Cr, 2·05; Mo, 0·53; and B, 0·0033 per cent. This alloy has a tensile strength of 76·9 tons/sq. in., yield strength of 51·2 tons/sq. in. with an elongation of 19·4 per cent and reduction in area of 56·7 per cent. The alloy is claimed to possess good welding properties.

Investigations taken up at NML have been aimed at developing low alloy high tensile steels utilizing indigenous alloying elements and possessing good weldability and corrosion resistance besides high strength to weight ratio. Steels containing different proportions of manganese, chromium, copper and in a few cases phosphorus have been investigated. Small proportions of vanadium and titanium were further added to the basic heats to study their effects with a view to hardening the ferrite and producing smaller grain size, both of which are known to impart higher strength. In a few cases, additions of aluminium and zirconium were also made with the object of getting finer grain size.

Some of the heats which showed promising results in respect of tensile strength (40 tons/sq. in. or above) and yield point (*c.* 30 tons/sq. in. and higher) are given in Table 1. These alloy steels showed good weldability. Atmospheric corrosion tests for these alloy steels are in progress. It is expected that due to low carbon content and the presence of some chromium and copper, these low alloy steels would have better corrosion resistance than normal plain carbon structural steels. In addition to these studies, a long-range research and development programme of work on low alloy steels at NML is concerned with the following projects: (i) studies on the melting practice to minimize the non-metallic inclusions in 1·5 per cent Mn steel; (ii) development of Mn-Mo steels with 0·2-0·4 per cent Mo (these steels will be similar to other standard steels but with lower Mo content, in which India is deficient); (iii) Cr and Cr-Mn steels with 0·5-1·6 per cent chromium and 0·3-1·4 per cent manganese; (iv) Cr-V steels with 0·6-1·8 per cent chromium and 0·1-0·15 per cent vanadium; (v) Cr-Mo steels with 0·9-6·0 per cent chromium and 0·2-1·0 per cent molybdenum; (vi) Ni-Cr steels with 0·7-3·0 per cent nickel and 0·7-1·0 per cent chromium; (vii) Ni-Cr-Mo steels with 1·0-3·0 per cent nickel, 1·0-1·7 per cent chromium and 0·1-0·6 per cent molybdenum; and (viii) effects of additions of boron to engineering steels.

Low Alloy Steels Resistant to Sulphide Cracking

Cracking of oil well tubing in deep bore condensate wells due to the presence of hydrogen sulphide is a problem of considerable importance in oil and natural gas production. Conventional Mn-Mo or Cr-Mo type high strength steels are susceptible to cracking due to the diffusion of atomic hydrogen into the metal produced by the action of hydrogen sulphide on steel. The problem of finding a suitable alloy for the above purpose has evaded solution for a long time. Extensive investigations carried out in France have led to the development of Cr/Al/Mo and Cr/V/Mo type low alloy steel[3] which has a thermodynamically stable structure of carbon-free ferrite with highly dispersed fine carbides. The alloy (C, 0·12; Cr, 1-2; Mo, 0·2-0·3; and Al, 0·3-1·0 per cent) possesses, in addition to good resistance to sulphide cracking, excellent physical properties with yield strength of 23-28 tons/sq. in. Lacq

TABLE 1 — CHEMICAL COMPOSITION AND PROPERTIES OF LOW ALLOY HIGH TENSILE EXPERIMENTAL HEATS

Sl No.	Heat No.	Chemical composition, %									Tensile properties				Weldability
		C	Mn	Cr	Si	S	Cu	P	V	Ti	Ultimate tensile strength tons/sq. in.	Yield stress tons/sq. in.	Elongation %	Reduction in area %	
1	21/5	0·21	1·69	1·16	0·16	0·020	0·63	0·004	0·09	—	45·7	—	25·00	63·4	Fair
2	21/7R	0·05	2·27	1·02	0·40	0·028	0·32	0·030	—	0·06	57·9	30·52*	18·75	54·6	Good
3	38	0·03	0·90	—	1·85	—	0·51	0·090	0·05	Trace	41·76	23·41*	31·00	60·0	do
4	39	0·09	1·39	—	1·68	—	0·44	0·070	—	0·02 Al	45·35	24·65*	31·20	57·0	do
5	37/3	0·07	1·34	—	0·62	—	0·44	0·070	Trace	0·06	36·42	25·75*	36·00	69·3	do
6	38/3	0·04	1·36	—	0·50	—	0·46	0·060	0·115	—	39·60	32·25	37·50	71·0	do
7	40/2	0·19	1·35	—	0·50	—	0·39	0·063	—	—	41·46	27·90	25·00	48·7	do
8	41/2	0·09	1·11	—	0·26	<0·04	0·45	<0·040	0·10	—	43·20	36·72	29·70	65·5	do
9	41/4	0·10	1·10	—	0·31	<0·04	0·42	<0·040	0·10	—	40·67	30·58	31·00	63·4	do

*0·1 per cent proof stress.

gas (methane, 69·2; other hydrocarbons, 5·4; nitrogen, 0·6; carbonic acid, 9·6; and hydrogen sulphide, 15·2 per cent), considered to be the most corrosive gas, is found near Pau in Lower Pyrenees in France. In view of the failure of American recommended gas carrying tubes, Acieries de Pompey were asked to develop a steel for the purpose. As a result, APS 10M4 steel was produced and the tubes of this steel were treated to obtain a thermodynamically stable structure containing carbon-free ferrite and finely dispersed carbides. These tubes have since been successfully used (*Fr. Pat.* 644,712; *U.S. Pat.* 360,677). Other laboratories in France have also developed certain steels for service under such corrosive conditions, e.g. MOVP steel with chromium 2·5 per cent; molybdenum 1 per cent and vanadium 0·5 per cent, developed by Uniaux Laboratories; Uranus 50 steel containing chrome, nickel, molybdenum and copper with an austenitic ferrite structure for corrosion proof well head valves of Lacq, developed by Societé Lorraine-Escaut; Virgo 7A steel with 13 per cent chromium is expected either to accelerate the linear velocity of the gas or to eliminate the introduction of corrosion inhibitors into the wells. Another steel under development at Lorraine-Escaut for tube manufacturing is Inoxesco 13 also with 13 per cent chromium for carrying the gas from the wells. These examples point to the need for developing similar steels for use under identical service conditions in India.

Stainless Steel

Stainless steel is used under various corrosive conditions. A common variety of stainless steel is the 18: 8 Cr-Ni austenitic stainless steel. However, this alloy is extensively used under mildly corrosive conditions even though less corrosion resistant alloys may well be used in its place.

Research and development work carried out during World War II in several countries showed the possibilities of partial substitution of nickel by manganese. Due to lower austenite stabilizing power of manganese, weight for weight replacement of nickel by manganese is not possible and in the presence of *c.* 15 per cent chromium it is no longer possible to render the low carbon alloys completely austenitic solely by the addition of manganese. Thus the addition of nickel or copper, or both, in addition to manganese was recommended by Mitchel[4]. On the basis of these findings, various alloys have been developed containing chromium, manganese and nickel in the proportions 18 : 4 : 4; 16 : 16 : 1; 17 : 6 : 4; 18 : 10 : 4, etc. Some of the results of studies on the partial replacement of nickel by manganese carried out at NML have been reported in an earlier communication[5] along with the corrosion resistance data for the steels obtained. The results obtained indicate that Cr-Mn-Ni steels can be readily worked down with good mechanical properties up to 0·25 per cent carbon and 0·1-0·2 per cent nitrogen. Compared to 18: 8 Cr-Ni steels, these steels possess higher yield and ultimate tensile strength without marked decrease in ductility and compare well with 18 : 8 Cr-Ni steel in respect of resistance to scaling at high temperature and corrosion resistance under mildly corrosive conditions.

The corrosion resistance properties of these alloys can be further improved by the addition of 2-3 per cent molybdenum to Cr-Mn-Ni (18 : 10-15 : 0·37-0·47) alloy[6]. The corrosion resistance of this type of alloy has been well established both in the laboratory and on plant scale. This work was further extended at NML to replace nickel completely by the addition of manganese along with nitrogen and copper, as both of them are strong austenite stabilizers. Such chromium-manganese-nitrogen stainless steels are stronger than 18 : 8 type stainless steel and have over 60 tons/sq. in. tensile strength. The percentage elongation on 1 in. gauge length ranged from 40 to 48; the steels also show adequate deep drawing properties.

Rare Earth Additions to Alloy and Stainless Steels

The advantages of the additions of misch metal in alloy and stainless steels have been reported. Cerium addition has been shown to improve the oxidation characteristics of nickel-chromium alloys such as the 80-20 wires and grids used for electrical heating elements. Allegheny-Ludlum Steel Corp., USA, has found rare earth oxide addition to stainless steels so advantageous that it has been adopted as a standard practice in their plant. Most working improvements obtained with misch metal additions have led to the development of alloys which could not under ordinary circumstances be manufactured commercially, particularly sulphuric acid resisting wrought stainless steels. Carpentar austenitic stainless steel No. 20 containing Cr 20, Ni 29, Mo 2 and Cu 3 per cent, which could previously be made available only in cast form, can now, on misch metal additions, be produced in wrought bars, strips, wire, sheet, etc. It is only wrought stainless steel which resists corrosion by hot boiling sulphuric acid of concentrations up to 10 per cent and resists the action of even concentrated sulphuric acid at 175°F.

Precipitation Hardening Stainless Steels

Stainless steels of the precipitation hardenable type are finding increasing applications as material of construction for air-frame components in high speed aircraft, as they offer not only the desired property of high strength but also the advantages inherent in their ' stainlessness ' and ease of fabrication. The well-known precipitation hardenable steels developed during the last decade are ' 17-4PH ', ' 17-7PH ' and ' PH15-7 Mo ' (Table 2).

The high strength values of these steels are related to martensitic transformation. Recently, it has been shown that high strength could be obtained from an austenitic structure also by solid hardening, carbide precipitation or intermetallic compound precipitation. So far the development of high strength stainless steels has been based on the use of nickel as one of the constituents. Extensive work has been carried out at NML in an attempt to replace a part of the nickel in making these steels by manganese. The use of interstitial elements like carbon and nitrogen and isothermal heat treatment has been tried to achieve extra high strengths. The steels investigated in this programme are 17 : 8 Cr-Mn-N steels and 17 : 6 Cr-Mn-N steels with and without the additions of small amount of nickel.

TABLE 2 — COMPOSITIONS OF PRECIPITATION HARDENABLE STAINLESS STEELS

	17-4PH steel	17-7PH steel	PH15-7 Mo steel
Carbon, %	0·04	0·07	0·07
Chromium, %	16·20	17·00	15·00
Nickel, %	4·00	7·00	7·00
Molybdenum, %	—	—	2·25
Aluminium, %	—	1·15	1·15
Copper, %	3·50	—	—
Niobium-tantalum, %	0·25	—	—

Further work in this series contemplated includes the study of (i) the effects of phosphorus additions, (ii) precipitation hardening effects produced by carbon and nitrogen, and (iii) the addition of aluminium, titanium, vanadium and boron singly or in combination with Cr-Mn-N steels to achieve extra high tensile strengths.

Heat Resistant Alloys

The requisite characteristics of heat resisting steels are: high ultimate strength and ductility, resistance to creep, resistance to corrosion and oxidation, resistance to thermal fatigue or shocks, and weldability and machinability. Standard creep resisting alloys vary from simple low alloy steels to high alloy steels and complex nickel and cobalt based alloys. In superheater tubes in medium pressure steam power plants for temperatures up to 900°F., low alloy steels of Mo or Cr-Mo type can be safely used as far as resistance to creep and oxidation is concerned. For temperatures of 540°C. and above, it, however, becomes necessary to use high alloy steels and for temperatures of 700°C. and above nickel or cobalt based alloys are used.

Resistance to residual ash corrosion — A greater part of the fuel ash released during combustion goes out along with the combustion gases, but a part of it is deposited on the walls of the boiler tubes or the blades of the turbine. Once a deposit has formed, its growth becomes inevitable and it impairs heat transfer properties and also under certain conditions reacts with the metal structure and causes corrosion. The resistance to corrosion of turbine blades and boiler tubes due to such ash deposits requires investigation.

Corrosion by residual ash from fuel oil has been studied extensively, but very little information is available about high temperature corrosion by fuel ash from coal. The problem is of importance in view of the fact that as a result of some recent developments, such as the increasing use of pulverized coal-fired boilers, fuel ashes with temperatures as high as 950°C. have to be handled. The nature of attack by both coal and fuel oil ash is similar. In both cases, the damage is due to low melting complex alkali sulphur. While in the case of fuel oil ash the corrosive species consists of sodium sulphate and vanadium oxide, in coal ash deposits the corrosive constituents are sodium and potassium sulphates and sulphur trioxide.

Resistance to corrodents other than gases and fuel ash — High temperature alloys used in the construction of steam turbines are required to possess, in addition to creep resisting properties, resistance to superheated steam and chlorides with which the steam is generally contaminated. Under such conditions, ferritic steels have been found to be most suitable.

Development of High Temperature Alloys in India

The majority of high temperature alloys are based on Fe-Cr, Co-Cr or Ni-Cr groups. In each of these alloy groups, the alloying elements, e.g. Cr, Mn, Fe, Co, Ni, etc., go into solution and thereby impart the necessary strength and oxidation resistance. However, in practice, it is necessary to introduce substantial amounts of other elements, e.g. titanium, vanadium, molybdenum, copper, tungsten, zirconium, etc., which form complex carbides. These complex carbides are known to increase the creep resistance of the alloys by increasing the complexing effect.

The development of heat resisting alloys in India requires immediate attention as these alloys occupy an important position in the alloy steel industry. For medium pressure boilers in which temperatures of up to 900°F. are encountered, the low alloy steels containing Mo or Cr-Mo can be used safely. Further improvement in the properties of alloys can be brought about by the addition of other carbide forming elements, viz. vanadium, titanium, niobium, etc., singly or in combination. Recently, it has been found that mild steel can be used for temperatures up to 400°C. after being subjected to certain special treatments. Investigations carried out at the Research and Development Laboratory, United Steel Companies Ltd[7], have shown the importance of small metallic and non-metallic elements in controlling the properties of metals and alloys. This improvement in the properties is due to the fact that an increase in the amount of aluminium nitride beyond an optimum proportion increases the grain size while excess nitrogen in solution imparts good creep resistance. Thus, by adding aluminium and nitrogen in certain well-defined proportions, it is possible to obtain a cheap high temperature steel. This improved quality mild steel will be specially suitable for such applications where a steel with good low temperature impact properties combined with good creep resistance at moderately high temperatures is required.

Ferritic stainless steels containing 10-17 per cent chromium possess excellent oxidation resistance, but improvement in their creep resistance by the addition of carbide forming elements needs attention, as this will help in the conservation of nickel in the production of nickel bearing 18:8 stainless steel. In this connection, the possible use of chromium bearing ferritic stainless steel for resistance to high sulphur coal ash in boilers requires investigation, as chromium steels appear to be more resistant than similar alloys containing nickel. The use of chromium steels in the construction of baffles fixed in front of superheater tubes is of special interest, since they are not subjected to load.

Another class of improved heat resistant alloys for use in the temperature range 550-650°C. which need detailed investigation are silicon and aluminium based alloys. Silicon and aluminium improve the oxidation resistance of steels considerably, but when added to steel singly in substantial amounts they have an adverse effect on its working properties. The creep resistance of alloys containing silicon or aluminium is also not satisfactory. Some silicon-aluminium steels developed at the Fulmer Research Institute, UK, possess high oxidation resistance. These steels have such a low carbon content (even down to 0·02 per cent) that it hardly seems proper to classify them as steels. The silicon content varies from 1 to 4 per cent. In materials combining both aluminium and silicon, the proportion of aluminium ranges from virtually zero to 3 per cent. The addition of 1 per cent chromium along with aluminium to high silicon bearing alloys increases their oxidation resistance at high temperatures. The oxidation resistance of the silicon-aluminium steels when exposed in air at 100°C. is comparable to that of austenitic stainless steel. The corrosion resistance at high temperatures of silicon-aluminium alloys has been found to be superior to that of mild steel in flue gas, synthetic atmospheres akin to flue gas but free from sulphur, air containing different proportions of moisture, and air containing both sulphur dioxide and sulphur trioxide. Aluminium and silicon bearing alloys are particularly suitable for such applications where much stress is not applied, e.g. for constructing machinery for thermal cracking of petroleum products, superheater tube hangers, heating elements, exhaust valves of internal combustion engines, etc.

Investigations have been carried out at NML on the effect of additions of Mn, Zr, V, Ti, B, etc., on (i) high temperature strength, (ii) brittleness due to grain growth, (iii) creep properties, and (iv) workability of Fe-Cr-Al based heating elements (with 10-25 per cent chromium and 3-8 per cent aluminium). The addition of some of these elements to these alloys has been found to be beneficial, and the resulting alloys can replace some imported heating alloys, such as ' nichrome ' and ' kanthal ' alloys.

Alloys for gas turbines — So far only nickel-base alloys have been considered standard construction materials for gas turbines. Though it is not possible to replace nickel completely, partial replacement of nickel may be possible. The earliest nickel-base alloys developed for high temperature applications were the nimonic group alloys containing *c.* 80 per cent nickel. But recent advances in the production of more complex alloys like Udimet 500, M-252, etc., containing only *c.* 50 per cent nickel have helped in the conservation of nickel. Such substitution has been brought about by the addition of small amounts of carbide and nitride forming elements like molybdenum, titanium, aluminium, etc. The formation of intermetallic compounds as in the case of nickel and aluminium has been shown to have a beneficial effect on the creep resisting

properties of the alloys. Development of heat resistant alloys, therefore, needs further study to determine factors promoting the high temperature strength of these materials. A better understanding of the role of the alloying principles is necessary before a greater number of alloying elements can be made use of in the production of these alloys. The most urgent problem facing India is to find substitute alloying elements for non-indigenous ones.

High temperature oxidation resistance — Alloys intended for service at high temperature should possess resistance to oxidation besides satisfactory high temperature creep strength and toughness. Oxidation is a gas-metal reaction accompanied by the formation of a solid reaction product on the metal surface. Once the solid reaction product is formed, further growth of the film is controlled by the stability of the film and diffusion of both gas and metal through the film. Heat resistant alloys commonly contain chromium as one of the alloying elements in the range 12-35 per cent. There are, in general, three groups of alloys: (1) chromium steels and cast irons, (2) austenitic Cr-Ni steels, and (3) Ni-Cr alloys. While alloys of group (2) contain at least 50 per cent iron and more chromium than nickel, group (3) alloys contain less than 30 per cent iron and considerably higher amounts of nickel than chromium.

Materials for use in atomic reactors — With increasing use of atomic energy for peaceful purposes, the problem of developing suitable alloys for nuclear reactors has become important. The materials used for reactors have to meet very stringent requirements. They should have (i) good resistance to corrosion, (ii) low neutron absorption cross-section, (iii) good strength and resistance to creep at elevated temperatures, and (iv) stability towards irradiation. Various types of fluids have been considered for the primary cooling system, the most important among which are high purity water and liquid metals.

Water-cooled nuclear reactors — Some of the present-day reactors are water-cooled reactors and various materials considered for use in their construction are aluminium, magnesium, zirconium, niobium and their alloys, stainless steel, Inconel, etc. Commercial aluminium has been found to be quite satisfactory for use up to 100°C., but for use at higher temperatures, it has been found necessary to use aluminium alloys containing nickel, iron, copper, etc. Alloys containing Ni 2 per cent, Fe 0·5 per cent, Si 0·2 per cent, Ti 0·2 per cent, Tr 0·05 per cent, and Be 0·05 per cent have been found to possess excellent resistance to corrosion in reactors operating at 220-250°C. For reactors operating at temperatures around 350°C., considerable development work is needed.

Zirconium and its alloys require greater attention since, in addition to their low neutron absorption cross-section, they are highly resistant to the action of water at high temperatures and possess good mechanical properties at high temperatures. Among the important alloys are Zircaloy-2 and 3. However, these alloys are also susceptible to damage by hydrogen picked up by them. Further work in the development of zirconium-based alloys by adding niobium, tin, iron, chromium and nickel is needed. Stainless steel and Inconel also possess good resistance to corrosion and have been used in some cases, in spite of their high neutron absorption cross-section. The high cost of such metals and alloys and stainless steels has prompted investigations towards the development of cheaper alternate materials. Work in this connection at the United States Atomic Energy Commission to evaluate carbon and low alloy steels as substitutes for stainless steel needs special mention.

Liquid metal coolants — Among liquid metal coolants, the most important are Na, Na-K eutectic, Bi, Pb, Pb-Bi eutectic, etc. Liquid metal coolants are specially needed for fast reactors. The problem of materials resistance to liquid metal corrosion has assumed special importance since the development of nuclear energy and considerable work is needed to evolve suitable materials. A special type of damage due to corrosion — material transport — is peculiar to liquid metals, whereby the material or an alloying component of the material dissolves in the coolant stream and is reprecipitated in another part, finally blocking the passage completely.

Many of the commercial engineering materials are resistant to the action of sodium and sodium-potassium up to 1000°F. Among the materials which need special mention are alloy steels of types 347, 310 and 316, Inconel X, etc. Carbon and low alloy steels or high chromium steels possess good resistance to corrosion by lead or lead-bismuth eutectic, but these readily attack stainless steel, Inconel, and some highly alloyed ferrous and non-ferrous materials.

Cast irons — Cast irons and alloyed cast irons can be used under various conditions involving the use of concentrated caustic soda, sulphuric acid, nitric acid and chromic acid. Unalloyed cast iron is not resistant to dilute acids, but when alloyed with nickel (Ni-resist), silicon (Duriorn) or silicon-molybdenum (Durichlor), its resistance to both weak and strong acids improves manifold.

A great impact on engineering design in a number of industries has been made since the introduction of SG iron. This alloy has found innumerable uses where strength and ductility properties better than those of ordinary cast iron are needed. Spheroidization of graphite is brought about by treating the molten cast iron with magnesium or other elements in small amounts. The success of the treatment depends on the composition of pig iron and so the possibilities of producing SG iron from Indian pig iron by inoculating it with different elements need careful study. Trial heats have been carried out at NML with a number of synthetic pig irons by inoculating them with calcium, zirconium, boron, zinc, sodium and magnesium. Only magnesium gave 100 per cent nodulization while calcium, zirconium and boron gave mixed nodules and flakes. Addition of sodium was found to give only graphite clusters whereas zinc did not give appreciable nodulization. Alloying of SG iron to reduce pitting type of attack which occurs under certain conditions needs investigation.

Nickel alloys — For several corrosive conditions encountered in the chemical industry, nickel-molybdenum alloys of Hastelloy group are important. However, these alloys are susceptible to weld decay, i.e. intergranular corrosion near the welds, which is due essentially to precipitation of molybdenum carbide at the grain boundaries near the welded zone. This type of attack can be minimized by lowering the carbon content and by additions of other alloying elements to modify the mechanism of carbide precipitation. Austenitic stainless steel is also made resistant to weld decay in a similar manner. Addition of stronger carbide forming elements such as vanadium, niobium, etc., is expected to reduce this type of attack. Addition of *c.* 2 per cent vanadium to Hastelloy containing 0·03 per cent carbon has been shown to reduce intergranular attack.

Ni-Cr-Mo-Fe alloys — In recent years, considerable attention has been paid to the development of alloys likely to possess resistance to a wider range of oxidizing and reducing acid environments and better resistance to pitting and stress-corrosion cracking in chloride environments than the Ni-Mo or Cr-Ni stainless steels. As a result of extensive research, Ni-Cr-Fe-Mo-Cu (40-45 : 21-22 : 21-31 : 3-6·5 : 1·25 per cent) alloys have been developed which are cheaper than Hastelloys and possess enhanced resistance to corrosion under reducing and oxidizing conditions[8].

High tensile aluminium-bronzes — Complex high tensile aluminium-bronzes are established engineering materials. In recent years, by the addition of manganese, nickel and small amounts of iron to aluminium-bronzes, alloys have been developed which are specially suitable for use in propellers, pumps, valves and condenser components. However, aluminium-bronzes are susceptible to stress-corrosion cracking. The addition of cadmium, tin or silver to these alloys has been claimed to have a beneficial effect by rendering them immune to intergranular stress-corrosion cracking in steam or other oxidizing aqueous acid and caustic vapours.

Rare earth additions to non-ferrous alloys — Apart from its use as deoxidizer in copper and copper alloys, addition of misch metal (1·3-11·0 per cent) to light metal and alloys, such as aluminium and magnesium alloys, increases their high temperature strength properties. Improved alloys have also been obtained by the addition of *c.* 0·3 per cent rare earth metals to Al-Cu-Si piston alloys and of 0·05-0·3 per cent rare earth metals to aluminium alloys containing manganese; Zr-Mg alloys have been found useful for fabricating jet engine parts. As alloying elements in amounts of the order of 1-3 per cent, rare earth metals raise the creep resistance of magnesium-base alloys and permit their use at elevated temperatures in aero-engines.

Metallic coatings — In most corrosion problems encountered, only one side of the surface comes into actual contact with the corroding medium. It is, therefore, economical to construct the main body of the component with a less corrosion resistant cheaper alloy and then coat the surface with a corrosion resistant alloy. This type of sandwiched structure can be developed either by rolling or by diffusion treatment.

Cladding generally consists of hot rolling of the 'sandwich block' prepared by edge welding of the assembly. The chief potentiality of this process lies in the production of clad steels where stainless steel or aluminium is clad over mild steel. While the former is of importance to chemical industries, the latter can be used for structural purposes. The possibilities of using aluminium cladding on creep resisting superheater alloy steel (Mo or Cr-Mo) for resistance against sulphates in coal-fired boilers offer scope of commercial application.

Studies have been carried out at NML on the cladding of stainless steel and aluminium on mild steel. By hot rolling a suitable 'sandwich' to the final required size it has been possible to get a composite structure possessing good ductility and deep drawing characteristics. Rolling temperatures found suitable for stainless steel and aluminium are 1150° and 500-550°C. respectively.

In addition to cladding, improvement in the corrosion resistance of the surface exposed to corrosive media may be accomplished by diffusion treatment. Other treatments like chromizing, siliconizing, calorizing, etc., also offer attractive propositions. The usefulness of these treatments is, however, limited by the size of material that can be treated. It is, therefore, necessary to investigate alternate treatments. Increase in the aluminium content of the surface layer can be brought about by spraying or hot dip aluminizing followed by high temperature diffusion treatment. Similarly, chromium, molybdenum, etc., can be deposited on the surface at high temperatures under low pressure from their vapourized halides.

Lines of Future Development

After World War II, significant advances have been made in the production technology of metals like titanium, zirconium, tantalum, niobium, etc., whose use as alloying elements is of recent origin. Alloys of these metals have scope for wide application in different fields. The main deterrent to their greater use as materials of construction is their high cost. However, India is favourably placed in respect of these metals. Titanium, the cheapest of the group, is the most versatile, specially in the construction of equipment for missiles, jet engines, chemical plant equipment, etc. While zirconium and niobium are finding increasing use in the field of atomic energy, tantalum is expected to be economical for use under high temperature corrosive chemical environments.

Cermets are another class of materials holding considerable promise for high temperature applications. For these applications, cermets are required to be resistant to oxidation and from this consideration, metal-bonded titanium carbide group of alloys is one of the most important. However, considerable research work is required to quantitatively assess the effects of such factors as shape and size of distribution of hard phases, and the type of binder material on strength and hardness. Similarly, research on new high temperature alloys based on intermetallic compounds is gaining prominence.

Some of the compounds worth investigating are silicides such as chromium silicide, molybdenum silicide, and aluminides such as nickel aluminide and titanium aluminide. Also of interest will be intermetallic compounds of transition metals such as $ZnCr_2$, Cr_2Ti, etc.

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Summer School in Nuclear Spectroscopy

A Summer School in Nuclear Spectroscopy will be held in Bangalore during 21 May to 11 June 1964 under the auspices of the Tata Institute of Fundamental Research, Bombay. Course of lectures at the school will be given by (1) Prof. B. R. Mottelson on Nuclear Coupling Schemes and Collective Motion; (2) Prof. I. Talmi on Shell Model Calculations of Nuclear Energies; and (3) Prof. C. A. Levinson on Hartree-Fock Methods in Nuclear Structure Theory. The courses will be for students who are well acquainted with the modern trends of the physics of nuclear structure calculations and who are either doing or planning to start research either in the theoretical or experimental aspect of the field. Further information regarding the school can be had from Dr S. K. Bhattacharjee, Tata Institute of Fundamental Research, Colaba, Bombay 5.

REVIEWS

NUTATION AND FORCED MOTION OF THE EARTH'S POLE FROM THE DATA OF LATITUDE OBSERVATIONS by Ye. P. Fedorov; translated from the Russian by Bertha S. Jeffreys (Pergamon Press Ltd, Oxford), 1963. Pp. xix+152. Price 50s.

This is an authoritative work with a rigorous mathematical approach attempting to reconcile the modern mathematical theory of earth's rotation with all the astronomical observations available at present. Starting with Oppolzer's classical theory of rotation for an absolutely rigid earth, the author points out some of the fundamental departures between the predictions of theory and field observations, one of the most notable among which is the 14-month period 'Chandler' wobble.

He then traces the historic development of the problem through the work of Hough, based on the assumption of a liquid core for the earth, as also the work of Newcomb who took into consideration the effect of elastic deformation of the earth on its rotation and showed that this should increase the Eulerian period.

In Chapter I the fundamental theory of precession and nutation is developed using the vector and tensor method. Whereas Oppolzer obtained the forced variation of latitude as one of the results of his theory of rotation for an absolutely rigid earth, the author treats the analogous problem with the fundamental assumption that the earth is an ideally elastic body. After deriving an equation of motion for the angular momentum vector, G, and the equations of precession and nutation, the author shows that the elastic deformation of the earth does not affect the motion in space of the angular momentum vector and also concludes that the equations of motion are practically unchanged for any assumptions about the interior of the earth, since for all admissible assumptions the tidal deformation of the earth has so little effect on the inertia ellipsoid and hence its effects may be omitted from the moments of external forces.

In Chapter II he takes up the nutation and forced motion of the earth's pole. After evolving the relation expressing the effect of the principal nutation terms on declination, the corrections for the nutation constant and for the ratio of coefficients of the principal nutation terms and the phase lags are derived in terms of a series of coefficients which in turn are determined from three cycles of extended latitude observations made by the International Latitude Service covering the period 1900-1934. Each of the three cycles constitutes observations on an average of nearly 25 star pairs covering periods well beyond one nutation cycle, namely 19 years. The method of reduction is discussed in exhaustive detail incorporating reduction to a common system of declination and proper motions, corrections for aberration due to Jupiter and Saturn, correction for small nutation terms, evaluation of correction for mean micrometer screw value, etc. In concluding the chapter, an exhaustive comparison is made of the value of nutation constant obtained from the analysis with those given by seven authors over the last half century.

Chapter III deals with the problem of forced motion of the pole with this fundamental question foremost—Does the forced motion take place in conformity with the theory of an elastic earth? The author takes up harmonic analysis of the latitude observations for evaluating the lunar diurnal and semidiurnal terms of latitude variation, using a highly condensed scheme of handling original data. After obtaining the final expression for the lunar diurnal term in latitude variation a comparison is made of the small periodic variation of latitude (period about a day) caused by the nutational motion of the instantaneous axis of rotation — generally referred to as the Oppolzer terms — with that predicted by the theory developed in Chapter I for an ideally elastic earth. While the period of 1·079 siderial day gives agreement on both sides, the radius of the circle of motion as deduced from the observations is almost double that predicted by theory as developed for an elastically deformed earth.

In the last chapter, the author makes an attempt to explain the causes of some of these discrepancies. Instead of the oversimplified model of a totally solid earth he assumes a liquid core of dimensions demanded by present-day seismological evidence and takes into account possible interactions between the elastic shell and the liquid core. In concluding the discussion he points out that the effect of the core on the motion of the shell is probably not limited to mechanical forces at the core boundary but also other forces, for example, those of a magnetic nature.

This exhaustive treatment is of immediate interest to geodesy as well as astronomy and leaves the serious reader convinced that a problem started almost a century and a half ago by Euler, Lagrange and others still poses a challenge to astronomers, solid earth geophysicists and space geophysicists alike. The reading of the work is necessarily slow in places, specially to those who may not be familiar with conventional terminology. The English translation from the original Russian by Bertha S. Jeffreys has been most perfect, in that the arguments at every stage of the discussion are brought out with lucidity. The foreword by Sir H. Jeffreys laying the theoretical groundwork for the problem of forced motion of earth's pole makes a fitting introduction to this serious and scholarly work.

M. S. KRISHNAN

LIGHT by R. W. Ditchburn (Blackie & Sons Ltd, London), Second Edition, 1963. Pp. xxvi+833. Price 75s.

This is the second and revised edition of a now well-known text-book, first published ten years ago. In this edition a considerable amount of new matter has been added, including some recent developments in the field of optics. The book is suitable for the Honours classes of Indian universities and as the scope is somewhat wider than the usual text-books

on light, it may with profit be consulted by the M.Sc. students. There are several topics treated in the book which do not normally form part of a course on light and there are others which could be explained in greater detail to clarify the argument to the student who takes to the subject for the first time. The bias of the author is mainly theoretical and experimental and technical details have been kept to a minimum. The addition of the chapters and sections on Optical Instruments, Radiation Detectors, and Aberrations of Optical Systems has considerably improved the scope of this edition.

There is a welcome departure in this book from the conventional historical presentation of the subject. The author begins by explaining the wave theory, the Fourier's series and the wave nature of light. These form a very desirable background for the next few chapters on Interference, Diffraction, etc. The chapter on Interference is rather short and more detailed explanations of some typical interferometers and of the fringes of superposition would have been welcome. The appendix to the chapter on Coherence Theory will be found very useful. Interferometric measurements have been adequately treated in a separate chapter. Again the chapter on Optical Instruments and the sections on Aberrations in the chapter on Defects of Optical Images are rather short, although the latter adequately treat the resolution of optical instruments and the optical transfer function. The rest of the book dealing with Diffraction Radiation Detectors, Double-refraction, Electromagnetic Theory, etc., is excellent and will be found useful also by research workers in allied fields for reference. The last chapter on the Limitation of Optical Instruments is a valuable addition to this edition, particularly because this important topic is often kept out of the regular course and is rarely to be found in a text-book.

Apart from the minor shortcomings suggested above it is an excellent text-book on light and perhaps one of the best of its type available in English.

P.K.K.

THE OPTICAL MODEL IN NUCLEAR AND PARTICLE PHYSICS by P. B. Jones (Interscience Publishers, a Division of John Wiley & Sons Inc., New York), 1963. Pp. vii+118. Price $ 4.50

The book by P. B. Jones is a useful introduction to the optical model. It deals almost entirely with the optical model in relation to nuclear physics; a short section on the scattering of mesons is added at the end.

The book assumes a knowledge of the basic ideas and facts of nuclear physics and a familiarity with quantum mechanics and with the mathematics of non-relativistic scattering theory. It will be most useful to those who have such a background and who wish to make a quick acquaintance with the techniques employed in the optical model of the nucleus, the different methods of approach to such a model and the various questions that arise in relation to each approach, and the application of these ideas to a study of nuclear structure and scattering on nuclei.

The book begins with a short account of the general features of the optical model. A summary of the definitions of the averaged cross-sections, an outline of the Born approximation for scattering by a complex potential and its application to the measurement of nuclear size, followed by a short sketch of how the wave equation for charged particles may be solved numerically completes the first chapter.

Of the remaining two chapters of the book, the second contains an introduction to the mathematics of the optical model and the third a discussion of the optical model in relation to nuclear structure and scattering on nuclei.

The second chapter is perhaps the most useful part of the book; it contains a lucid discussion of the mathematical methods employed in the optical model. A summary of the basic results of scattering theory is given and is followed by an account of two different formulations of the optical model — the high-energy formulation, in which the optical model operator is introduced and related to the nucleon-nucleon potential through the cluster expansion, and the low-energy formulation using the method of Kapur and Peierls. Questions that are discussed are the validity of the impulse approximation, the limitations of the cluster expansion, and the averaging procedure used in obtaining the 'gross structure'. The relation between the high- and low-energy formulations is also discussed; the other approaches, that of Siegert and of Kumblet and Rosenfeld, are briefly mentioned. Only elastic scattering is treated throughout.

In the last chapter is discussed the choice of simple optical potentials and the various corrections needed, followed by an account of the analysis of angular distributions and polarizations in elastic scattering. There is a fairly detailed discussion of the fitting of the optical potential to experimental data. Finally, there is a short section on the optical potential for the scattering of pi-mesons and K-mesons. The book closes with a useful list of references.

Important features of the book are its readability, its critical discussion of various problems and the presentation of mathematical methods with clarity. The title of the book may lead one to expect a discussion of the optical model in relation to elementary particle scattering, perhaps an account of the diffraction picture of high-energy scattering and its predictions and limitations. The only reference to elementary particles in the book is, however, a short section on the scattering of pi- and K-mesons by nuclei.

A useful addition to the book, which would not unduly increase its length, would be a discussion of diffraction scattering by an optical sphere. The addition, perhaps in the form of an appendix, of some more details of approximations and numerical methods employed in practical calculations using the optical model would enhance the utility of the book to research workers.

K. RAMAN

NUCLEAR FUSION — Proceedings of the Conference on Plasma Physics and Controlled Nuclear Fusion Research, Salzburg, Austria, 4-9 September 1961 (International Atomic Energy Agency, Vienna), 1963. Pp. 869-1327. Price $ 10.00 or Sch. 210 or 60s. stg

This supplement is Part 3 of the Proceedings of the Conference on Plasma Physics and Controlled Nuclear

Fusion Research held in Salzburg, 4-9 September 1961. It contains the papers presented at sessions VII and IX.

In session VII, the papers presented dealt with stability of the toroidal pinch discharge, the influence of the Hall effect on hydromagnetic stability, spectroscopic investigations of plasma in the wavelength range 0·1-2·0 mm., electric and magnetic field fluctuations in high current toroidal discharges and the plasma loss in Zeta which is responsible for the major part of the energy loss at high energies. A new method of plasma diagnostics for determining the magnitude of the flux of neutral particles in the energy range 100 eV. to 10 keV. is reported. Studies on spectral investigations in the 'Alpha device', noise radiation by a hot plasma in the centimetre and millimetre wavelength range, experiments on joule heating of plasma in a strong magnetic field, the influence of impurities on ionization and heating of deuterium plasma and experiments on particle motion in stabilized and hard core pinches are reported. Papers on the turbulent plasma convection in a longitudinal magnetic field, stability of various linear hard core and pinch systems, the effect of external electric and magnetic field on the stability of a plasma, perpendicular to the magnetic field in a weakly ionized medium, experimental studies on the project MEST, and runaway electrons in a toroidal z-pinch discharge in hydron are presented.

In session IX, the various papers reported are on the beam-plasma interaction in the presence of a magnetic field, theoretical investigations on the double-stream instability and the resulting breakup of the two streams, non-linear stability of plasma oscillations, experiments on the confinement of plasma in magnetic traps, experimental study of the Landau damping of longitudinal plasma electron oscillations, magneto-acoustic resonance, absorption by a plasma of the energy of varying large-amplitude electromagnetic fields and resonance excitation of cyclotron waves in a plasma created by a strong high-frequency discharge. The rest of the papers deal with the measurement of wavelength of ion cyclotron waves propagating along magnetic lines of force, interaction of an electron beam with a plasma in a magnetic field and radio-frequency emission from plasmas not in thermodynamic equilibrium.

Abstracts of all the papers which were presented in abstract form only together with the list of participants in the conference are given at the end of the supplement.

F. C. AULUCK

THE THEORY OF SUPERCONDUCTIVITY: Vol. IV of the International Science Review Series, edited by N. N. Bogoliubov (Gordon & Breach Science Publishers Inc., New York), 1963. Pp. xii+357. Price $ 4.95

This volume is a collection of important papers on the present state of the microscopic theory of superconductivity. This is a phenomenon which, though discovered over fifty years ago, is still presenting many difficulties in the formulation of a complete theory. The various attempts to understand these difficulties and in overcoming them extend over a long period. Also many physicists have contributed towards elucidating the theory of superconductivity. While it is desirable to have a detailed and logical review of all these attempts, it is perhaps pointless to compile one at this uncertain and incomplete stage of development of the subject in which we still have to find satisfactory explanations for many of the properties associated with superconductivity. The present editor, who is himself a front-rank investigator in this field, has, therefore, rendered a very useful service by publishing the important theoretical papers in a readily available book form, reprinted from the journals in which they were first published.

In a clearly written preface, the editor presents a general critical survey of the developments since 1950 to the present day. After the discovery of superconductivity and its recognition as an entirely new and fundamental physical phenomenon, the first step in its understanding was the formulation of a phenomenological theory on the basis of classical electrodynamics. At first this presented some serious difficulties which were removed by F. & H., London, in 1935.

The actual explanation of the thermal properties of a superconductor was, however, found to involve the formulation of a microscopic theory incorporating quantum statistical laws. The first major step in achieving this was that of Frölich (1950), who recognized that the explanation of the phenomenon was to be found in discovering the manner of interaction of the lattice of atoms with the free conduction electrons in metals. This led to the prediction of an isotope effect which was soon verified by experiments. The next major advance was the postulation of the formation of correlated pairs of electrons of opposite spins and momenta, as a necessary step in accounting for the condensation of the conduction electrons observed in superconductivity. This has also been shown to lead to the existence of an energy gap in the excitation spectrum. The numerous theoretical tools and techniques described by the many investigators in the field are reproduced in original in this attractively bound volume under review. Such a collection is very useful as a reference book and will benefit all those actively engaged in research in this field. It is also bound to stimulate further research on the theory of superconductivity. One may recommend its addition to libraries and to personal collections of physicists working in this field.

K. G. RAMANATHAN

THEORY OF APPROXIMATION OF FUNCTIONS OF A REAL VARIABLE by A. F. Timan; translated from the Russian by J. Berry; English translation edited by J. Cossar (Pergamon Press Ltd, Oxford), 1963. Pp. xii+631. Price £ 5

This book embodies, apart from the classical theory, recent Russian research work in the theory of approximations. The starting point of the theory is the famous Weierstrass theorem that every continuous function defined on a closed finite interval can be uniformly approximated by suitable sequences of polynomials and the theorem of Chebyshev on the existence and uniqueness of the best approximating polynomial of given degree.

The book consists of eight chapters. A brief indication of the main topics covered by each chapter

is given below which will give an idea of the aim and scope of the book.

Chapter 1 contains an account of the theorem of Weierstrass quoted above, its generalizations, like the Stone-Weierstrass theorem, approximation by rational functions on infinite intervals, approximations by trigonometric polynomials to periodic continuous functions and approximations in the class L_p. Approximations to bounded uniformly continuous functions on the whole line by integral functions of order one bounded on the real axis and weighted approximations are also considered in this chapter.

Chapter 2 gives a detailed account of the theory of best approximations starting from the theorem of Chebyshev quoted above. The problem of best approximation is formulated in the setting of a normed linear space and several special cases are considered. Uniqueness of the best approximation and the existence of best approximating polynomials corresponding to a given sequence of decreasing positive numbers and the determination of best approximating polynomials in some special cases are the topics considered in this chapter.

Chapter 3 is devoted to the study of compact classes of functions in function spaces, that is classes of functions possessing the property that any sequence of functions belonging to the class contains a subsequence converging in the space considered. Criteria for compactness are derived in terms of the modulus of continuity for continuous functions, and in terms of integral modulus of continuity for function classes L_p and in terms of entropy and capacity based on the notion of ϵ-nets for general normed linear spaces. Classes of functions analytic on an interval and quasi-analytic classes are other topics discussed in this chapter.

Chapter 4 discusses properties of polynomials and integral functions of exponential type. Interpolation problems, representation problems and external properties of polynomial and integral functions are the topics considered in this chapter.

Chapter 5 deals with estimation and convergence of the best approximating polynomials based on hypothesis of differentiability of functions considered and analyticity of functions considered. Chapter 6 attacks the converse problems to those discussed in Chapter 5, namely derivation of differentiability properties from the rapidity of convergence of best approximations. Chapter 7 contains more results of the type discussed in Chapters 5 and 6.

The final chapter (8) formulates the problem of approximation as the property of convergence of a sequence of linear operators defined on the concerned function spaces and discusses the problem of approximation from this point of view.

At the end of each chapter there are several problems and theorems which supplement those considered in the text. At the end, the author collects together known results used in the body of the book. There is a bibliography running to 19 pages at the end, more than half of which are papers published in Russia between 1950 and 1959. The book contains a wealth of details which would be found useful by would-be students and research workers in this field.

V. GANAPATHY IYER

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

The book under review is a self-teaching manual for IBM 1620 FORTRAN. The author does not presume any prior knowledge on the part of the reader about digital computers and computer programming. The machine features which are relevant to the programmer (e.g. variable word length) have been described. It also includes description of some basic programming aspects such as flowcharting and debugging.

The presentation of FORTRAN statements enables the reader to construct programmes at an early stage. Special reference can be made to PUNCH and READ statements. Every statement is illustrated with a set of examples. Problems and their solutions have been presented in a way that enables the reader to work out solutions in the space provided and compare them with the correct ones.

The appendix section gives the modifications necessary for IBM 7090, 7094 and 1401 FORTRAN. If the reader intends to use FORTRAN IV which is available on 7094, he should look into special features like mixed mode arithmetic, variations of FORMAT statement, etc.

The book is recommended to the class of people who want to use digital computers for solving their problems but do not have any prior knowledge about computers.

K. S. KANE

INTRODUCTION TO FUNCTIONAL ANALYSIS FOR SCIENTISTS AND TECHNOLOGISTS by B. Z. Vulikh; translated from the Russian and edited by Ian N. Sneddon (Pergamon Press Ltd, Oxford), 1963. Pp. xi+404. Price 70s.

The concept of an operator, which is a generalization of the notion of a function, plays a fundamental role in mathematical abstraction. Functional analysis treats operators with a view to their applications in all branches of pure and applied science. In fact the theory of integral equation has been one of the incitements to the creation of functional analysis. The present treatise, which is Vol. 32 of international series of monographs in pure and applied mathematics, gives an excellent introduction to functional treatment of integral equations, methods of approximations, boundary value problems, series-summation and allied topics.

The first two chapters deal with finite and infinite dimensional Euclidean spaces. Vectors spaces, norm of a vector and a linear operator, matrices, functional, adjoint and self-adjoint operators, eigen values, eigen vectors, complex Euclidean space, all are lucidly explained and motivation given in each case. Abstract theorems are illustrated with particular cases easy to understand. The concepts of positivity, homogeneity, symmetry, additivity, commutativity, associativity, distributivity, triangular inequality and allied ideas are used in relation to norms, spaces and sets, and their significance is explained in a simple manner.

In Chapter II the l^2-space is defined, and it is shown even at the expense of some repetition, that most of

the results for the finite dimensional spaces can be extended to infinite dimensional spaces.

The next five chapters treat metric spaces, continuous operators in metric spaces, normed spaces, Hilbert space and L^2-space. All abstract ideas are introduced gradually keeping in view that the reader may not be an abstract mathematician. For example, the elements of the theory of sets form an introduction to metric spaces.

The remaining chapters contain linear operators and functionals, adjoint and self-adjoint operators in Hilbert space, completely continuous operators, approximate solution of functional equations, and partially ordered sets.

A number of misprints have crept in, but these can be easily corrected by any serious reader.

The book will prove of great interest and profit all workers who require a knowledge of some of the modern abstract ideas which permeate all branches of science and technology.

B. R. SETH

STATISTICAL MECHANICS by Kerson Huang (John Wiley & Sons Inc., New York), 1963. Pp. xiii+470. Price $ 10.75

In the first six chapters of the book the author gives a lucid, self-contained exposition of the principles of thermodynamics and the kinetic theory of gases and sets the stage for discussing his main subject — statistical mechanics. The next three chapters contain an excellent account of classical and quantum statistics treated by the method of Gibbsian ensembles. The material contained in the book up to the end of Chapter 10 on the partition function will be very useful to students preparing for the Honours and the M.Sc. examination of Indian universities, particularly because the author has taken care to avoid unnecessary sophistication both in the style of writing and the presentation of the mathematics. An interesting feature of this part of the book is the derivation of Boltzmann's equation from the dynamics of binary collisions and its application to viscous flow and calculation of the transport coefficients. The famous Chapman-Enskog method of solving Boltzmann's equation by successive approximation is discussed briefly in Chapter 6. As is well known, this method does not yield the most general solution of the equation but yields precisely the solutions needed by the physicist, namely those that depend on the time implicitly through the local density, velocity and temperature. In the reviewer's opinion this chapter should be expanded to meet the needs of those who have other preoccupations in research or who find it difficult to follow Chapman and Cowling's Mathematical Theory of Non-uniform Gases. In the chapters on the Ideal Fermi and Bose Gases the author includes brief discussions on Landau diamagnetism, Pauli paramagnetism, de Haas-van Alphen effect, Bose-Einstein condensation and other topics of interest to people working on the physics of the solid state or on the theory of liquid helium. The next chapter deals with dilute imperfect gases in which the interparticle forces, though small, are not quite negligible. The behaviour of these gases at low temperatures is studied with the help of Fermi's method for pseudopotentials. The method is based on the idea that a particle with a large de Broglie wavelength does not see the details of the potential but feels only its general effect, so that a description in terms of three parameters only is possible. The concluding portions of the book are devoted to more advanced topics in statistical mechanics, such as cluster expansions, phase transitions, and Onsager's exact solution of the two-dimensional Ising model. 'New developments in the theory of many body systems, with applications to liquid helium, are also presented.'

S. DATTA MAJUMDAR

RECENT PROGRESS IN MICRO-CALORIMETRY by E. Calvet & H. Prat; edited and translated from French by H. A. Skinner (Pergamon Press Ltd, Oxford), 1963. Pp. xii+177. Price 60s.

A few years ago two books in French appeared from the same authors entitled *Microcalorimétrie; applications physico-chimiques et biologiques* (1956) and *Récent Progrès en Microcalorimétrie* (1958). The authors have now brought the subject up to date (1963) and published the present volume, which has been edited and translated from the French by Dr H. A. Skinner, Senior Lecturer in Physical Chemistry at Manchester University and President of the Commission on Experimental Thermochemistry of the International Union of Pure & Applied Chemistry. This book is a book of importance and especially so to all interested in measuring minute outputs of heat over long periods of time, though the technique may also be used for other purposes. The appearance in English of a book on micro-calorimetry was overdue, and the authors are to be congratulated on obtaining Dr Skinner as translator.

In the world of heat, there has often been in the historical contributions from France (e.g. Lavoisier, Carnot, Berthelot), an appreciation of the subject of heat and its subtleties which is unique. Even in the gas laws, pressure effects may have been handled well by Boyle of England, but for temperature effects, we hand ourselves over to Charles or Gay-Lussac, both of France. Thermodynamics in its early stages owes much to Sadi Carnot and his *Reflexions sur la Puissance motrice du feu* (1824). It is good to find this sustained interest from France now developing the fields of micro-calorimetry and thermogenesis.

The main difference in the technique of micro-calorimetry from that of classical or normal calorimetry is that measurements are made of the rate of heat development at each instant rather than of the overall quantity of heat. By this procedure a thermokinetic curve is obtained which provides a guide to the kinetics of the process and from which, by summation, we may measure the heat evolved over any chosen time interval.

Micro-calorimetric studies were begun in 1923 by A. Tian who continued the work till 1932 and developed his own calorimetric apparatus and mathematical expressions. It is on Tian's foundations that the authors have built, improving or modifying the techniques and obtaining greater accuracy: they claim that energy outputs of the order of one microwatt can now be recorded in their sensitive calorimeters.

In Part 1, full particulars with diagrams are given of the design and methods of use of the (Tian-Calvet) micro-calorimeter and attention is drawn to numerous practical details and their importance, e.g. the use of several identical thermocouples (regularly placed), the compensating of Peltier and Joule effects, the use of twin calorimeters in opposition, the avoidance of parasitic e.m.f.s and of heat produced by mechanical effects (shock, vibration stirring, etc.), and several other refinements, such as the necessary thermostatting of certain parts of the equipment. Chapters 1-6 of Part 1 form, indeed, a model of clear and concise description of these topics, covering the theory and manipulation of the apparatus, its calibration and the assessment of precision. Nevertheless, in the opinion of the reviewer any research worker in this field, unfamiliar with the technique, would save himself years of time and trouble by studying for a while under the expert guidance of one of the authors "*Ars longa, vita brevis*". Part 2 by Calvet deals not only with normal physical and chemical applications, such as the measurement of thermal diffusion coefficients and thermal conductivities, heats of solution, dilution, mixing and gelatinization, but also with such topics as heat of esterification and saponification, mercerization, adsorption processes, including measurement of specific surface and molecular surface area and the mechanism of dissolution. Specific micro-calorimetric studies are included on the chemistry of alumina (including activated alumina), and on the chemistry of cements (including the hydration of calcium aluminates and of calcium silicates), on micro-calorimetry and high temperatures (100-1000°C.) covering thermal dehydration studies of gypsum, hydrargillite, bayerite and boehmite, i.e. different forms of hydrated alumina. Studies of the oxidation of ethylene by air at 270°C. on silver oxide catalyst are also included.

The final section (Part 3) by Prat deals with biological applications, chiefly plant thermogenesis, bacterial thermogenesis, thermogenesis of animals of variable body temperature (mainly insects, though mention is also made of reptiles and amphibians) and the thermogenesis of homotherms, i.e. animals of constant body temperature. This section concludes with a remarkable comparison of biological thermogenetic sources, showing the heat output from several individual categories, i.e. for man, dog, mouse, grasshopper, germinating wheat grain, drosophila, living cells, bacterium in division. This order which is roughly that of physical magnitude is also largely the order of thermic flows, man giving the most. But when the heat output is expressed per gram weight, the order is largely reversed; the bacterial cell now heads the list giving 400 cal./hr/g., next drosophila giving 10-40, man 1-4 and wheat grain 0·1-0·4 cal./hr/g. "On the same scale, the heat output from the sun is well below that of any living being; astrophysicists have estimated that the sun radiates *c.* $0{\cdot}4\times10^{29}$ cal./hr which (in relation to its huge mass of 2×10^{33} g.) represents only a very modest output of a bacterium! This is a striking feature of living matter, especially of micro-organisms, and offers scope for deeper speculation."

It would appear that micro-calorimetry may be increasingly useful for comparing bacterial strains and for testing antibiotics, and can render great service in certain biological and medical fields. Indeed, by the methods recorded here, we are now in a position to pay attention to the minute heat outputs developed over long periods of time in such processes as cement hardening, seed germination and the like. It is the opinion of the authors that the micro-calorimeter may well become a "rather commonly used instrument in research laboratory within a period of 10-20 years from now". The reviewer is inclined to agree, but considers that the authors have rather underemphasized the degree of craftsmanship, care, experience necessary in the work.

J. W. WHITAKER

RHEOLOGY OF EMULSIONS — Proceedings of a Symposium, Harrogate, October 1962; edited by P. Shermann (Pergamon Press Ltd, Oxford), 1963. Pp. vii+146. Price 50*s*.

This book contains ten papers presented at a Symposium on the Rheology of Emulsions organized by the British Society of Rheology at Harrogate in October 1962.

The papers discuss some of the recent work on emulsion flow by experts in their fields under the titles: (1) Effect of droplet flocculation on emulsion viscosity, (2) Hydrodynamic aspects of the formation of emulsions, (3) Free energy calculations of diffuse double layer systems. The 'Secondary minimum', (4) The behaviour of deformable drops in laminar shear flow, (5) Effect of particle aggregation on the rheological behaviour of disperse systems, (6) Stabilization of emulsions with gum acacia, (7) The influence of emulsifier concentration on the rheological properties of emulsions, (8) Dielectric behaviour of emulsions, (9) The effect of concentration on the viscosity of suspensions and emulsions, and (10) The physical structure of ice cream.

The subject matters deal with the principles of emulsification, flocculation and aggregation; effect of stabilizers such as gums on emulsion viscosity; dielectric dispersion properties of oil-in-water and water-in-oil type of emulsions under shearing flow.

The application of the Verwey-Overbeek theory of colloid stability has been invoked to interpret many of the results. In the last paper the importance of the rheological studies (creep measurements) of ice cream in connection with its manufacture, distribution and consumption has been brought out. The book is rounded off by a chapter recording the general discussions by the participants.

In summary, this book is well produced and contains a great deal of information which will be of interest to many engaged in emulsion research and technology.

A. B. BISWAS

PRINCIPLES OF NUCLEAR REACTOR ENGINEERING by S. Glasstone (Macmillan & Co. Ltd, London), 1960. Pp. ix+861. Price 30*s*.

This book was first published in 1956 and ever since has maintained its place as an introductory treatise to anyone interested in the study of nuclear reactor engineering. Dr Glasstone had the assistance of a

number of members of staff of the Oak Ridge National Laboratory, one of the leading centres of research and development in the field of reactor technology in the US. Covering as it does a wide range of basic sciences which constitute nuclear engineering, namely nuclear physics, reactor physics, heat transfer and thermal aspects, and material damage due to radiation to name only a few, the book neither suffers from being too specialized or cursory in its treatment.

The chapters devoted to reactor theory constitute probably the best written introduction to the subject and are embellished with useful mathematical examples. The discussion of shielding and thermal aspects of nuclear reactor systems is thorough and introduces the mathematical techniques clearly while at the same time the physical concepts are explained very well. The other chapters, namely processing of nuclear reactor fuel, nuclear reactor matetials and radiation protection, to mention only a few, are also extremely well written, being both precise and at the same time intelligible to the non-specialist.

In conclusion, the book serves as a thorough introduction to any serious student of nuclear reactor engineering and as such the release of a paper-back edition which will bring the book within the reach of a larger number of people is most welcome. It may also be mentioned that a revised, up-to-date and enlarged version of this book has been brought out by Glasstone and Sesonske (D. Van Nostrand Inc.), and this revised version has brought the subject up to date.

M. R. SRINIVASAN

INTRODUCTION TO STRUCTURAL PROBLEMS IN NUCLEAR REACTOR ENGINEERING edited by J. R. Rydzewski (Pergamon Press Ltd, Oxford), 1962. Pp. iv+404. Price 84*s*.

This book is the result of a week's special course organized by Southampton University in spring 1960 with a view to familiarizing civil and structural engineers with structural problems arising in nuclear reactor engineering. The lecturers included members of the university staff and also experienced designers from the nuclear industry.

The first three chapters give a general introduction to nuclear reactors, materials in nuclear reactor construction and construction of pressure vessels in mild steel. These chapters are essentially descriptive in nature and should be capable of being understood by persons with a basic engineering training. The chapters on linear elastic analysis of statically indeterminate structures, introduction to the elastic behaviour of shells and plates and matrix progression method in structural analysis deal with advanced analytical and computational techniques in structural engineering. There is a chapter on thermal stresses which goes into this problem in considerable detail and another on plasticity and creep of metals. The next three chapters, namely direct designs of grillages, reactor pressure vessel analysis and gas duct flexibility analysis deal with actual problems faced in the design of structures of the graphite gas-cooled reactor, the type of reactor being developed in UK. These chapters include numerical examples and thus facilitate a better understanding of the subject matter. An earlier chapter (Chapter 5) deals with the use of computers in structural problems and serves as a useful introduction to the application of computers. The last chapter deals with the application of experimental stress analysis and gives a brief review of the different experimental techniques. An appendix gives a short review of concrete pressure vessels which are being employed both in France and UK for the gas-cooled graphite reactors.

The book covers a wide range of subjects in the field of structural engineering and a knowledge of matrices is necessary for those who wish to follow the chapters on analytical and computational techniques. Since a number of different authors have contributed different chapters, there is an understandable weakness in that the chapters differ in the depth of content. It may be mentioned that in a field that is rapidly developing, namely nuclear reactor engineering, there is always the difficulty of writing books which are up to date. Thus, the emphasis has definitely shifted from steel to concrete pressure vessels for the large graphite gas-cooled reactors which are being built in France and UK. The book only makes a brief mention of the concrete vessel in the appendix. Nevertheless, the book should serve as an introduction for structural engineers who are entering the nuclear reactor field and in parts as a useful reference for those engaged in the design of nuclear reactors.

M. R. SRINIVASAN

NUCLEAR POWER TODAY AND TOMORROW by Kenneth Jay (The English Language Book Society and Methuen & Co. Ltd, London), 1963. Pp. 269. Price 7*s*. 6*d*.

This book was first published in 1961 and now a paper-back edition has appeared. The author, Mr Kenneth Jay, is a member of the scientific staff of the United Kingdom Atomic Energy Authority's Research Group. The object of the book, as has been explained by Sir Roger Makins, Chairman, United Kingdom Atomic Energy Authority, in his foreword, is to provide the layman an understanding of the nature of nuclear power and to explain some of the major problems which have to be overcome in making practical use of it.

The first chapter deals with energy, atoms and neutrons, and gives a brief explanation of the principles of radioactivity, nuclear fission, transmutation and self-sustaining chain reaction. The second chapter deals with nuclear fuels and fuel cycles and explains in an easily intelligible way the concepts of conversion, breeding and irradiation lifetime. A brief description of different types of reactors that have been conceived is provided in Chapter 3. Economics of nuclear power is discussed in Chapter 4 though, of course, the frame of reference is a British type nuclear station using the graphite gas-cooled reactor. The author brings out the advantages of operating nuclear power stations at base load. The next chapter examines briefly the nuclear power programmes of Britain, USA, USSR, Canada, France and West Germany. Chapters 6 through 10 provide description of different reactor systems and their suitability for power generation purposes. The systems described are those that have been developed in UK, USA, Russia, Canada and France which have

carried out the major share of original work in the development of nuclear reactor systems. Chapter 11 deals with the prospects of nuclear ship propulsion, industrial heat from nuclear reactors and other industrial applications of radiation, such as sterilization and polymerization. Chapter 12 presents some of the problems involved in the development of nuclear reactors and briefly discusses the question of safety and siting. While a comprehensive treatment of such questions is clearly outside the purview of the book, the discussion is such that it can be followed by the layman.

In conclusion, it may be stated that the author has succeeded in the objective of providing the layman with an overall picture of what nuclear power is and how it can be harnessed for man's use. The book is written in a very lucid and understandable style and contains a number of interesting illustrations.

M. R. SRINIVASAN

EXPANDED PLASTICS edited by A. A. Moiseyev, V. V. Pavlov & M. Ya. Borodin; translated from the Russian by B. J. Hazzard and edited by Leslie N. Phillips (Pergamon Press Ltd, Oxford), 1963. Pp. ix+170. Price 42*s*.

The book under review is a compilation of a few technical papers on the industrial applications of expanded plastics for fabricating certain structures such as aerial fairings, housings, reflectors, etc., by Soviet scientists during the last few years.

The first two papers deal with the formation and physical properties of polystyrene and PVC foams and the use of various blowing agents. The third paper describes the technique of the use of polymer/monomer pastes for preparing foamed articles, permitting the use of low pressures and thereby reducing the manufacturing costs. The fabrication and mechanical behaviour of aerial fairings has received particular attention in the following article together with a detailed account of the technique of autoforming articles from expanded plastics. The principles of the formation and properties of various grades of phenolic/rubber base foams are detailed in the next paper, laying emphasis on the technology of filling articles with these foams. The process of the manufacture of reflectors for radars from expanded plastics is described in the next paper including information on the moulds used, precautions to be taken and economics of the process. A detailed account of the various stages of the technique for making aerial fairings, based on rigid polyurethanes, is given in the eighth paper, which also includes results of certain investigations on the effect of temperature on their mechanical properties. Besides, constructional details of the manufacture of small and large rigid reflectors, preparation of panels and slabs for thermal insulation, radio transport inserts, lightweight sealing compounds, etc., all based on polyurethanes, are included. The last article gives a brief and incomplete survey of recent advances in the chemistry and technology of cellular plastics in western countries, but unlike all the other papers, it has a list of references.

Throughout the publication, free use of trade names and code numbers of various commercial products has been made. This is no doubt convenient to a routine engineer conversant with the applications of such foams but it becomes a drawback for a research chemist. In all papers, emphasis is on the engineering aspects, technique of fabrication and the use of expanded plastics and chemistry of foaming materials has received relatively less attention. There is no mention of foams based on cellulosics and ureaformaldehyde resins and very little information is given on polystyrene foaming beads, which are now widely used in western countries.

This compilation of a set of papers on technical investigations in the same field should serve as a good reference book and prove useful to design engineers in the field of thermal insulation and fabrication of special articles such as aerial fairings and reflectors for radars, etc.

S. L. KAPUR

FOOD DEHYDRATION: Vol. 1 — PRINCIPLES by W. B. Van Arsdel (AVI Publishing Co. Inc., Westport, Connecticut), 1963. Pp. xi+185. Price $ 11.00

No comprehensive presentation of the principles involved in dehydration has been done in a form as attempted by the present author. In an admirable way he has covered in about eight chapters the properties of water vapour and air, heat and mass transfer, drying behaviour of various fluid substances, factors influencing rate of drying, estimation of drying time, characteristics of tunnel drying and other types of drying like sun drying, drum drying, vacuum drying, puff drying, freeze drying, spray drying and the latest method of foam mat drying. The bibliography at the end of each chapter is well covered. Appendices giving symbols and units as well as the methods of moisture determination in dehydrated foods are useful additions.

The author has rightly stressed the need for enormous amount of well-designed experimental work for theoretical analysis of dehydration data. Available data have been presented well. It should prove to be of great value to research workers and students of food technology.

C. P. NATARAJAN

BATTERIES RESEARCH AND DEVELOPMENT IN NON-MECHANICAL ELECTRICAL POWER SOURCES — Proceedings of the Third International Symposium, Bournemouth, October 1962; edited by D. H. Collins (Pergamon Press Ltd, Oxford), 1963. Pp. xv+464. Price £ 6

The astounding post-war developments in the fields of electronics, armaments and space technologies posed to the scientists the problem of exploring new avenues of portable power supply. This led in recent years to the discovery and the developments of a galaxy of modern batteries, such as heavy duty highly compact silver oxide-zinc cell, activated type long shelf life magnesium cells, solar cells, fuel cells, constant voltage low drain mercury oxide cell, etc. At this juncture a new book on the subject of batteries is most welcome.

This volume represents the complete proceedings of the Third International Symposium on Batteries held in United Kingdom in October 1962. It includes 32 research papers and discussions preceded by the opening address delivered by Sir Solly

Zuckerman, Chief Scientific Adviser to the Ministry of Defence, United Kingdom. The papers are of mixed interest and cover a wide spectrum of modern batteries.

Sir Zuckerman has focused attention on the present and future demands and practical possibilities of using the newer types of batteries in industry and defence services. The opening address is followed by a paper of Holdsworth and Eggelton, rich in information on the problems of the performance, servicing and the stringent requirements of secondary batteries in modern supersonic aircraft. Robinson and Walker report in the next paper their investigations on several physical and chemical characteristics of different types of separators made out of microporous rubber or PVC, resin bounded paper, latex-keiselguhr, polythene cellulose and wood. In Chapter 3, Burbank discusses the floating characteristics of lead acid battery consisting of electrodes incorporated with traces of calcium. Certain other aspects of lead acid battery such as the three-step and constant potential charging of aircraft batteries, discharge characteristics, stability and reactivity of α and β lead dioxide electrodes and the analysis of the plate materials have been discussed in other papers on lead acid accumulators. Doran, the author of Chapter 7 on 'The nickel-scandium hydroxide electrode', uses scandium hydroxide solution in lieu of the conventional potassium hydroxide solution and reports its influence on the charge and discharge characteristics of nickel electrode.

Introducing the material problems confronted with in producing a statisfactory silver-zinc secondary cell, Farmery and Smith, the authors of the very well-written Chapter 14, review the earlier developments and present their own investigations on the problems of separator, charge acceptance of silver and its alloys, sludging, corrosion of zinc plate, self-discharge, dendrite growth, etc. With a view to reducing the time of activation to 1 sec. of activated type of silver-zinc cell, Reasbeck suggests, in Chapter 30, the improvements in the design of various cell components such as the cell pack, container, manifold, electrolyte reservoir, gas generating cartridge, etc.

As an alternative to the thermal energy converters, fuel cells have a very promising future. Some of the important fuel cell systems have been dealt with in five different chapters of the book. Based on the cathodic reduction of oxygen and the anodic oxidation of hydrazine in alkaline solution, Gillibrand and Lomax designed hydrazine fuel cell. The cell showed open circuit voltage as 1 volt and delivered 100 ma./cm.^{2} current continuously for two years. Ruetschi and coworkers report, in Chapter 17, the use of palladium-silver catalyst for hydrogen electrode and silver-nickel catalyst for oxygen electrode. Justi and Winsel, working on double skeleton-catalyst (DSK) electrode system, also describe H_2-O_2 alkaline fuel cell. Hart and Powell have made a study of three-phase (gas, fused electrolyte and solid electrode) contact to throw light on the mechanism by which gas molecules reach the zone of chemical reaction. The economic aspects of fuel cells have been described by Hart and coworkers in the next chapter.

Being an important component of satellites, solar cells have gained wide attention in recent years. The work includes two chapters on solar cell, one a treatise by Reasbeck on the electron and proton radiation damage in solar cells when the latter are placed in equatorial orbits and the other paper on the assessment of the electrical power available in satellites.

Other chapters of the book deal with zinc-silver chloride cell, zinc-manganese dioxide and indium-bismuth/mercuric oxide alkaline cell systems, gas formation in dry cells, chemical and electrochemical reduction behaviour of manganese dioxide and the other related topics such as the use of titanium in battery and the new electrochemical devices of testing batteries.

In general, the discussions on papers are of high order. The only discrepancy noticed in the book is the ill-arranged contents which at first glance do not produce a pleasing impression on a reader acquainted with the subject. However, this well-illustrated and excellently printed book has much to offer to battery technologists as well as to electrochemists.

P. B. MATHUR

CONFERENCE ON DESIGN METHODS — Papers Presented at the Conference of Systematic and Intuitive Methods in Engineering, Industrial Design, Architecture and Communications, London, September 1962; edited by J. Christopher Jones & D. G. Thornley (Pergamon Press Ltd, Oxford), 1963. Pp. xiii+222. Price 50s.

The key problem in engineering education is to obtain a satisfactory balance between a purely scientific approach in which problems are approached logically and what can be described as the artistic approach in which emphasis is placed on an intuitive appraisal of the right solution. The present tendency is to concentrate entirely on the scientific approach and to rely on qualified engineers gaining experience of the artistic approach by actual practice. The increasing complexity of engineering problems, particularly those related to very large projects, makes it more important that engineers can visualize the most likely solution to any design problem without going through the impossibly lengthy process of eliminating unsatisfactory solutions by a purely logical approach. This aspect of engineering is referred to as design and the present book contains a collection of papers given at a Conference on Systematic and Intuitive Methods in Engineering, Industrial Design, Architecture and Communications which was held with the objective of bringing together workers from a wide variety of fields to establish systematic methods for tackling design problems. The papers cover an extremely wide range of topics from the use of electronic digital computers in design work to a discussion of the psychological aspects of creative art. It is clearly impossible to give an adequate review of such a wide range of subjects, and this in fact is hardly necessary since the last paper in the volume is in itself a review of what occurred at the conference.

The importance of tackling education on an approach of the type attempted in this conference is clearly very high. Any technical teacher will find material in this volume which will cause him to reappraise his method of teaching. The type of

activity which is envisaged is described in the opening address by Prof. Christopherson who outlines a possible course in design in which the emphasis is placed on encouraging students to provide solutions to practical problems of a type not usually considered in an academic course. Later papers discuss the particular problems associated with such activities as town planning, system engineering, instrument design and architecture. These papers contain the results of the authors' experience in systematizing the approach to a design problem.

It may be argued that the truly artistic approach is effective largely because of its complete reliance on a purely intuitive method which cannot be systematized. On the other hand, there can be no question that considerable economies in relatively routine design work can be effected by pin-pointing the problems which have to be solved and by emphasizing the interrelations between different portions of the complete project. Several papers give extremely useful and clear illustrations of the ways in which this can be done.

The reviewer feels very strongly that an approach of this type must be incorporated in technical education to avoid the restricting influence imposed by syllabuses which overemphasize the logical scientific approach. For this reason he strongly recommends any technical teacher to study those papers which are relevant to his subject with a view to encouraging students to develop their intuitive powers.

JOHN BROWN

RUSSIAN-ENGLISH PHYSICS DICTIONARY by Irving Emin & the Consultants Bureau Staff of Physicist-Translators (John Wiley & Sons Inc., New York), 1963. Pp. xxx+554. Price $ 14.00

The rapid development of science and technology is bringing in its wake a spate of new concepts and new terms to explain them. Besides, science and technology are fast proliferating into narrow specialized fields and every field is acquiring its own special vocabulary and its separate linguistic domain which are not fully intelligible to people in other fields. This is calling forth the need for compilation of special dictionaries devoted to respective fields.

The *Russian-English physics dictionary* by Irving Emin and his collaborators on the staff of the Consultants Bureau has fulfilled a long-felt need for a reliable dictionary containing terms currently being used in Russian physics literature. Soviet science is achieving phenomenal progress and is fast stealing a march over other countries in many fields, evoking wide interest all the world over.

The Consultants Bureau has been doing a great service to the cause of science by offering the scientists the unique opportunity of access to Soviet science through its cover-to-cover translation of contemporary Russian scientific literature. A number of useful dictionaries also owe their origin to the efforts of this organization and the present one is another in the series.

The compilation of a dictionary takes long years of painstaking work on the part of the lexicographer and by the time the dictionary comes out in print its utility is greatly impaired by the coming into use of new terms. No work of lexicography, however skilfully executed, can, therefore, lay claim to being comprehensive, more so in a rapidly developing field as physics and the present one is no exception to that. Yet the present work is an improvement over the existing ones in so far as it has included many obscure terms, compound words and phrases, and has given the expansion of abbreviations of grammatical forms, names of Soviet institutions, units of measures, etc., which are so ubiquitous in Russian scientific literature and are not available from one single source. The idea of including an alphabetical list of technical and grammatical endings and of Russian phonetic transliteration forms, a do-it-yourself supplement to enable the user to record any new term that he may subsequently come across in scientific literature and the reference section giving grammatical and other materials, is something novel about the dictionary.

One point that the reviewer would like to mention in this connection is about the inclusion in a special dictionary of general non-technical words and such technical terms which have already appeared in standard reference works and which have no special significance with reference to the special field. Although it is still a debatable point yet the reviewer is inclined to favour those who suggest that three dictionaries — a general language, a polytechnical and a special dictionary — are indispensable for any good scientific translation and that inclusion of such words in a special dictionary is much less useful, especially when it cannot dispense with the need for the other two. Proceeding from this premise many words — ' chemodan ' (suitcase), ' avtor ' (author), ' chestnost ' (honesty) — to cite only a few which occur in any ordinary dictionary, could possibly have been excluded making room for other useful terms from physics and related fields.

This is by no means a defect of the book and the reviewer has no intention to underrate its usefulness. It is hoped that this dictionary will serve as a useful tool in the hands of those who have to deal with Russian scientific literature. This dictionary is a must for the readers and the translators alike of Soviet physics.

SARADINDU GUHA

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ELECTROMAGNETIC THEORY AND ANTENNAS — Proceedings of a Symposium, Copenhagen, 1962: Parts I & II; edited by E. C. Jordon (Pergamon Press Ltd, Oxford), 1963. Pp. Part I, xxx+658; Part II, ix+1330. Price £ 10 10s. per set

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THE DISTRIBUTION AND ABUNDANCE OF TSETSE by J. P. Glasgow (Pergamon Press Ltd, Oxford), 1963. Pp. xi+241. Price 60*s*.

COFFEE PROCESSING TECHNOLOGY: Vol. I — FRUIT GREEN, ROAST AND SOLUBLE COFFEE; Vol. II — AROMATIZATION PROPERTIES — BREWING, DECAFFEINATION, PLANT DESIGN (AVI Publishing Co. Inc., Westport, Connecticut), 1963. Pp. Vol. I, xvi+598; Vol. II, xii+379. Price Vol. I, $ 18.25; Vol. II, $ 31.75

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NOTES & NEWS

A new state of water

The possible existence of a new state which can be called the state of 'modified liquid' in addition to the three conventional states of water, viz. steam, liquid and ice, has been suggested by a group of investigators working at the surface phenomena laboratory of the USSR Academy of Sciences and at the physics laboratory of the Kostroma Technological Institute. While studying the behaviour of liquids in capillaries, it has been observed that when cooled to temperatures even below 0°C. water in the capillaries contracts normally while its viscosity and other properties were found to change. Similar characteristics were observed in the case of acetic acid, methyl alcohol and acetone. In the case of water confined to a capillary, the viscosity was found to increase by *c.* 12 times the normal value. This peculiar observation has been explained as follows: The inside surfaces of all capillaries are lined with adsorption films of the liquid and if the capillary is sufficiently narrow the film will block it. A small increase in the thickness of the film at one place may immediately cause the layers to merge together, and the adhering liquid will close the bore of the capillary. In this unusual state of the liquids in the capillary, the molecules are linked to one another by long chain networks. The formation of such structures upsets the ordinary bonds in the molecules. If the process of bond destruction proceeds beyond the point where the previous conditions cannot be restored, the new state having different properties comes into existence [*Sov. Features*, **1** (No. 30) (7 December 1963), 5].

Ultrasonic diffraction modulation of optical maser oscillations

A new technique of using the ultrasonic diffraction effect as a shutter to gate and thus amplitude modulate the output of a ruby optical maser has been reported from the research laboratories of the Aircraft Corporation, East Hartford, Connecticut. An earlier method of controlling the feedback of a ruby maser by synchronizing the usual random output pulses with an applied ultrasonic frequency makes use of the ultrasonic refraction effect. In addition to the application in controlling the output of the lasers, the new technique, with slight modifications, will make possible investigations aimed at a fuller understanding of the dynamic behaviour of laser oscillators.

The new technique makes use of the well-known fact that a diffraction pattern is obtained by the propagation of a plane parallel monochromatic light beam through an ultrasonic field whose wavelength is much smaller than the width of the beam. It is also known that the higher order diffraction patterns experience a frequency shift due to the Doppler effect. In the actual design, an ultrasonic cell is inserted into a laser cavity. The progressive ultrasonic phase grating thus established can be a controlling attenuator in the laser's optical path. In addition the progressive acoustic wave by varying the refractive index can perturb the laser in the study of its dynamic operation and hence these perturbations can be used to study the effect of non-uniform distribution of excited Cl^{3+} ions along the length of the ruby rod on the oscillational behaviour of the laser. A special form of the cell which maintains steady progressive waves and completely avoids reflection has also been designed. The theory of the charge in the oscillational behaviour of a ruby laser's pulsations under periodically changing optical path length conditions is not presently known, but it is known that such perturbation experiments can be expected to yield information on the dynamic behaviour of laser oscillation [*J. appl. Phys.*, **34** (1963), 2984].

Visual observation of rapidly moving ferromagnetic domains

A technique developed at the Department of Physics, University of Sheffield, England, provides a new tool for investigating ferromagnetic domain structures under dynamic conditions. It is hoped that by employing the new technique, a clearer picture of the anomalous eddy current loss in ferromagnetic steels may be obtained. The method may also prove useful for the examination of the hysteresis loops associated with the movement of a single wall, thereby obtaining information on wall dynamics, the behaviour of closure domains and the influence of surface imperfections.

Hitherto the studies made on ferromagnetic domains have been carried out under static field conditions using the magnetic colloid technique. For observing rapidly moving domain walls an inertialess system must be employed. This is possible in the new method by the use of the longitudinal Kerr magneto-optic effect conventionally used for examining domain structure in evaporated Ni-Fe and similar films. Any departure from true planarity (arising from surface imperfections and grain boundaries) of the surface reduces the optical contrast achievable. In this method, the requirement of a mirror-like strain-free surface is produced by carefully polishing the specimen using conventional metallographic technique followed by a prolonged annealing *in vacuo*. Then an anti-reflection coating of zinc sulphide is deposited on the surface. By this coating with a suitable dielectric the effective angle or Kerr rotation has been found to be increased six-fold.

In operation, a sample prepared as described above is placed in the conventional Kerr effect equipment. Then the frequencies of the light source (a commercial stroboscope employing a high-pressure xenon arc) and the magnetic field (obtained from a signal generator) can be made nearly equal and the domain walls can be seen moving at the difference frequency. This method is suitable for qualitative studies and is useful at frequencies of up to 1000 c/s. Photographic recording is permitted in an alternative procedure by synchronizing the field with the

light source and introducing a variable phase control between the two, thus allowing the examination of the instantaneous domain structure at any part of the magnetization cycle. With an exposure of 1 min. sharply defined domains could be photographed. Thus the domain configuration is exactly reproducible from one cycle to the other [*Phys. Lett.*, **7** (No. 2) (1963), 104].

Spectroscopic method for measuring electron temperature in plasma

A spectroscopic method for measuring electron temperature in high temperature plasmas has been used at the Culham Laboratory (of the UK Atomic Energy Authority), Abingdon, Berkshire, England. The method based on the relative intensities of spectral lines from the same species of Li-like ions has the advantages of wider range of the electron temperature and better accuracy over other known methods which have their own limitations.

In a high temperature plasma such as those obtaining in the solar corona or those produced in thermonuclear research, when the only excitation process that is important is the excitation from the ground state by electron collision, followed by the emission of a photon, the population n_q of level q relative to the population n_1, of the ground level is

$$n_q/n_1 = n_e S_{1q}/A_q \quad \ldots (1)$$

where n_e (cm.$^{-3}$) is the electron density, A_q (sec.$^{-1}$), the Einstein transition probability of level q and S_{1q} (cm.^{3} sec.$^{-1}$) is the electron collisional excitation function for electron temperature T_e. The intensities of the spectral lines are, therefore, proportional to S_{1q} which is different for different levels. This ratio of intensities from two levels of the same ion depends only on atomic constants and the electron temperature.

To obtain a ratio that is sensitive to T_e, upper levels widely separated in energy should be used. The Li-like ions are particularly well suited from this point of view and are also free of metastable levels which invalidate the use of the coronal equation. Thus the relative intensities of the lines corresponding to the transitions $2s^2S_{\frac{1}{2}}-2p^2P^0_{3/2}$ and $2s^2S_{\frac{1}{2}}-3p^2P^0_{\frac{1}{2},3/2}$ are chosen for evaluation in a number of Li-like ions. Using Seaton's cross-section for allowed transitions in ions and assuming a Maxwellian velocity distribution for the free electrons, the intensity ratio of the two transitions can be shown to be related as follows:

$$\frac{I_{1q}}{I_{1r}} = \frac{f_{1q}\chi_{1r}\bar{g}(\chi_{1q}/kT_e)}{f_{1r}\chi_{1q}\bar{g}(\chi_{1r}/kT_e)} \times \exp\left(\frac{\chi_{1r}-\chi_{1q}}{kT_e}\right) \quad \ldots (2)$$

where f and χ are respectively the absorption oscillator strength and excitation potential of the relevant transitions, and $\bar{g}(\chi/kT_e)$ is a mean Kramers-Gaunt factor. Eq. (2) is valid for both the steady state and the transient conditions of the plasma. Thus determining experimentally the ratio I_{1q}/I_{1r}, T_e can be read from a precalibration chart between T_e and I_{1q}/I_{1r}, drawn from values for several Li-like ions evaluated theoretically; the values are obtained from the relevant known literature data and methods for determining f.

The method has been applied to the high temperature pinch discharge under a variety of conditions in the reactor Zeta. The measurement of electron temperatures using this method gave values consistent with previous spectroscopic measurements made in Zeta under similar conditions [*Nature, Lond.*, **198** (1963), 1291].

Generation of electric power from algae-produced methane

A method for producing electric power from solar energy through the intermediary of algae-produced methane has been worked out at the Sanitary Engineering Research Laboratory, University of California, Berkeley, USA. The method is based on trapping the solar energy in unicellular algae, and converting this trapped energy into the chemical energy of methane and other short chain hydrocarbons through the agency of methane bacteria; the methane is burned in a gas-turbine generator system to produce electricity.

The unicellular species of algae, *Chlorella vulgaris, C. pyrenidosa, Scenedesmus obliques* and *S. quadricauda*, are grown under most favourable conditions of growth and a nutrient added. Organic wastes, especially sewage, constitute an economical source of nutrient. Since the greater part of organic waste is too complex in nature to be directly available to algae, bacteria are added to the culture to break down the complex substances to the simple forms usable by algae. Most of the bacteria needed are, however, present in the sewage waters.

For use in methane production, harvesting of algae involves initial concentration and dewatering. Initial concentration is accomplished by centrifugation or by chemical precipitation (aluminium sulphate or lime). This step results in a slurry having a solids concentration of 1·5-2·0 per cent. Dewatering is accomplished by passing the slurry through a basket type centrifuge or by pouring it on a sand bed. The dewatered slurry has a solids content of 12-15 per cent. The dewatered paste is diluted sufficiently to bring the solids content down to 5 per cent.

The transformation of the cellular energy to the chemical energy of methane is accomplished by anaerobic digestion of the slurry. The harvested algae slurry is introduced into the digester where acid-forming bacteria break it down to short straight-chain fatty acids. The acids together with carbon dioxide released by the acid-forming bacteria are converted into methane by mathane-forming bacteria. Material not susceptible to bacterial attack is discharged as a sludge. The digestion is carried out at 43°C. or more for 20 days.

Methane gas produced is burned and the heat energy is used in a conventional plant to generate electricity [*Solar Energy*, **7** (1963), 86].

Stereospecific synthesis of DL-quinic acid

The total synthesis of quinic acid reported earlier [Grewe, R., Lorenzen, W. & Vining, L., *Chem. Ber.*, **87** (1954), 793] starts from a symmetrical molecule, viz. hydroquinone. A symmetrical molecule, however, does not permit the incorporation of C^{14} into specific positions of the molecule. A stereospecific synthesis of DL-quinic

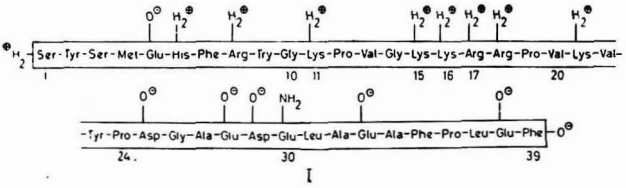
acid has now been reported from the Department of Pharmaceutical Chemistry, University of Kansas, USA.

The synthesis was performed through an initial Diels-Alder reaction of *trans, trans*-1,4-dichlorobuta-1,3-diene with benzyl α-acetoxyacrylate. The resulting 1α-acetoxy-2α, 5α-dichlorocyclohex-3-ene 1β-carboxylate is first converted into the chlorolactone by heating at 150° for 22 hr and then *cis*-hydroxylated using osmium tetroxide to give 1-acetyl-6-chloroquinide in 46 per cent yield. This on hydrogenolysis using W-6 Raney nickel catalyst yields DL-1-acetylquinide which in turn is converted into the triacetyl derivative by refluxing in acetic anhydride. Triacetylquinide is readily converted to quinic acid by heating it in aqueous potassium hydroxide followed by ion-exchange chromatography [*J. Amer. chem. Soc.*, **85** (1963), 2184].

Total synthesis of adrenocorticotrophic hormone

The total synthesis of β-corticotropin (ACTH) has been achieved at the CIBA Laboratories, Basle. The synthetic product obtained is identical with the natural ACTH derived from porcine sources with respect to R_f values, colour reactions and biological activity.

The starting material is L-phenylalanine *t*-butyl ester (position 39 in ACTH; I) and proceeds in a stepwise manner by the addition of one appropriately substituted amino acid *p*-nitrophenyl ester after the other to the protected pentadecapeptide (positions 15-39). This compound obtained in a pure state by counter-current distribution is then reacted with the protected octapeptide (positions 17-24) by the method of mixed anhydrides. The resulting derivative (positions 17-39) is purified by counter-current distribution, hydrogenated and condensed with the azide of the protected hexapeptide (positions 11-16). The resulting protected nonacosapeptide (positions 11-39) is extensively purified by counter-current distribution in the same solvent system and hydrogenated. Condensation with the decapeptide derivative (positions 1-10) by means of dicyclohexyl carbodiimide



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gives a crude, protected nonatriacontapeptide which is purified by counter-current distribution. The purification by counter-current distribution is followed by chromatography on thin layers of alumina. Material from the pure fractions is then treated with trifluoroacetic acid to remove all protecting groups and converted to the acetate salt. The purity of the resulting compound (ACTH) is established by thin-layer chromatography on silica gel.

With the synthesis of ACTH, all three types of hormones of the anterior and median lobes of the pituitary have been achieved [*Nature, Lond.*, **199** (1963), 172].

Synthesis of 1-olefins by selective catalytic dehydration of 2-alcohols

1-Olefins have been obtained as the major products (with *c.* 5 per cent of 2-olefins) by carrying out the dehydration of secondary 2-alcohols with thoria. 2-Butanol, 2-octanol, 4-methyl-2-pentanol and 1-cyclohexyl-1-ethanol have been converted to the corresponding 1-olefins in yields of 93, 95-97, 96-98 and 96-98 per cent respectively. The conversion is carried out in a flow system at 350-450° with contact times of 0·1-0·5 sec. and the products separated by distillation. The most active and selective thoria catalysts for the reaction are obtained by calcining thorium oxalate at 350-450° for a few hours.

In the mechanism proposed for the selective dehydration the alcohol is presumed to be chemisorbed on the catalyst surface in a suitable conformation followed by concerted elimination of the elements of water [*J. Amer. chem. Soc.*, **85** (1963), 2180].

Hormone action and enzyme induction

A problem of current interest to biological scientists is the elucidation of the process by which certain hormones exert their remarkable stimulation of the growth of certain mammalian tissues. The problem has been tenaciously pursued by several groups of workers and in recent years a number of interesting facts have come to light.

Adrenocorticoid affects hepatic metabolism by enzyme induction. A number of independent reports confirm that the *de novo* synthesis of several hepatic enzymes is increased by hydrocortisone treatment [Kenney, F. T., *J. biol. Chem.*, **237** (1962), 1610, 3495; Feigelson, P. & Greengard, O., *J. biol. Chem.*, **237** (1962), 3714; Weber, G. & Singhal, R. L., *Fed. Proc.*, **22** (1963), 636; Segal, H. L. & Hopper, S., *Fed. Proc.*, **22** (1963), 409]. The mechanism of hormone action in these inductions, therefore, assumes considerable significance.

Experiments with microbial systems have shown that induced synthesis of enzymes reflects a primary alteration in the rate of formation of the specific RNA. M. Feigelson, P. R. Gross and P. Feigelson [*Biochim. biophys. Acta*, **55** (1962), 495] found that cortisone administration to rats led to a marked stimulation in the incorporation of precursors into the RNA fractions of liver. Using pulse labelling techinques, F. T. Kenney and F. J. Knell [*Proc. nat. Acad. Sci., Wash.*, **50** (1963), 493] have reported an interesting correlation between the effect of hydrocortisone on RNA synthesis and its effect on protein synthesis. Their results show that hydrocortisone treatment of rats resulted in a 2-3 fold stimulation of the rate of liver *nuclear* RNA synthesis but no change occurred in the cytoplasmic RNA. The hormone stimulated RNA synthesis manifested after a lag period of 30 min. and the hormone stimulated protein synthesis became apparent only after 30 min. of the hormone stimulated RNA synthesis had been in progress. The induced RNA was qualitatively indistinguishable

from the RNA formed in the absence of hormone. In stimulating amino acid incorporation *in vitro* into proteins, nuclear RNA from induced livers was slightly more active than that from non-induced livers. These observations suggest that the hormone stimulates formation of messenger RNA. However, that the induced RNA could be wholly or even largely functional as messenger is not in accord with our present knowledge of hydrocortisone effects on hepatic protein synthesis. Isotope incorporation into soluble liver proteins *in vivo* is increased 10-20 per cent in the first few hours of hormone treatment, a result consistent with the selective induction of a few enzymes, but not proportional to the large increase in the nuclear RNA synthesis observed by Kenney and Knell. These workers, therefore, conclude that only a fraction of the induced RNA is active as messenger. L. D. Garren and R. R. Howell [*Fed. Proc.*, **22** (1963), 524] have recently reported similar results.

More interesting are the observations made lately by several independent groups of workers on the mode of action of estrogens. All their results point to an action of estrogens on protein synthesis very similar to that of the adrenocorticoids described above.

The early response to estradiol is characterized by a rapid acceleration of synthetic reactions leading to the accumulation of phospholipid, RNA and protein in the uterus. When protein synthesis is blocked by puromycin, these increases induced by estrogen are also blocked [Mueller, G. C., Gorski, J. & Aizawa, Y., *Proc. nat. Acad. Sci., Wash.*, **47** (1961), 164]. It is, therefore, suggested that the primary action of the hormone is to accelerate the synthesis of rate-limiting enzymes for these anabolic pathways, and that the elucidation of the nature of this protein synthesis becomes critical for an understanding of the mechanism of action of estrogen. W. D. Noteboom and J. Gorski [*Proc. nat. Acad. Sci., Wash.*, **50** (1963), 250] have conducted short-term experiments (2 and 4 hr after hormone treatment) in order to ascertain the nature of the protein synthesis stimulated by estrogen *in vivo*. The relationship between RNA and protein synthesis in rats treated with estrogen was studied, utilizing puromycin inhibition of protein synthesis. Certain interesting facts emerged in the course of this study. These workers found no effect on protein synthesis 2 hr after hormone treatment while nuclear RNA synthesis was considerably stimulated. Protein synthesis was, however, stimulated between 2 and 4 hr interval. At 2 hr, RNA polymerase increased 100 times in the hormone treated rats. Puromycin reduced protein synthesis as well as the stimulated RNA synthesis in the hormone treated rats while it had no effect on RNA synthesis in controls. Puromycin blocked the increased activity of RNA polymerase due to estrogen, but had no effect on the enzyme in the control rats. The authors conclude from these results that one of the earliest estrogen effects is the induced synthesis of a small group of proteins which are essential for the elaboration or amplification of the initial estrogen action and that the increased metabolic activity of the uterus due to estrogen action can be attributed to its influence on the production of these proteins.

Identical conclusions have been arrived at by H. Ui and G. C. Mueller [*Proc. nat. Acad. Sci., Wash.*, **50** (1963), 250] using an entirely different approach. These workers have prevented RNA synthesis by using actinomycin D and used this effect for studying the action of estrogen on RNA and protein synthesis. Their results indicate that actinomycin D, which blocks RNA synthesis, prevents the estrogenic acceleration of phospholipid and protein synthesis. Since the antibiotic does not affect the basic processes of protein synthesis in control uteri, it appears that the acceleration of this process awaits the information contained in the new RNA. The summation of these findings is the tentative conclusion that estradiol stimulates the synthesis of certain proteins necessary for the induced synthesis of new RNA which supplies the protein-synthesizing machinery with the information essential to the amplification of the initial hormone response.

G. P. Talwar and S. J. Segal [*Proc. nat. Acad. Sci., Wash.*, **50** (1963), 226] found in experiments with actinomycin D that the estradiol induced vaginal cornification could be prevented by the mere application of the antibiotic. They further observed that intratesticular injection of actinomycin D prevents the immature rat testes from responding to exogenous gonadotrophin. In view of the recognized interference of actinomycin D in the formation of polyribonucleotides, these results point out to the necessity of an initial stimulation of RNA synthesis in order to effect target organ changes. It is interesting that similar findings have been reported with respect to the action of growth hormone (Talwar, G. P., Gupta, S. L. & Gross, F.), thyroxin [Tata, J. R., *Nature, Lond.*, **197** (1963), 1167] and androgen [Liao, S. & William-Ashman, H. G., *Proc. nat. Acad. Sci., Wash.*, **48** (1962), 1956]. It has been suggested that " the unifying mechanism in the action of a variety of stimulatory hormones, irrespective of their chemical nature, is the triggering of messenger RNA synthesis, specific for initiating the secondary biologic events characteristic of the target organ concerned " [Talwar, G. P. & Segal, S. J., *Proc. nat Acad. Sci., Wash.*, **50** (1963), 226]. — (Miss) P. MALATHI

The mechanism of genetic transcription

The essence of the dogma in respect of the mechanism of genetic transcription acceptable in our time can be briefly summarized by the following familiar diagram:

DNA ⟶ RNA ⟶ Protein

The simplest imaginable transcription mechanism one can propose would suggest the synthesis of complementary RNA copies of DNA. The RNA so formed would then mimic the base ratio of its parental DNA. This has been shown to be true by several recent investigators [Geidusche, K. E. P., Nakamoto, T. & Weiss, S. B., *Proc. nat. Acad. Sci., Wash.*, **47** (1961), 1405; Chamberlin, M. & Berg, P., *Proc. nat. Acad. Sci., Wash.*, **48** (1962), 81; Hayashi, M., Hayashi, M. N. & Spiegelman, S., *Science*, **140** (1963), 1313]. These workers have shown that, *in vitro*, when double stranded DNA is employed as the template, the DNA dependent RNA polymerase mediates the synthesis of RNA

copies complementary to each of the two strands.

However, several experimental evidences obtained *in vivo* suggest that the transcription of genetic messages may not involve both the strands of DNA. Also, as critically appraised by R. W. Hendler [*Science*, **142** (1963), 402], this scheme cannot solve the problem of removing the unwanted strand from the picture.

To prove decisively whether it is both the strands or part of each strand or only one strand of the DNA that is involved in the actual transcription of genetic messages, M. Hayashi, M. N. Hayashi and S. Spiegelman [*Proc. nat. Acad. Sci., Wash.*, **50** (1963), 664] have made use of the hybridization test of B. D. Hall and S. Spiegelman [*Proc. nat. Acad. Sci., Wash.*, **47** (1961), 137] in their studies. To provide the experimental requisites, the authors have turned to the DNA virus $\phi \times 174$, which is known to contain only one of the two complementary strands [Sinsheimer, R. L., *J. mol. Biol.*, **1** (1959), 43]. On infection by the virus, the complement of the injected strand is synthesized and a duplex called the 'replicating form' (RF) results. The RF-DNA hybrid can be obtained in pure form by chromatography on methylated albumin columns.

The viral message production in the host cell starts only after the production of RF form of the DNA virus. The viral RNA fraction (the message fraction) has been isolated in pure form and subjected to hybridization tests with the single stranded mature viral DNA and the RF-DNA. It has been shown that the single stranded DNA cannot be hybridized with the viral RNA, while the RF-DNA doublet can do so. This suggests that the complement of the RF-DNA which serves as a template for message production corresponds to the complement of the DNA strand found in the vegetative particle. This has been further strongly supported by the base composition of the RNA hybridized to the RF-DNA, which is similar to the base composition of the vegetative single strand and is complementary to the RF form.

Thus, the evidences obtained *in vivo* would conclusively point out that it is the single strand of the DNA that is involved in the genetic transcription. — KUNTALA JAYARAMAN

Precursors of benzoquinone ring of ubiquinone

The biosynthesis of ubiquinone in rat has been demonstrated using radioactive precursors, acetate-C^{14} and mevalonate-2-C^{14}, for the isoprene side chain [Olson, R. E., Dialameh, H. G. & Bentley, R., cited in *Ciba foundation symposium on quinones in electron transport* (J. A. Churchill Ltd, London), 1961, 264; Gloor, U. & Wiss, O., *Arch. Biochem. Biophys.*, **83** (1959), 216], phenylalanine-U-C^{14} for the benzoquinone ring [Bentley, R., Ramsey, V. G., Springer, C. M., Dialameh, H. G. & Olson, R. E., *Biochem. Biophys. Res. Commun.*, **5** (1961), 443] and methionine-methyl-C^{14} for the methoxyl-methyl groups [Lawson, D. E. M. & Glover, J., *Biochem. Biophys. Res. Commun.*, **4** (1961), 223]. A detailed study of the intermediary metabolism of phenylalanine leading to the formation of the quinone moiety, however, has not been attempted so far.

Recently, R. E. Olson, R. Bentley, A. S. Aiyar, H. G. Dialameh, P. H. Gold, V. G. Ramsey and C. M. Springer [*J. biol. Chem.*, **238** (1963), 3146] have shown that the side chains of phenylalanine and tyrosine are totally lost in the biosynthesis of ubiquinone and that certain benzoate derivatives may function as intermediates in the biosynthesis. These authors have also established formate as the source of the ring-bound methyl group as well as the methoxyl-methyl group. Acetate-1-C^{14}, DL-tyrosine-3-C^{14} and DL-phenylalanine-3-C^{14} are all incorporated into the isoprene side chain of Q_9, while formate-C^{14}, L-tyrosine-U-C^{14}, L-phenylalanine-U-C^{14} and ring labelled benzoate are all incorporated into the benzoquinone ring of Q_9. However, carboxyl labelled benzoate and benzoquinone-U-C^{14} are not incorporated into Q_9 of rat. The incorporation of label into Q_9 from all the precursors is of the same order of magnitude, ranging from 0·0035 per cent with formate-C^{14} to 0·022 per cent with L-tyrosine-U-C^{14}. The higher incorporation of radioactivity into Q_9 with tyrosine-U-C^{14} than with phenylalanine-U-C^{14} suggests that benzoate is not in the main pathway. *In vitro* 'swamping' experiments with liver slices have shown that when 'cold' mevalonate is added in the presence of 'hot' acetate, there is a dramatic dilution effect on the specific activity of Q_9. Similarly, when cold *p*-hydroxybenzoate is added in the presence of tyrosine-U-C^{14}, there is dilution effect to the extent of 99 per cent. These experiments support the hypothesis that *p*-hydroxybenzoate is on the main pathway from tyrosine to Q_9:

Phenylalanine
↓
tyrosine
↓
benzoate → *p*-hydroxybenzoate
↓
Q_9 nucleus

The non-incorporation of phenylalanine-3-C^{14} and tyrosine-3-C^{14} into the benzoquinone ring of Q_9 and its attached methyl group suggested that a C-methylation of the benzenoid nucleus might occur in Q_9 biosynthesis. Such a reaction has been demonstrated by these workers and formate-C^{14} has been shown to be incorporated into both ring-methyl group and ring-methoxy-methyl groups.

In another paper, H. Rudney and W. W. Parson [*J. biol. Chem.*, **238** (1963), 3137] have shown that *p*-hydroxybenzaldehyde-U-C^{14} is incorporated into the benzoquinone moiety of Q_{10} and rhodoquinone of *Rhodospirillum rubrum*, while tyrosine-U-C^{14}, *p*-hydroxybenzaldehyde-carbonyl-C^{14}, tyrosine-3-C^{14} and phenol-U-C^{14} are not incorporated into Q_{10}. The addition of unlabelled tyrosine to cells growing with *p*-hydroxybenzaldehyde-U-C^{14} has not been found to decrease the specific activity of Q_{10} isolated. This proves that tyrosine is not an intermediate in the conversion of *p*-hydroxybenzaldehyde to Q_{10}. These results also show that in the conversion of *p*-hydroxybenzaldehyde to Q_{10}, the aldehyde carbon is lost. Although the observed loss of aldehyde group from *p*-hydroxybenzaldehyde in the formation of Q_{10} suggests that ubiquinone biosynthesis involved a 6-carbon aromatic intermediate, which is subsequently hydroxylated, O-methylated and C-methylated, phenol-U-C^{14} is not incorporated into Q_{10}.

In yet another paper, R. Braun, V. C. Dewey and G. W. Kidder [*Biochemistry*, **2** (1963), 1070] have conclusively demonstrated that in a protozoan *Tetrahymena pyriformis*, phenylalanine-U-C^{14}, phenylalanine-3-C^{14}, phenylalanine-C^{14}-OOH, tyrosine-U-C^{14}, DL-tryptophan (benzene)-C^{14}, acetate-1-2-C^{14} and D-glucose-U-C^{14} are not incorporated into the benzoquinone moiety of Q_{10}, while all the above tracers are incorporated into the isoprene side chain of Q_{10}. Shikimic acid pathway for the biosynthesis of ubiquinone in an organism with animal-like nutrition should be absent and this is substantiated by the non-dilution of label into ubiquinone of *T. pyriformis* when grown in the presence of glucose-U-C^{14} and shikimic acid.

These considerations and findings show that in animals like the rat the C_3 side chain of the phenylamino acids is available only for the biosynthesis of the polyisoprene side chain of Q_9. The β-carbon of phenylalanine and tyrosine, as well as the carboxyl of benzoate, are lost in the biosynthesis of benzoquinone ring and its attached methyl group. These results are not consistent with the hypothesis postulating homogentisate and toluquinone as intermediates for that portion of the phenylamino acid carbons entering the mevalonate pathway. Braun *et al.* suggested that the pathway to the benzoquinone ring is via a stepwise degradation of phenylamino acid side chain to the benzoate level. It has been suggested that the carboxyl group may be essential as a 'handle' for the oxidative reactions leading to hydroxylation and possibly alkylation before it is lost.

In the case of photosynthetic bacterium *R. rubrum*, the results indicate that the benzoquinone nucleus is not formed directly from phenylamino acids, but is derived from aromatic compounds which arise earlier in the shikimic acid pathway.— V. C. JOSHI

Nucleic acids and metals

Binding of metals to nucleic acids and their substituent nucleotides has been known for quite some time [Katz, S., *J. Amer. chem. Soc.*, **74** (1952), 2238], but their possible role in the structure and function has been only recently suggested by the work of B. L. Vallee and coworkers at Harvard Medical School, Boston.

W. E. C. Wacker and B. L. Vallee [*Fed. Proc.*, **18** (1959), 345] have isolated a nucleoprotein containing 1080 μg. of Cr per gram dry weight from beef liver, representing a 20,000-fold aggregation of this metal in a specific biological material, which is a unique observation and implies specific association.

Detailed investigations of the above workers on the metal content of ribonucleic acid (RNA) from diverse sources [*J. biol. Chem.*, **234** (1959), 3257] showed the presence of Mg, Ca, Sr, Ba, Al, Cr, Mn, Fe, Ni, Cu, Pb and Zn, by emission spectrographic analysis. Beef liver RNA contained the following concentrations of metals (μg./g. of RNA): Ca 930; Mg 530; Fe 370; Zn 291; Cu 147; Ba 99; Cr 86; Mn 81; Ni 63; Al 37; and Sr 26. RNA from calf pancreas, horse kidney cortex and *Euglena gracilis* contained 120, 52 and 69 μg. of Pb respectively, while the s-RNA of calf pancreas did not contain any Pb; Cd was present only in horse kidney cortex RNA. The ratio of total metal-phosphate is 1:50 (total gram atom of metal per mole of phosphate $\times 10^{-2}$) which is remarkably constant regardless of the biological source of RNA. Even after dialysis and EDTA treatment (6 times with 0·1*M* EDTA), it contained significant concentration of Sr, Ba, Co, Fe, Cu, Mn, Al and Mg, confirming the firm binding of metals to RNA. Fe of RNA forms a mixed complex with 1,10-phenanthroline (OP), $(RNA.Fe)OP_n$, attesting to the firmness of the attachment of this metal to RNA.

On the basis of the above findings the authors suggest that metals may play a role in the maintenance of configuration of RNA molecule, perhaps linking purine or pyrimidine bases or both through covalent bonds involving nitrogen atoms or π electrons of the bases.

By their studies on the effect of metals on the conformation of RNA, K. Fuwa, W. E. C. Wacker, A. F. Bartholomay and B. L. Vallee [*Proc. nat. Acad. Sci., Wash.*, **46** (1960), 1298] have demonstrated that metals in RNA maintain the secondary helical structure of the molecule through the formation of intramolecular bonds. During the phase transition studies, i.e. the effect of gradual heating on the melting of the ordered helical structure of RNA due to the disruption of intramolecular hydrogen bonds, a remarkable stabilization of molecular conformation was noted by the addition of the metal ions of the first transition period of the Periodic Table. Reformation of the ordered structure of RNA by the addition of metal (Ni in this case) even at elevated temperature (50°C.) indicated the formation of bonds attributed to metals even when hydrogen bonds were being destroyed. These results suggest the existence of tertiary folding in RNA, the transition metal atoms serving ascross-linking device through chelation, which is produced and maintained by metal bonds.

After establishing the role of metals in the stabilization of the structure of RNA by metals, the biological role of metals in RNA was investigated by W. E. C. Wacker [*Biochemistry*, **1** (1962), 859]. The effect of Zn deprivation in *Euglena gracilis* on its growth and nucleic acid protein metabolism has been studied. RNA and protein showed a decrease by half the normal value while amino acids and DNA increased four times and two times respectively, with a marked accumulation of acid-insoluble phosphate (10 times the normal value). There was a considerable increase in the content of all metals in the cell (4-15 times the normal value) except Zn which was only one-tenth the normal value. Surprisingly Mn was the only metal which showed 60 times accumulation when cultures were grown in light. These results indicate the potential functional significance of the presence of metals in RNA and suggest that the lesion characteristic of Zn deficiency reflects the participation of the metal in biosynthetic processes from RNA to protein.

W. E. C. Wacker, M. P. Gordon and J. W. Huff [*Biochemistry*, **2** (1963), 716], in an effort to establish the role of metals in the biological function of RNA, have studied the metal content of tobacco mosaic virus (TMV) from various hosts and TMV-RNA.

The effect of heat and EDTA treatment has also been investigated. The results were similar to those obtained earlier. All the metals reported earlier, except Pb, were present. Metals bound to TMV protein could be easily removed by EDTA while those of TMV-RNA resisted removal by EDTA even at elevated temperatures.

In view of these observations the authors have concluded that metals intrinsic of RNA are bound as chelate complexes to nitrogen bases. The firmness of binding also indicates that 'sandwich' complexes may exist. Studies on TMV and *E. gracilis* have also clearly demonstrated the functional role of metals in RNA. That the metals could add further specificity to any code for protein synthesis has also been suggested.

T. Yamane and N. Davidson [*Biochim. biophys. Acta*, **55** (1962), 609, 780] have studied the complex formation of various metals with nucleic acids. Studies on the stabilization of TMV-RNA *in vitro* using metal salts and its relation to infectivity were initiated by B. Singer and H. Frankel Conrat at the University of California, Berkeley, USA [*Biochemistry*, **1** (1962), 52]. The metals Ag, Hg and In showed pronounced effect in increasing the resistance of TMV-RNA to pancreatic and tobacco nucleases. Hg^{2+} and Fe^{2+} showed marked changes in ultraviolet absorption and inactivated TMV-RNA, while silver acetate caused a small shift and caused no loss of infectivity. In^{3+} caused no spectral change but loss of infectivity results with increase in concentration. In fact, free RNA was recovered from enzyme-treated metal complex by simultaneous treatment with a chelating agent and bentonite. Evidence has been presented that Hg and Ag exert their influence by complexing the nucleic acid and not by inactivating the enzyme. Sedimentation studies ruled out the possibility of enzyme protection by aggregation. Competitive binding studies showed that in RNA the binding affinities and sites for Hg, Ag and Mg are independent of one another. Most of the divalent metals caused hypochromicity but no protection against enzymes.

B. Singer [*Biochim. biophys. Acta*, (1964), in press] has studied in detail the complexes of TMV-RNA with radioactive Ag, Hg^{2+}, Ca^{2+} and Fe^{3+} ions and suggests that except Ca^{2+}, all other metals studied interacted with bases.

These results again show the importance of metals in nucleic acids and definitely suggest their active participation in the biological functional role of RNA.—RAVINDRANATH

Progress Reports

National Dairy Research Institute, Karnal

The research activities and training programmes of the institute during the year ending 30 June 1961 are surveyed in the institute's report No. 21. A Statistics Section and a Dairy Extension Division were started during the year. The report also includes brief accounts of the activities of the Southern Regional Station, Bangalore, and the Central Artificial Insemination Station and the Animal Nutrition Centre, sponsored by the Indian Council of Agricultural Research.

Investigations on the metabolism of nutrients in the rumen of cows and buffaloes have revealed that the production of acetic acid in the buffalo rumen is more rapid than in the cow, which explains the higher fat content in buffalo milk. Studies on the digestion of cellulose in rumens have shown that in the initial stages, the rate of digestion of cellulose is much higher in the buffalo, but after 72 hr there is no marked difference. The percentage of cellulose digested is low in coarse fodders. In the Dairy Technology Division, studies were completed on the packing and storage of dehydrated butter fat. It has been shown that the characteristic ghee flavour can be imparted to dehydrated fat by homogenization or viscolizing with 2 per cent freshly prepared skimmed milk curd followed by open pan clarification at 120°C. Sufficient progress has been made in studies aimed at standardization of an accelerated test to determine the shelf life of ghee produced and stored under different conditions.

A method developed in the Dairy Chemistry Division for the detection of admixtures of cow milk and buffalo milk or diluted buffalo milk sold as cow milk is based on the fact that carotene which gives a characteristic fluorescence under ultraviolet light is totally absent in buffalo milk. Thus while pure buffalo milk does not give any fluorescence, samples containing cow milk give fluorescence. Among the studies in hand are those relating to the compositions of proteins of cow and buffalo milk, effect of climatic factors on the composition of milk, effect of time of milking on the composition of milk. It has been shown that in the case of cows, morning milk is the poorest in respect of both fat and solids-not-fat. But in the case of buffaloes no appreciable difference has been observed between the compositions of milk from two milkings, the slight difference being in favour of evening milk.

In the Dairy Bateriology Division studies have been undertaken on methylene blue test for cow and buffalo milk in relation to standard plate count, *p*H and other related factors. It has been shown that, in general, raw buffalo milk has a higher lactenin content than raw cow milk. The influence of breed, stage in lactation and other factors on lactenin content is under study.

Applied Physics Research in Australia

The first report of the Division of Applied Physics (1961-62), formed during 1961 by the amalgamation of the Metrology and the Electrotechnology Divisions of the National Standards Laboratory, records its main activities during the year. The division is responsible for maintaining the mechanical and electrical standards — primary as well as secondary. A calibration service based on these standards and covering a wide range of physical measurements has also been provided. A programme of work has been initiated on the absolute determination of gravity which is so essential in the realization of the units of measurement of other physical quantities; the problem assumes significance as no absolute measurement of gravity has previously been made in the southern hemisphere and the ties obtained by relative pendulum measurements and gravimeters were all with reference to stations many thousands of miles distant.

Fundamental research work has also been undertaken in the following fields: study of magnetic viscosity and its origin in the newer materials of high purity and oriented crystal structure; hardness of alkali halides arising from divalent impurity content (hardness has been found to increase with only the number of impurity ions and not to depend on the state of their aggregation); dielectric absorption studies, with the electric field in different directions, on large crystals of dodecyl myristate; relative permittivity at low frequencies of some alicyclic compounds. For cyclohexanol and cyclopentanol the experimental values of the relative permittivity are several times larger than those calculated by using Onsager's equation. The dielectric absorption mechanism in these secondary alcohols seems to be similar to that in aliphatic long-chain alcohols.

A few of the outstanding achievements resulting from the division's activities during the year are detailed below:

A photoelectric microscope for use in connection with a line standard interferometer for determinations of 1 metre lengths has been developed. The microscope permits an accuracy of setting on the lines of at least 0·01 μ. The instrument, in conjunction with a transistorized equipment and a reversible decade counter, has also been used to determine Moire fringe fractions by reading offsettings on the indicating meter when the fringes are coincident. In the field of time and frequency standards, a new system has been constructed which enables a continuous intercomparison of the three-ring crystal oscillators. By providing for each oscillator a phase shifter driven through a digital gear box, by a synchronous motor, it is possible to apply known small corrections to the oscillators to bring them closer to the nominal frequency. The gear box consists of a number of small differentials and clutches which permit a fine adjustment of 1 in 10 in. in the frequency. The remaining small differences and drifts are indicated by a direct recording of the relative phase of the oscillators. In vibration research it has been shown that the natural frequencies of any seismic mounting, likely to be met with in practice, can be calculated in terms of an equivalent four-isolator symmetrical mounting. The method applies to a mounting on any number of identical and equally loaded isolators in any layout, not necessarily coplanar or symmetrical, which satisfies a simple derived condition determining the degree of coupling of the vibration modes. In the field of production engineering, the light-slit principle of illumination, in conjunction with a measuring microscope and a profile projector, has been used for the measurement of tool geometry. Considerable interest has been evinced in this illuminator design by a number of industrial units. The technique, which facilitates measurement of difficult and inaccessible profiles which cannot be projected by the normal method, is particularly useful in establishing data from which to measure the various tool angles and enables the cross-section of a tool-cutting edge to be viewed at any plane along its length. The technique has also been used for measuring crater wear and checking the indexing of flutes, teeth, etc., of such tools.

Subjects of investigation and development in the field of length standards include improvement of reproducibility (to better than 1 in 10^8) of the new K^{86} standard of length employing a photoelectric Fabry-Perot interferometer and electromechanical techniques, light sources, calibration of surveying tapes, air bearings, screw threads, production of scales and graticutes on linear dividing engine. A prototype instrument which will indicate, within certain limits of temperature, the density of opaque liquid at a standard temperature irrespective of the actual temperature of the liquid has been developed. A sensitive electrical indicating device for use with a low-load proving level has been designed for accurate measurement of very small indentor loads. A generating process has been evolved to produce, by machine lapping, metal surfaces up to 6 in. in diameter and flat to within 1/20 of a wavelength. The time required is only one-tenth of that required for skilled hand-finishing.

Work in the domain of electrical standards has been concerned with such aspects as the international comparison of the ohm and the volt, absolute determination of the ohm, frequency stable resistors, reliable measurement of capacitance, low-frequency bridge measurements, and improvement of sensitivity of bridge detectors. With a view to eliminating long-term drifts a new design of the calculable capacitor has been evolved which is based on the cross-capacitor principle. The cross-capacitor is of square cross-section and is of the circular instead of the linear type, i.e. the four conducting electrodes enclose a toroid. The matching of a high-impedance capacitance bridge to a vacuum-tube amplifier has been improved by the use of a low-loss inductor ($Q = 800$) in the input circuit. From an analysis of coaxial transmission lines it has been shown that the simple loss-free theory is adequate if the overall Q factor of each resonator in symmetrical four-terminal network is greater than 100. A set of compact coaxial line impedance standards consisting of a resistor and matching network has been constructed.

New Periodical

High Temperature

The English translation of the Soviet journal *Teplofizika Vysokikh Temperatur* will be published under the title *High Temperature* by the Consultants Bureau Inc., New York. The annual subscription (6 issues) is $ 50.00; further details can be had from the American Institute of Physics, 335 East 45th Street, New York 17.

Supplement

ABSTRACTS

of Published Research Papers from National Laboratories and Sponsored Research Projects of CSIR

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INDEX TO CONTENTS

ABSTRACTS

53 PHYSICS

533.6.04 Aerofoils

252. SUBRAMANIAN, N. R. & TIRUMALESA, D. (National Aeronautical Laboratory, Bangalore): A note on the prediction of the shock-wave position on airfoils at transonic speeds, *J. aero. Soc. India*, **15** (1963), 53

Sinnott's technique for predicting shock-wave position on airfoils at transonic speeds has been applied to the inviscid theories of Spreiter, Rotta and Hosokawa to assess the improvement thus brought about for comparison with experiments in the case of two-dimensional non-lifting circular arc airfoils. The shock position, shock upstream pressure, drag and pressure distributions for two typical cases thus predicted have been compared with experimental results. It has been found that the shock position thus obtained does not follow the similarity rule obtained from inviscid theories but follows the parameter used by Sinnott. The shock position is very much improved in comparison with the unmodified theories. However, it corresponds more to the downstream sonic point than the experimental shock position. For thicker airfoils Sinnott's method does not give satisfactory results beyond $M_\infty = 0{\cdot}85$, while for thinner airfoils it is useful up to $M_\infty = 0{\cdot}97$. Thus it has been found that the application of Sinnott's technique leads to a definite improvement in predicting shock positions and leads to almost the same results whatever theory is used as the starting point.

253. TIRUMALESA, D. (National Aeronautical Laboratory, Bangalore): Effect of aerofoil curvature on the shock-boundary layer interaction and aerofoil pressure distributions at transonic speeds, *Tech. Note No. TN-AE-20-63* (National Aeronautical Laboratory, Bangalore), 1963

The effect of aerofoil curvature on the shock-boundary layer interaction and aerofoil pressure distributions at transonic speeds when there is no shock-induced separation has been studied for a circular arc aerofoil of 8 per cent relative thickness. In this case it is found that the upstream extent of interaction decreases with increase in shock upstream Mach number or more rearward shock positions. Due to this decrease in the upstream extent, the upstream Mach number is not much changed for an aerofoil thickness ratio of 8 per cent. However, it appears that the effect will be of significance in the case of thinner aerofoils.

534.8 Ultrasonics

254. SESHAGIRI RAO, M. G. & RAMACHANDRA RAO, B. (Physics Department, Andhra University, Waltair): Ultrasonic velocity in aqueous solutions of electrolytes and hydration numbers, *Indian J. pure appl. Phys.*, **1** (1963), 362

The variation of ultrasonic velocity and compressibility with concentration has been studied in solutions of six electrolytes, viz. sodium molybdate, sodium chromate, potassium phosphate, potassium formate, calcium formate and calcium iodide, some of them having compound acid radicals. Total hydration numbers have been estimated, employing the equation given by Wada *et al.* [*J. acoust. Soc. Amer.*, **22** (1950), 880], for these salts as well as for a number of salts for which the relevant data are available in literature. The variation of total hydration number with cationic radius by the ultrasonic method has been studied and the results have been discussed in the light of the data obtained by other methods, viz. activity coefficient and dielectric constant methods. There is a qualitative agreement between the hydration number obtained by different methods for a single electrolyte. In general, the hydration number decreases with increasing cationic radius. Lithium hydroxide has a hydration number lower than that expected from the above general rule. In beryllium and calcium nitrates the hydration number increases with increasing cationic radius. Sulphuric acid has a very high hydration number whereas nitric and hydrochloric acids have very low hydration numbers. An interesting observation is that the hydration number obtained by the ultrasonic method for ammonium hydroxide has a negative value. Suitable explanations have been provided for the deviations and anomalies observed.

536.2 Thermal Conductivity

255. BANSAL, T. D. (National Physical Laboratory, New Delhi): Evaluation of real and effective thermal conductivity values, *Indian J. pure appl. Phys.*, **1** (1963), 415

Three types of thermal conductivity (k) values have been defined, viz. (i) apparent thermal conductivity or the experimentally determined value of k, (ii) real thermal conductivity, i.e ideal value of k which would apply if the temperature drop across the material had been infinitesimally small, and (iii) effective thermal conductivity, i.e. value of k under actual conditions of application. A mathematical investigation has been carried out to compute the real and effective values of k from the experimental value. It has been found that a constant of the experiment, designated as the X-factor, is also

necessary for calculating the real and effective values of k from the experimentally determined value of k. The methods of computation of the X-factor have been outlined for different types of materials and for the cases when the experimental material is in the form of a slab, concentric sphere and coaxial cylinder. The need for extensive collaborative effort for the experimental verification of the analysis presented in the paper is emphasized.

537.226 Dielectrics

256. SAROJINI, (Miss) V. (Department of Physics, Andhra University, Waltair): Molar polarization measurements in a mixture of isopropyl alcohol and pyridine in benzene, *Indian J. pure appl. Phys.*, **1** (1963), 399

Measurements on molar polarization have been carried out in a mixture of isopropyl alcohol and pyridine in benzene, with a view to drawing inferences regarding the formation or otherwise of hydrogen bonded complexes. Association constants and dipole moments of the complexes have also been evaluated from the measurements. The results obtained are consistent with the results reported by Cleverdon *et al.* [Cleverdon, D., Collins, G. B. & Smith, J. W., *J. chem. Soc.*, (1956), 4499] on a mixture of *n*-butyl alcohol and pyridine.

538.22 Diamagnetics

257. JATKAR, S. K. K., JATKAR, V. S. & MUKHEDKAR, A. J. (Department of Chemistry, University of Poona, Poona): Solvent effect on magnetic susceptibility of liquid binary systems, *Indian J. Chem.*, **1** (1963), 465

The diamagnetic susceptibilities of ten binary systems have been studied using the Gouy technique. The mole fraction-molar susceptibility plots for the systems studied do not show a linear relationship. The deviations of the observed diamagnetic susceptibility values from the Widemann's additive law are discussed in the light of probable molecular interactions. The correlation between electron polarization and diamagnetic susceptibility, which holds for liquids of different structures, has been found to hold good for binary mixtures also, thereby showing that the dispersion electrons play an important role in diamagnetic susceptibility. It is pointed out that the order of deviation of the vibrational frequencies is the same as that of deviation from diamagnetic susceptibility ($\Delta_{\chi M}$).

539.19 Molecular Physics

258. RADHAKRISHNAN, M. (Department of Physics, Annamalai University, Annamalainagar): Urey-Bradley force field: XY_4 type lead halides, *Indian J. pure appl. Phys.*, **1** (1963), 402

The potential constants of PbF_4, $PbCl_4$, $PbBr_4$ and PbI_4 have been evaluated using the Urey-Bradley type of potential function and applying Wilson's group theoretical method. Of the four potential constants K, H, F and F', as the higher halogen members are substituted, the value of F does not show any regularity in its variation while the values of K, H and F' decrease.

259. VENKATESWARLU, K. & RAJALAKSHMI, (Miss) K. V. (Kerala University Department of Physics, U.C. College, Alwaye): Urey-Bradley force field and thermodynamic properties: Pyramidal XY_3 type molecules, *Indian J. pure appl. Phys.*, **1** (1963), 380

The force constants for fifteen molecules of pyramidal XY_3 type have been evaluated using the Urey-Bradley type of potential force field. The thermodynamic properties of five molecules have been calculated for twelve temperatures on the basis of rigid rotator, harmonic oscillator approximation.

260. VENKATESWARLU, K. & THANALAKSHMI, (Miss) R. (Kerala University Department of Physics, U.C. College, Alwaye & Department of Physics, S.R. College, Tiruchirapalli): Urey-Bradley force field and thermodynamic properties: Bent symmetrical XY_2 type molecules, *Indian J. pure appl. Phys.*, **1** (1963), 377

A normal coordinate treatment has been carried out for a number of bent symmetrical XY_2 type molecules belonging to the C_{2v} symmetry, using the Urey-Bradley potential function. The repulsion constant varies inversely as the nth power of the distance between the non-bonded atoms, where n ranges between 4 and 6. The thermodynamic properties of eight molecules for eleven temperatures in the range 100-1000°K. have also been calculated on the basis of a harmonic oscillator, rigid rotator approximation.

539.2 Solid State Physics

261. RADHA, (Miss) T. S. (Department of Physics, Indian Institute of Science, Bangalore): Turnover in the forward characteristics of p-type germanium point contact diodes, *Indian J. pure appl. Phys.*, **1** (1963), 372

Turnover has been observed in the forward biased point contact p-type germanium diodes. Turnover voltage has been found to decrease with increasing ambient temperature and the turnover disappeared at 130°C.

262. RADHA, (Miss) T. S. & SURYAN, G. (Department of Physics, Indian Institute of Science, Bangalore): Some observations on turnover in the reverse characteristics of germanium point contact diodes, *Indian J. pure appl. Phys.*, **1** (1963), 388

Static and dynamic reverse characteristics of *n*-type germanium point contact diodes in vacuum, gas and liquid coolants have been investigated and the variation of turnover voltage and current with viscosity, latent heat and boiling point of the coolant surrounding the diode has been studied. In addition to the turnover phenomenon, looping and cross-over of the return trace have been observed both in dynamic and static characteristics.

263. VISWESWARA MURTHY, S. (Department of Physics, Indian Institute of Science, Bangalore): Frequency-pulling in nuclear magnetic resonance absorption experiments, *Indian J. pure appl. Phys.*, **1** (1963), 398

The frequency-pulling effect in a marginal oscillator in nuclear magnetic resonance experiments is discussed. It has been shown that the frequency-pulling effect is directly proportional to the square of the resonance frequency and inversely proportional to the line width.

539.5.01 Rheology

264. CHARI, S. S. & JOGLEKAR, G. D. (Division of Industrial Physics, National Physical Laboratory, New Delhi): Rheological model and viscoelastic properties of green carbon rods, *Indian J. Technol.*, **1** (1963), 405

A method is reported for evaluating the viscoelastic constants involved in the extrusion of carbon rods in terms of a rheological model and the significance of the viscoelastic constants is discussed. The behaviour of the model under different experimental conditions is represented by the equation

$$\gamma = \frac{\tau}{G_1} + \frac{\tau}{G_2}(1 - e^{-t/\lambda}) + \frac{\tau}{\eta_3}.t$$

where τ is the stress; γ, the strain; t, the time; λ, the retardation time constant; G_1 and G_2, the shear moduli of the instantaneous and the delayed strain respectively; and η_3, the melt viscosity.

53 : 549.73 Ferrites

265. LAROIA, K. K. (National Chemical Laboratory, Poona): A new ferrite of magnetoplumbite structure, *Indian J. pure appl. Phys.*, **1** (1963), 396

A new ferrite of the chemical composition $Tl_{\frac{1}{2}}La_{\frac{1}{2}}Fe_{12}O_{19}$ has been formed by solid state reaction between thallous nitrate, lanthanum oxide and α-ferric oxide at 1300°C. The crystal structure is isomorphous with magnetoplumbite. The unit cell is hexagonal with $a = 5{\cdot}89$ A., $c = 23{\cdot}4$ A. and $c/a = 3{\cdot}97$. The unoriented sample when sintered at 1300°C. has the following properties: remanence (B_r), 1630 gauss; induction coercivity ($_BH_c$), 1300 oersted; intrinsic coercivity ($_IH_c$), 2700 oersted; and Curie temperature (T_c), 430°C. The addition of a small amount of bismuth oxide to the ferrite causes a decrease in the saturation magnetization. An analysis has been made of the results of different attempts to form magnetoplumbite phase of the general formula $AFe_{12}O_{19}$ and it has been suggested that positive results can be obtained only when the ionic radius of the A-ion is in the range 1·06-1·40 A.

535 : 548 Crystallography

266. AGGARWAL, P. S. & GOSWAMI, A. (National Chemical Laboratory, Poona): Structures of evaporated films of zinc sulphide and cadmium sulphide, *Indian J. pure appl. Phys.*, **1** (1963), 366

Electron diffraction study of the structures of evaporated films of zinc and cadmium sulphides on the (100), (110) and (111) faces of rock salt crystals at different temperatures has shown that the deposits grow epitaxially and develop different orientations of α- (hexagonal) and β- (cubic) phases. Depending upon the substrate temperature the deposits consist of α or β varieties or a mixture of them, even though the initial materials evaporated were entirely of cubic or hexagonal structure.

267. BADACHHAPE, S. B. & GOSWAMI, A. (National Chemical Laboratory, Poona): An electron diffraction study of thallium iodide, *Indian J. pure appl. Phys.*, **1** (1963), 370

Electron diffraction study of the structure of precipitated thallium iodide has shown that thallium iodide is predominantly cubic (CsCl type) in nature with the crystal sizes varying from 35 to 50 A. The method of preparation of thallium iodide has a profound influence on its structure. Intensity measurements suggest that the scattering of electrons takes place under kinematical conditions.

54 CHEMISTRY

541.11 Thermodynamics

268. ANANTARAMAN, A. V., BHATTACHARYYA, S. N. & PALIT, S. R. (Indian Association for the Cultivation of Science, Jadavpur, Calcutta): Excess thermodynamic function of binary mixtures: Benzene-fluorobenzene and carbon tetrachloride-fluorobenzene systems, *Indian J. Chem.*, **1** (1963), 459

Excess Gibbs free energy, heats of mixing and volume change of mixing have been measured for benzene-fluorobenzene and carbon tetrachloride-fluorobenzene systems. The results have been analysed in the light of Balescu's theory and our modified approach [Anantaraman, A. V., Bhattacharyya, S. N. & Palit, S. R., *Trans. Faraday Soc.*, **59** (1963), 1101; *Physica*, **28** (1962), 633; *Trans. Faraday Soc.*, **57** (1961), 40]. As observed in our previous publications, the results do not agree with Balescu's theory. Benzene-fluorobenzene system has extremely small excess functions and within the limited experimental accuracy the sign of g^E is extremely difficult to predict. For the other system the excess functions seem to be almost purely of dipolar origin, the contribution of central forces being negligible.

269. RAM GUPTAL (Chemistry Department, Lucknow University, Lucknow): Calculation of activation energy of self-diffusion in some solid metals, *J. Indian chem. Soc.*, **40** (1963), 671

A simple method for calculating the activation energy of self-diffusion (Q) in some solid metals, utilizing the total binding energy of the metal as calculated from the Pauling's concept of the metallic valency, has been proposed. The values of Q, estimated for different metals, have been compared with the available experimental data. There is reasonable agreement between the two sets of values.

270. RASTOGI, R. P. & BLOKHRA, R. L. (Department of Chemistry, University of Gorakhpur, Gorakhpur): On the choice of phenomenological coefficients, *J. chem. Phys.*, **39** (1963), 241

The concentration and temperature dependence of the modified cross-coefficient as suggested by Van Ryssellberghe have been studied. The relative constancy of the conventional cross-coefficient and Ryssellberghe cross-coefficient has been examined in the case of thermal diffusion.

271. RASTOGI, R. P., NIGAM, R. K., SHARMA, R. N. & GIRDHAR, H. L. (Department of Chemistry, University of Gorakhpur, Gorakhpur): Entropy of fusion of molecular complexes, *J. chem. Phys.*, **39** (1963), 3042

A new thermistor calorimeter has been designed for the measurement of heats of fusion. Heats of fusion of *p*-nitrotoluene, *p*-toluidine, benzophenone, diphenylamine, 1 : 1 benzophenone-diphenylamine complex and 1 : 2 urea-phenol complex have been determined.

272. SRIVASTAVA, R. C. (Department of Chemistry, University of Gorakhpur, Gorakhpur): Transport processes in thermo-cells, *J. Indian chem. Soc.*, **40** (1963), 585

The domain of validity of thermodynamics of irreversible processes has been examined experimentally in the case of transport processes in thermo-cells. Earlier theory of thermo-cells has been revised to suit the experiments described. The data obtained have also been used to study the effect of concentration, temperature and the nature of other ion on the heat and entropy of transport.

541.121 Phase Studies

273. MUKERJI, JOYDEB (Central Glass & Ceramic Research Institute, Calcutta): A dta technique used in the study of the phase equilibrium diagram $CaO\text{-}CaF_2\text{-}2CaO.SiO_2$, *Cent. Glass Ceram. Res. Inst. Bull.*, **10** (1963), 78

The paper is a part of a work devoted to the study of the ternary phase equilibrium system $CaO\text{-}CaF_2\text{-}2CaO.SiO_2$. Details of one of the experimental techniques employed, viz. dta, are given with special reference to the set-up of the dta apparatus. The dta experiments were done in a hermetically closed pure platinum capsule for experiments up to 1500° and in a similar platinum-20 per cent rhodium capsule for experiments above 1500°. dta experiments in closed capsule opens the possibility of work in a closed or a controlled atmosphere and with volatile materials; 150-200 mg. of a sample is sufficient for one experiment and work can be done up to 1700°.

54.124 Reaction Mechanism

274. RASTOGI, R. P., BASSI, PARAM S. & CHADHA, S. L. (Chemistry Department, University of Gorakhpur, Gorakhpur): Mechanism of the reaction between hydrocarbons and pioric acid in the solid state, *J. phys. Chem.*, **67** (1963), 2569

The kinetic data for reactions between hydrocarbons, i.e. naphthalene, phenanthrene, anthracene, and pioric acid in the solid state are recorded. The measurements have been made at various temperatures and for particles of various sizes. For elucidating the mechanism, photoreaction in the solid state has been studied. Experimental results are best fitted by an equation of the type

$$\xi = 2k_i.l.e^{-p\xi}$$

where ξ is the thickness of the boundary and k_i and p are constants. The factor p is found to be approximately independent of temperature and particle size; k_i and energy of activation increase in the following order: naphthalene > phenanthrene > anthracene. It has also been found that k_i varies linearly with the surface area of the particles. It is fairly definite that the reaction is diffusion controlled. There is evidence to show that bulk diffusion or lattice diffusion is non-existent. The probable diffusion mechanisms have been discussed.

275. SENGUPTA, KALYAN K. & ADITYA, S. (Department of Applied Chemistry, University College of Science & Technology, Calcutta): Kinetics and mechanism of the oxidation of malonic acid by ceric salts, *Z. phys. Chem.* (*NF*), **38** (1963), 25

The kinetics of the oxidation of malonic acid by ceric salts (ceric sulphate, ceric nitrate and ceric perchlorate) have been studied. The order of the reaction is 1. The reaction is faster when ceric perchlorate is used as oxidant than when ceric nitrate or ceric sulphate is used. The oxidation is slowest in ceric sulphate solution. The activation energies in the case of the oxidation by ceric sulphate, ceric nitrate and ceric perchlorate are $16{\cdot}1 \pm 0{\cdot}5$, $11{\cdot}5 \pm 0{\cdot}5$ and $9{\cdot}2 \pm 0{\cdot}4$ kcal./mole respectively. The values of $-\Delta S$ for these three processes are $16{\cdot}5 \pm 1{\cdot}0$, $31{\cdot}4 \pm 1{\cdot}0$, $38{\cdot}6 \pm 1{\cdot}2$ E.U. respectively. H^+ ions retard the rate of reaction. The oxidation appears to proceed through the initial formation of an activated complex and subsequently through free radicals.

276. SRIVASTAVA, P. K. (Department of Chemistry, Banaras Hindu University, Varanasi): Mechanism of oxidation of thiocarbamides: 1-Methyl-3-phenylthiocarbamide, *Indian J. Chem.*, **1** (1963), 432

1-Methyl-3-phenylthiocarbamide has been found to give on oxidation N-2-benzothiazolyl-N,N′-dimethyl-N″-phenylguanidine, the structure of which has been confirmed by synthesis. In the mechanism proposed for the oxidation the related substituted formamidine disulphide and formamidine monosulphide salts, amidinothiocarbamide and the isomeric 3-(N-methyl-N′-phenylformamidino)-2-methyl-iminobenzothiazole are formed as intermediate stages.

541.124-8 Chemical Reactions

277. AGARWAL, K. L. & DHAR, M. M. (Central Drug Research Institute, Lucknow): Nature of products formed by the action of polyphosphate

ester on nucleotides, *Indian J. Chem.*, **1** (1963), 451

Treatment of nucleotides with polyphosphate ester yields nucleotide polyphosphates and not polynucleotides as previously claimed [Schramm, G., Grötsch, H. & Pollmann, W., *Angew. Chem., internat. Ed.*, **1** (1962), 1].

278. DIXIT, S. N. & VERMA, V. K. (Department of Chemistry, Banaras Hindu University, Varanasi): Oxidative debenzylation of 1,1,5-trisubstituted-2-S-benzyliso-4-thiobiurets: Formation of 5-(N-substituted-anilino)-3-substituted-imino-1,2,4-dithiazolines, *Indian J. Chem.*, **1** (1963), 487

5-(N-methylanilino)-3-phenylimino-, 5-(N-methylanilino)-3-methylimino-, 5-(N-ethylanilino)-3-phenylimino-, 5-(N-ethylanilino)-3-methylimino-, 5-(N-phenylanilino)-3-phenylimino, 5-(N-phenylanilino)-3-*p*-tolylimino-1,2,4-dithiazolines have been synthesized by the oxidative debenzylation of the corresponding 1,1,5-trisubstituted-2-S-benzyliso-4-thiobiurets.

279. MEHROTRA, R. C. & GUPTA, V. D. (Department of Chemistry, University of Rajasthan, Jaipur): Reactions of stannic chloride with acetylacetone, *J. Indian chem. Soc.*, **40** (1963), 911

A detailed study has been made of the reaction between stannic chloride and acetylacetone. In refluxing benzene, the reaction in varying molar ratios yields a light brown crystalline solid corresponding to $SnCl_2(AcAc)_2$ (I), which has been shown to be a simple monomeric, non-conducting compound. In cold, a product, corresponding in analysis to $SnCl_4$-HAcAc, is obtained to which the plausible formula $[(HAcAc)_2SnCl_2]SnCl_6$ has been assigned. This has been confirmed by its observed conductivity in nitrobenzene as well as by the isolation of an identical product by adding stannic chloride to $[(HAcAc)_2$-$SnCl_2]Cl_2$ obtained by passing hydrogen chloride in a solution of (I).

280. NAIR, G. VIJAYAKUMARAN (Department of Chemistry, Banaras Hindu University, Varanasi): Interaction of benzoyl isothiocyanate and primary and secondary amines: Formation of the related benzoyl thiocarbamides and thiocarbamides, *J. Indian chem. Soc.*, **40** (1963), 953

The interaction of benzoyl isothiocyanate and certain primary and secondary amines, leading to the formation of the corresponding 1-substituted- and 1,1-disubstituted-3-benzoyl thiocarbamides, and the hydrolysis of the latter to the related thiocarbamides have been described. The reaction is of general preparatory value for thiocarbamides which are otherwise more difficultly obtained.

281. SRIVASTAVA, P. K. & RAMACHANDRA RAO, Y. (Department of Chemistry, Banaras Hindu University, Varanasi): Mechanism of oxidation of thiocarbamides: 1-Benzylthiocarbamide, *J. Indian chem. Soc.*, **40** (1963), 803

Analogous to the oxidation of phenylthiocarbamide to Hector's base, the final product of oxidation of 1-benzylthiocarbamide has been shown to be 3-benzylimino-4-benzyl-5-imino-1,2,4-thiadiazolidine. In this oxidation, the related bis-formamidine disulphide, monosulphide, and probably the 1-benzylformamidino-1-benzylthiocarbamide also are formed as intermediate stages. On reduction with ammoniacal hydrogen sulphide, the 3-benzylimino-4-benzyl-5-imino-1,2,4-thiadiazolidine affords, as expected, thiocyanic acid and the above related amidinothiocarbamide as principal products and small quantities of 1-benzylformamidino-3-benzylthiocarbamide which has been shown to arise by an isomeric change of 1-benzylformamidino-1-benzylthiocarbamide.

541.13 Electrochemistry

282. GUPTA, S. L. & SARASWATHI, L. (Birla College, Pilani): Effect of a.c. ripple on the behaviour of bromothymol blue at the dropping mercury electrode, *Proc. Rajasthan Acad. Sci.*, **9** (Pt 2) (1962), 23

The effect of 50 c/s. a.c. ripple of varying magnitudes, i.e. from 10 to 150 mV. (r.m.s.), on the behaviour of bromothymol blue at the d.m.e. has been studied. The lowering of the capacity as well as the magnitude of the desorption peak have been found to diminish with increase in a.c. ripple. This diminution in the magnitude of the peak with increase in a.c. ripple is in accordance with the theory of maximum based on adsorption and desorption phenomena at the d.m.e.

283. NARAYAN, R. (Central Electrochemical Research Institute, Karaikudi): Anomalous polarographic maximum, *Indian J. Chem.*, **1** (1963), 535

The occurrence and the nature of the maximum in the current-voltage curves obtained by the addition of Cu^{2+} ions to a solution containing potassium chloride as the supporting electrolyte have been investigated with dropping mercury and rotated platinum electrodes. It has been observed that small amounts of Cu^{2+} induce a maximum at the reduction potential of oxygen. This is explained as due to the removal of Cu^{2+} ion as hydroxide and consequent decrease in the contribution due to Cu^{2+} to the total limiting current. It has also been shown that the maximum depends on the concentration of oxygen in the solution.

541.182 Colloids

284. SANGAL, SATENDRA P. (Chemical Laboratories, University of Allahabad, Allahabad): Behaviour of chromotropic acid as a colloidal electrolyte in aqueous solution, *Bull. chem. Soc. Japan*, **36** (1963), 1349

The nature of chromotropic acid as a colloidal electrolyte has been established from electrical conductance studies. The curve obtained by plotting the square root of concentration and molar conductance of the reagent solution is not linear and resembles that of a colloidal electrolyte. The temperature coefficient per degree centigrade per hundred units of conductance at 35°C. is between 1·5 and 1·7. The temperature of zero conductance, determined by extrapolation, is −20·0°C.

285. SANGAL, SATENDRA P. (Chemistry Department, University of Allahabad, Allahabad): Behaviour of *p*-benzyl sulphonic acid azoresorcin (sodium salt) (Tropaeolin-O) as a colloidal electrolyte in aqueous solution, *Vijnana Parishad Anusandhan Patrika*, **6** (1963), 17

The behaviour of *p*-benzyl sulphonic acid azoresorcin (Tropaeolin-O) as a colloidal electrolyte has been studied. The curve obtained by plotting the square root of concentration and the molar conductance resembles the curve obtained by McBain for the colloidal electrolytes. The temperature of zero conductance obtained by the extrapolation of the curves obtained by plotting the specific conductance against temperature has been calculated to be $-23{\cdot}5°$ and the temperature coefficient per hundred of the conductance to be from 0·94 to 1·62. These results establish the colloidal nature of the tropaeolin in aqueous solution.

541.41 Complex Compounds

286. FAZLUR RAHMAN, S. M. & MALIK, ANEES UDDIN (Chemical Laboratories, Muslim University, Aligarh): Studies on the composition and stability of Cu (I)-disodium 1,8-dihydroxynaphthalene-3,6-disulphonate complex, *Indian J. Chem.*, **1** (1963), 424

The nature and composition of the pink-coloured complex disodium 1,8-dihydroxynaphthalene-3,6-disulphonate (DNS) forms with Cu (I) has been investigated by spectrophotometric and conductometric methods. These studies reveal that the complex has the composition Cu_2 (DNS) and it exhibits maximum adsorption at 430 mμ; chemical analysis confirms the composition of the complex. The complex is stable between *p*H 5·0 and 7·0. The values of formation constant (K) and the free energy of formation ($\Delta F°$) for the complex are $2{\cdot}1 \times 10^4$ and $-2{\cdot}58$ kcal. respectively at 30°C.

287. SANGAL, SATENDRA P. & DEY, ARUN K. (Chemical Laboratories, University of Allahabad, Allahabad): Cadmium sulfodichlorohydroxydimethylfuchsondicarboxylate chelate — A spectrophotometric study, *Bull. chem. Soc. Japan*, **36** (1963), 1347

Sulfodichlorohydroxydimethylfuchsondicarboxylate forms a 1:2 violet-coloured chelate ($\lambda_{max.}$ 540 mμ) with cadmium (II). The chelate is stable between *p*H 9·5 and 11·5. The values of stability constant as determined by two different methods are 9·1 and 9·0 at 25°C.

288. SUBBARAMAN, P. R. & SHETTY, P. S. (National Chemical Laboratory, Poona): Polarographic minima in metal-triphosphate complexes, *Indian J. Chem.*, **1** (1963), 507

Cathodic polarograms of copper (II), iron (III), bismuth (III), titanium (IV), vanadium (V), molybdenum (VI) and uranium (VI) from sodium triphosphate solutions exhibit minima around the electrocapillary maximum (ECM), particularly at low concentrations of the supporting electrolyte. The minima vary in intensity from metal to metal and are totally absent when the cathodic steps rise at potentials more negative to the ECM. The depth and width of these minima increase with increasing *p*H. Large cations such as cesium and tetrabutyl ammonium tend to suppress these minima in the order of their adsorbability on the cathode. The effect of a given cation on the minima depends on the particular metal complex undergoing reduction.

543 Chemical Analysis

289. SANGAL, SATENDRA P. (Department of Chemistry, University of Allahabad, Allahabad): 1-(*o*-Arsonophenylazo)-2-naphthol-3,6-disulphonate (thoron) as an indicator for the complexometric determination of thorium, *Vijnana Parishad Anusandhan Patrika*, **6** (1963), 49

1-(*o*-Arsonophenylazo)-2-naphthol-3,6-disulphonate (thoron) has been used as a chelatochrome indicator in the complexometric determination of thorium (IV) against EDTA. Two drops of 0·5 per cent solution of indicator give a sharp end point. Titrations are possible up to dilution 0·005M solutions, a *p*H range of 2·5-3·0 and at all temperatures ranging between 0° and 100°. Interference due to a large number of foreign ions has been observed and it is seen that sodium, potassium, lithium, silver, magnesium, calcium, barium, zinc, cadmium, mercury, lead, manganese and ammonium do not interfere.

290. SANGAL, SATENDRA P. & DEY, ARUN K. (Chemical Laboratories, University of Allahabad, Allahabad): Microdetermination of palladium (II) using 1-(*o*-arsonophenylazo)-2-naphthol-3,6-disulfonate (thoron) as a colorimetric reagent, *Microchem. J.*, **7** (1963), 257

Palladium (II) forms a reddish violet 1:1 chelate with 1-(*o*-arsonophenylazo)-2-naphthol-3,6-disulfonate (thoron) ($\lambda_{max.} = 525$ mμ). This has been used in the colorimetric determination of palladium (II) on a micro scale, and the conditions for the measurements have been worked out. Beer's law is adhered to with 0·35-25·4 p.p.m. of palladium in the presence of a large excess of thoron. Measurements may be made over a wide temperature range between *p*H 2·0 and 10·0. The sensitivity is 0·0106 γ/cm.^{2} (Sandell) and 0·106 γ/cm.^{2} (practical). A large number of cations and anions have been found to interfere and must be removed.

291. SANGAL, SATENDRA P. & DEY, ARUN K. (Department of Chemistry, University of Allahabad, Allahabad): Murexide as an indicator in thorium-EDTA titration, *Talanta*, **10** (1963), 1115

Murexide (ammonium purpurate) has been found suitable as an indicator for the complexometric determination of thorium. Murexide forms a yellow complex with thorium which turns pink when an excess drop of EDTA is added to it. To obtain sharp end points, 0·1 ml. of murexide (0·04 per cent) is sufficient. It is possible to estimate thorium in dilutions up to 0·005M at *p*H 2·5 in the temperature range 0-100°. There is no interference from Li, Na, K, Ag, Ca, Sr, Ba, Mg, Hg^{2+}, Al, As^{3+} or Mn^{2+}. The following ions interfere: Cu^{2+}, Au^{3+}, Be, Zn, Cd, Ti^{4+}, Zr^{4+}, Sn^{4+}, Sn^{2+}, Pb, V^{5+}, Sb^{3+}, Bi^{3+}, Cr^{6+}, Mo^{6+}, W^{6+}, Fe^{3+}, Co^{2+}, Ni, Ce^{4+}, UO_2^{2+}, tartrate, citrate, borate,

phosphate and fluoride. Fe^{3+}, if present, can be masked by ascorbic acid.

292. SINGH, ERIC JOHN & DEY, ARUN K. (Department of Chemistry, University of Allahabad, Allahabad): Analysis of samples of jewellery alloys using Weisz ring oven method, *Indian J. Chem.*, **1** (1963), 545

Samples of platinum-copper and gold-copper alloys have been analysed quantitatively by ring colorimetry after separating the component metals by the ring oven technique. The metals can be estimated with an accuracy of $\pm 1{\cdot}9$ per cent by this procedure.

293. VERMA, M. R., GUPTA, P. K. & PATHAK, V. K. (National Physical Laboratory, New Delhi): Estimation of acetate group in metallic acetates, *ISI Bull.*, **15** (1963), 276

The conventional method for the estimation of metallic acetates involving the determination of their metal content cannot be applied to basic or sub-acetates where the ratio between the metal and the acetate ions is indefinite or to compounds having an unknown number of molecules of water. A new method is reported in which the acetates are assayed by the direct determination of their acetic acid content. This method gives results which are in agreement with those obtained by the conventional method and has the added advantage that it can be applied to basic salts or salts whose composition is otherwise uncertain. The method, though somewhat laborious and time consuming, is particularly suitable for the determination of acetic content of basic and sub-acetates.

294. YAG DUTT & SINGH, R. P. (Department of Chemistry, University of Delhi, Delhi): Purpurogallin and some related compounds as analytical reagents: Part II — A spectrophotometric study of zirconium complexes with 3′,4′-dihydroxybenzotropolone, *Indian J. Chem.*, **1** (1963), 471

The composition of the two chelates formed between zirconium and 3′,4′-dihydroxybenzotropolone has been investigated employing absorbance measurements, and it has been found that zirconium and 3′,4′-dihydroxybenzotropolone form 1:1 and 1:2 complexes. The colour intensity of the complexes is maximum in $0{\cdot}5$-$1{\cdot}5N$ hydrochloric acid and the values of log K_1 and log K_2, determined by continuous variation and mole-ratio methods, in $0{\cdot}8N$ HCl at 20°C. and ionic strength of $0{\cdot}8M$, are 4·5 and 8·3 respectively. The complex obeys Beer-Lambert's law at 540 mμ in the concentration range 0·5-15 p.p.m. of zirconium. Interference due to a number of cations and anions has also been investigated.

545.844 Chromatography

295. DUTTA, J. (Bose Institute, Calcutta): A carrier-gas bypass system for multiple-column gas-liquid partition chromatography apparatus, *Sci. & Cult.*, **29** (1963), 153

A carrier-gas bypass system for gas-chromatography apparatus has been designed and constructed. It can be used with three chromatographic columns at a time. The carrier gas can be passed through any one, two or all the three columns at a time with the help of this system.

296. DUTTA, J. & HOQUE, M. (Bose Institute, Calcutta): Construction of a simple gas-liquid partition chromatograph, *Trans. Bose Res. Inst.*, **25** (1962), 109

A simple gas-liquid partition chromatography apparatus suitable for research laboratories has been constructed from easily available materials. The capacities for resolving the components of a mixture of hydrocarbons of three different chromatographic columns with tritolyl phosphate, dinonyl phthalate and squalane respectively as the stationary phase have been compared.

297. GUPTA, A. S. & SUKH DEV (National Chemical Laboratory, Poona): Chromatography of organic compounds: I — Thin layer chromatography of olefins, *J. Chromatog.*, **12** (1963), 189

A method for the thin layer chromatography of olefins over a silica gel silver nitrate mixture is described.

547.56 Phenols

298. SETHI, S. C., AGGARWAL, J. S. & SUBBA RAO, B. C. (National Chemical Laboratory, Poona): Effect of various substituents on the antioxidant properties of catechol, *Indian J. Chem.*, **1** (1963), 435

A number of catechol derivatives have been examined with a view to studying the effect of the substituents on their overall performance as antioxidants. It has been observed that the presence of an acyl, ester or carboxyl group, in the decreasing order, reduces the activity of the compound. Introduction of an allyl group *para* to the *ortho* dihydroxy as in the case of 4-allyl catechol enhances the antioxidant properties to a great extent.

547.596 Terpenes

299. DAMODARAN, N. P. & SUKH DEV (National Chemical Laboratory, Poona): Some new humulene-based sesquiterpenoids, *Tetrahedron Lett.*, **28** (1963), 1941

Using the strong absorption at 970 cm.$^{-1}$ in the infrared as a pointer for humulene-based sesquiterpenes, a number of new sesquiterpenoids of the humulene family could be isolated from the essential oil of *Zingiber zerumbet*. The structures of two α-epoxides —humulene epoxide-I and humulene epoxide-II respectively — and an alcohol humulenol have been deduced. Two unidentified ketones, humulene diepoxide, (+)-ar-curcumene and caryophyllene epoxide have also been isolated from the oil.

300. MAHESHWARI, M. L., VARMA, K. R. & BHATTACHARYYA, S. C. (National Chemical Laboratory, Poona): Terpenoids: XLVII — Structure and absolute configuration of nor-ketoagarofuran, 4-hydroxy-dihydroagarofuran, 3,4-dihydroxydihydroagarofuran and conversion of

β-agarofuran to α-agarofuran, *Tetrahedron*, **19** (1963), 1519

In addition to the furanoid compounds reported previously, three more crystalline furanoids of the selinane group have been isolated from agarwood oil, obtained from the fungus infected plant *Aquillaria agallocha* Roxb. The structures and absolute configurations have been determined by their interconversions into the compounds previously reported.

547.914 Gums

301. DEB, S. K. & MUKHERJEE, S. N. (Department of Chemistry, Jadavpur University, Calcutta): Molecular weight and dimensions of guar gum from light scattering in solution, *Indian J. Chem.*, **1** (1963), 413

The molecular weight and molecular dimension of guar gum have been determined by light scattering measurements. The molecular weight of the gum, after necessary correction, has been found to be $1{\cdot}72\times10^6$. On the assumption of a spherical configuration, the diameter of the gum molecule is found to be 200·3 mμ, which remains unaltered on adding potassium ions. The low density of the gum, i.e. 0·068 per cent, suggests that the gum undergoes high solvation in aqueous solution.

302. FAROOQI, M. I. H. & KAUL, K. N. (National Botanic Gardens, Lucknow): Chemical investigation of gum from *Albizzia procera* Benth., *Indian J. Chem.*, **1** (1963), 542

D-Galactose, L-arabinose and L-rhamnose in the ratio of 6:4:1 as well as glucuronic and 4-O-methylglucuronic acids have been isolated from the gum obtained from *A. procera* Benth. The gum has been found similar in properties to gum arabic.

54 : 58 Plant Chemistry

303. SASTRY, G. P., BARUAH, J. N. & RAO, P. R. (Regional Research Laboratory, Jorhat): (−)-epi-Gallocatechin from *Acacia arabica* bark, *Indian J. Chem.*, **1** (1963), 542

(−)-epi-Gallocatechin has been isolated from the ethyl acetate extract of the bark of *A. arabica* Willd. The ethyl acetate-soluble fraction exhibits fungitoxicity comparable to that exhibited by condensed type of tannins obtained from the bark.

304. SHARMA, R. C., KHAN, S. Y., ASIF ZAMAN & KIDWAI, A. R. (Department of Research in Unani Medicine & Department of Chemistry, Muslim University, Aligarh): Chemical examination of *Corchorous acutangularis* Lam., *Indian J. Chem.*, **1** (1963), 502

Quercetin has been isolated from the ethanolic extract of the fresh plant of *C. acutangularis* Lam.

305. SRIVASTAVA, S. N., BHAKUNI, D. S. & SHARMA, V. N. (National Botanic Gardens, Lucknow): Chemical examination of *Acrostichum aureum* Linn., *Indian J. Chem.*, **1** (1963), 499

β-Sitosterol, an alcohol $C_{29}H_{49}O$, and sodium chloride in unusual amounts (1·1 per cent) have been isolated from the stem and leaves of *A. aureum* Linn.

306. SRIVASTAVA, S. N., BHAKUNI, D. S. & SHARMA, V. N. (National Botanic Gardens, Lucknow): Chemical investigation of *Thespesia populnea* Soland., *Indian J. Chem.*, **1** (1963), 451

A tentative structure has been assigned to the new flavonoid colouring matter thespesin, $C_{19}H_{20}O_5$, isolated from the fruits of *Thespesia populnea* Soland. in an yield of 0·4 per cent. Ceryl alcohol and β-sitosterol have also been isolated from the unsaponifiable matter of the seed oil.

547 : 542.915 Organic Synthesis

307. JOSHI, K. C. & JAUHAR, (Miss) A. K. (Department of Chemistry, University of Gorakhpur, Gorakhpur): Studies in fluorochalkones and related compounds: Part II — Synthesis of fluorocoumaranones and fluoroflavones, *Indian J. Chem.*, **1** (1963), 477

Some chalkones, derived from 2-hydroxy-5-fluoro-, 2-hydroxy-3-chloro-5-fluoro- and 2-hydroxy-3-bromo-5-fluoroacetophenones, have been converted into fluorine-substituted benzylidene coumaranones by the action of ethanolic potassium hydroxide on their dibromides and into fluoroflavones by direct selenium dioxide oxidation. Some chalkones from 2-hydroxy-3-chloro-5-fluoroacetophenone have also been prepared.

308. JOSHI, K. C. & SEN GUPTA, (Miss) JHARNA (Chemistry Department, University of Gorakhpur, Gorakhpur): Synthesis of some fluorohydroxyketones and related compounds of potential biological interest, *J. Indian chem. Soc.*, **40** (1963), 851

Several fluoro-hydroxyketones and related compounds derived from 2-bromo-4-fluoro- and 2-chloro-4-fluorophenol have been prepared with a view to evaluating their biological activity.

309. RAMACHANDRA ROW, L., RUKMINI, (Miss) C., SUBBA RAO, G. S. R. & SRINIVASULU, C. (Department of Chemistry, Andhra University, Waltair): Furanobenzopyrones: Part VI — Synthesis of some furano-(3′,2′,6,7)-flavones, *Indian J. Chem.*, **1** (1963), 521

8-Methoxy-, 8-methoxy-3″,4″-methylenedioxy-, 3″,4″-dimethoxy- and 3″,4″-methylenedioxyfurano-(3′,2′, 6,7)-flavones have been synthesized by subjecting benzoyl and piperonyl derivatives of 5-acetyl-6-hydroxy-7-methoxycoumaran to Baker-Venkataraman migration. Cyclization of the resulting diketone followed by dehydrogenation with Pd-C Linstead catalyst (30 per cent) gives the furanoflavone.

310. SIDHU, G. S., THYAGARAJAN, G. & RAO, NAGABUSHAN (Regional Research Laboratory, Hyderabad): A new synthesis of 1,2,4,6-tetrazepines, *Tetrahedron Lett.*, **24** (1963), 1637

Starting from bisformamido-*o*-nitrobenzaldehydes, a new synthesis of 1,2,4,6-tetrazepines has been developed. This method holds promise also for a novel synthesis of a variety of aza heterocyclic system and of fused rings derived therefrom. 1H-[1,2,4,6]-Tetrazepine-[4,5-b]-indazole and 1H-[1,2,4,6]-tetrazepine-[4,5-c]-benzotriazine have been synthesized

from 5,6-dihydro-5-*o*-nitrophenyl-4H-[1,2,4,6-]-tetrazepine.

311. SINGH, K. P., GEORGE, K. & SAKSENA, S. S. (Department of Chemistry, Banaras Hindu University, Varanasi): A convenient synthesis of ethyl cyclohexanone-4-carboxylate, *Indian J. Chem.*, **1** (1963), 498

Ethyl cyclohexanone-4-carboxylate has been synthesized by condensing diethyl malonate with ethyl acrylate followed by Dickman cyclization of the resulting pentane-1,3,3,5-tetraethyl carboxylate. Subsequent decarboxylation of the product with *p*-toluenesulphonic acid gives ethyl cyclohexanone-4-carboxylate in 70 per cent yield.

312. ZAHEER, S. H., SIDHU, G. S. & DAKSHINAMURTY, H. (Regional Research Laboratory, Hyderabad) & (MRS) LALITA BALDEV SINGH (Osmania University Women's College, Hyderabad): Synthesis of trimethylgallates of 1,2,3,4-tetrahydroquinoline-N-ethanols, *Indian J. Chem.*, **1** (1963) 479

Trimethylgallates of seven Bz-substituted 1,2,3,4-N-tetrahydroquinoline ethanols have been synthesized, as possible CNS depressants, by the condensation of trimethylgalloyl chloride with 1,2,3,4-tetrahydroquinoline-N-ethanols in 80-90 per cent yields. 1,2,3,4-Tetrahydroquinoline-N-ethyl trimethylgallate has been found to cause a pronounced decrease of locomotor activity in mice [LD_{50} i.p. > 800 mg./kg.].

55 METEOROLOGY

551.508.7 Hygrometry

313. JOHN, P. T. (Heat & Power Division, National Physical Laboratory, New Delhi): An apparatus for determining vapour pressure and moisture transfer in a porous medium, *Indian J. pure appl. Phys.*, **1** (1963), 392

A simple apparatus, which is essentially a modified dew point hygrometer, designed and constructed by the author is described and used for the determination of vapour pressure in a porous sheet, board or slab. The apparatus requires no calibration and gives sufficiently accurate and reproducible results.

314. JOHN, P. T. (National Physical Laboratory, New Delhi): Vapour pressure and relative humidity in a porous medium: A semi-empirical treatment, *Indian J. Technol.*, **1** (1963), 437

Correlations have been developed between vapour pressure, relative humidity, relative moisture content and temperature in porous media from theoretical considerations and their validity confirmed by experimental determinations in the case of sandy loam, clay and timber. It has been found that in porous media, though vapour pressure increases with temperature, relative humidity remains almost constant. Relative humidity depends on relative moisture content and hence relative moisture content is also independent of temperature.

551.573 Evaporation

315. DEO, A. V., GEORGE, K. V., SANJANA, N. R., KULKARNI, S. B. & GHARPURE, M. K. (National Chemical Laboratory, Poona): Open-air evaporimeter studies on the water evaporation reduction due to hexadecyl (cetyl) alcohol, octadecoxy-ethanol and other monolayers, *Indian J. Met. Geophys.*, **14** (1963), 453

Monomolecular films of cetyl and other *n*-long chain alcohols, *n*-octadecoxy and other ethanols, and their mixtures, which in earlier laboratory experiments were found to be effective in reducing evaporation from water surface, have been tested in the open air in evaporimeters and small ground level brick-cement lined tanks. It has been found that the alkoxy-ethanol monolayers are more effective than the alcohol monolayers. The results have been discussed in the light of the known physical properties of these substances, especially as monolayers.

57 BIOLOGICAL SCIENCES

576.8 Bacteriology

316. CHATTERJEE, G. C. & DAS, S. K. (Department of Applied Chemistry, University College of Science & Technology, Calcutta): The reduction of dehydroascorbic acid by several strains of *Vibrio cholerae*, *Naturwissenschaften*, **50** (1963), 712

The presence of dehydroascorbic acid (DHA) reductase in seven different strains of *Ogawa* and one *Inaba* of *Vibrio cholerae* has been investigated. A fairly good amount of reduction of DHA can be obtained by the strains so far investigated.

317. DAS, S. K. & CHATTERJEE, G. C. (Department of Applied Chemistry, University College of Science & Technology, Calcutta): Pyrithiamine adaptation of *Staphylococcus aureus*: Part II — Tricarboxylic acid cycle and related enzymes, *J. Bact.*, **86** (1963), 1157

Evidence for the stimulated operation of the tricarboxylic acid cycle in *Staphylococcus aureus* after pyrithiamine adaptation is presented. In the cell-free extracts, isocitric, glutamic, malic and succinic dehydrogenases and catalase were found to be stimulated after adaptation of *S. aureus* to pyrithiamine. Besides such stimulation, the appearance of isocitratase and malate synthetase in the adapted strain supports the appearance of the glyoxalate bypass after such adaptation. There is little change in the activities of reduced nicotinamide adenine dinucleotide (NADH) and reduced nicotinamide adenine dinucleotide phosphate (NADPH) oxidases and diaphorase. Lactic dehydrogenase, NADH-cytochrome *c* reductase, NADPH-cytochrome *c* reductase could not be demonstrated either in the normal or in the pyrithiamine-adapted *S. aureus*. These observations support the postulation that there is a stimulation in the tricarboxylic acid cycle and can account for the very marked stimulation in the utilization of acetate by the organism after adaptation.

318. GUPTA, B. M., CHANDRA, K. & CLIFFORD, I. (Central Drug Research Institute, Lucknow): Human intestinal bacteriophage: Part V — Effect of yeast adenylic acid on virus adsorption and plaque formation by coli-dysentery phage CVX-5 on purine-deficient *Escherichia coli*, *Ann. Biochem.*, **23** (1963), 395

Resistance of a partially purine-deficient strain of *Escherichia coli*, strain Kasauli, to coli-dysentery T phage CVX-5 has been studied in a chemically defined medium. It has been found that host resistance can be reversed and the viral infective centres recovered if yeast adenylic acid is added to the test agar plate. Evidence has been obtained that the resting cells of the purine-deficient bacteria do not permit adsorption and entry of the phage into the bacterial cells in the absence of adenylic acid.

319. MUKERJEE, S., GUHA ROY, U. K. & RUDRA, B. C. (Indian Institute for Biochemistry & Experimental Medicine, Calcutta): Studies on typing of cholera vibrios by bacteriophage: Part V — Geographical distribution of phage-types of *Vibrio cholerae*, *Ann. Biochem.*, **23** (1963), 523

Using the phage-typing technique, 4651 strains of *V. cholerae*, isolated in Calcutta between 1955 and 1963 have been studied. The strains from recent epidemics in other areas of West Bengal, other States of India as well as in Pakistan, Afganistan, Nepal, Burma and Thailand were also phage-typed. All five phage-types were found to occur in Calcutta epidemics while types 1 and 3 vibrios were found in other places in India and East Pakistan. Some type 5 vibrios were isolated in Madras and Andhra Pradesh but types 2 and 4 strains were not found anywhere outside Calcutta. All type 1 strains were non-lysogenic. Three hundred and eight out of 2459 Calcutta strains belonging to types 2, 3, 4 and 5 were lysogenic. None of the cholera vibrios isolated outside Calcutta proved to be lysogenic. It has been concluded that phage-typing, which has proved to be the method of choice for differentiating *V. cholerae* from *V. el tor*, may also appear to be of crucial importance for bacteriological characterization of fresh cholera outbreaks by differentiating the two O-group I vibrios should, in near future, *El Tor* infection coexist with classical cholera in some areas as the recent trend indicates.

320. VORBRÜGGEN, VON HELMUT, PAKRASHI, SATYESH CHANDRA & DJERASSI, CARL (Department of Chemistry, Stanford University, California & Indian Institute for Biochemistry & Experimental Medicine, Calcutta): Arborinol, ein neuer triterpen — Typus, *Liebig's Ann. Chem.*, **57** (1963), 668

Two new epimeric pentacyclic triterpenes, named arborinol, m.p. 270-2°C. and iso-arborinol, m.p. 298-9°C. having molecular formula $C_{30}H_{50}O$, have been isolated from the leaves of *Glycosmis arborea* (Rutaceae). Combination of physical methods such as nuclear magnetic resonance spectrum, optical rotatory dispersion and mass spectrometry along with chemical degradations led to the structures of these two triterpenes. They are 3-hydroxy-Δ9-(11)-13β, 14α-methylursanes, isoarborinol being the more stable 3β variety.

577.1 Biochemistry

321. RAO, G. J. S. & CAMA, H. R. (Department of Biochemistry, Indian Institute of Science, Bangalore): Action of N-bromosuccinimide on some mammalian haemoglobins, *Indian J. Chem.*, **1** (1963), 443

The tryptophane contents of human, cow, sheep and rat haemoglobins have been estimated by a spectrophotometric method using N-bromosuccinimide (NBS). Species differences are observed in the tryptophane content of the haemoglobins and in the reactivities of the tryptophane residues towards NBS. All the six tryptophane residues in human and cow haemoglobins are attacked by NBS, whereas in sheep and rat haemoglobins 4 tryptophane residues react readily and 4 more react with obligatory requirement of urea, thereby suggesting a non-polar environment around these masked residues. The new N-terminal amino acids formed on cleavage of the C-tryptophyl peptide bonds of the different haemoglobins with NBS are threonine and glycine.

577.15 Enzymes

322. BALASUBRAMANIAN, A. S. & BACHHAWAT, B. K. (Neurochemistry Laboratory, Department of Neurology & Neurosurgery, Christian Medical College Hospital, Vellore): Regional distribution of three enzymes associated with sulphate metabolism in sheep brain, *Indian J. exp. Biol.*, **1** (1963), 179

The regional distribution of three enzymes associated with sulphate metabolism has been studied in the sheep brain. These enzymes, namely 3′-phosphoadenosine-5′-phosphosulphate (PAPS) synthesizing enzyme system, PAPS degrading enzyme and arylsulphatase A, show marked differences in their respective activities in the grey and white matter in different regions of the brain. The implications of the results with respect to the metabolism of inorganic sulphate, mucopolysaccharides and cerebrosulphatide in the brain have been discussed.

323. JAMDAR, S. C. & MOOKERJEA, S. (Department of Physiology, University College of Science, Calcutta): Effect of anabolic and catabolic hormones on transaminase activity in riboflavin deficiency in rats, *Indian J. exp. Biol.*, **1** (1963), 198

The effects of cortisone, testosterone and insulin on transaminase activities of liver, muscle and kidney of rats have been studied in riboflavin deficiency. Hepatic levels of both aspartic-glutamic and alanine-glutamic transaminases have been found to increase, while there is significant reduction in the levels of these enzymes in muscle and kidney in riboflavin deficient animals. Alanine-glutamic transaminase level is significantly increased and is found to be more sensitive to cortisone treatment in normal and riboflavin deficient animals. The catabolic effect of cortisone is enhanced in riboflavin deficiency, whereas testosterone and insulin fail to act anabolically in riboflavin deficiency.

58 BOTANY

581.8 Cytology

324. BEZBARUAH, H. P. (Regional Research Laboratory, Jorhat): Induced tetraploidy in *Asclepias curassavica* L., *Curr. Sci.*, **32** (1963), 376

Tetraploids of *A. curassavica* L. obtained by colchicine treatment have been found to show improved characteristics such as better growth, thicker and broader leaves, and larger stomata over those of normal diploids.

325. JANAKI AMMAL, E. K. & BEZBARUAH, H. P. (Regional Research Laboratory, Jorhat): Induced tetraploidy in *Catharanthus roseus* (L.) G. Don., *Proc. Indian Acad. Sci.*, **57** (1963), 341

Tetraploidy has been introduced in *Catharanthus roseus* by colchicine treatment. The tetraploids showed vigorous growth and had bigger flowers and larger stomata than those of normal diploids.

326. NIRULA, SATYA (Division of Botany, Indian Agricultural Research Institute, New Delhi): Ultraviolet-X-ray interaction in relation to frequency and types of chromosome aberrations and mutations in *Triticum aestivum* L., *Indian J. exp. Biol.*, **1** (1963), 210

The effects of subjecting dry seeds of bread wheat to combined and separate treatments of ultraviolet and X-rays on the frequency of chromosome aberrations, and the rate and spectrum of mutations have been studied. Somatic chromosome aberration frequency has been found to increase with dose in X-ray treatments. Pre-treatment with ultraviolet promotes reunion and thereby increases the frequency of two-hit aberrations and the total aberration rate. At meiosis in microsporocytes, a corresponding increase in translocation frequency is observed in ultraviolet pre-treated plants. The rate of viable morphological mutations increases with the X-ray dose. When pre-treated with ultraviolet, the mutation rate is reduced at 11000r, 16500r and 33000r of X-rays but is enhanced at 22000r. Mutations affecting ear characters constitute 92 per cent of the total number of mutations isolated in ultraviolet pre-treated material, while this frequency is about 84 per cent following X-ray treatment. Thus in spite of its poor penetrating ability, it appears that ultraviolet irradiation can be effectively used for irradiating seeds of wheat, the caryopsis of which allows direct exposure of the embryo.

582.28 Fungicides

327. BARUAH, J. N., RAO, P. R., JANARDHANAN, K. K. & GANGULY, D. (Regional Research Laboratory, Jorhat): Fungitoxicity of different polyphenolic fractions of *Acacia arabica* bark, *J. Instn Chem. (India)*, **35** (1963), 303

The fungitoxicity of different polyphenolic fractions isolated from the bark of *Acacia arabica* has been determined with reference to *Piricularia oryzae* Cav. The polymerized condensed tannins have been found to be mainly responsible for the fungitoxicity.

61 MEDICAL SCIENCES

611.6 Urogenital System

328. GOSWAMI, AJIT, KAR, AMIYA B. & CHOWDHURY, S. R. (Central Drug Research Institute, Lucknow): Uterine lipid metabolism in mice during the oestrous cycle: Effect of ovariectomy and replacement therapy, *J. Reprod. Fertil.*, **6** (1963), 287

Uterine lipid components of mice have been analysed during different stages of the oestrous cycle and after ovariectomy and replacement therapy. During oestrus, and in ovariectomized animals subjected to oestrogen treatment, there was a fall in total lipid concentration and percentage of triglycerides, but an increase in concentration of phospholipids, as compared to the corresponding di-oestrous values. Progesterone antagonized the effect of oestrogen and restored triglyceride concentration to the di-oestrous level. In comparison, the effect of progesterone on total lipids or phospholipids was less marked. There was no significant change in uterine cholesterol concentration during different stages of the oestrous cycle or after ovariectomy and hormone therapy. In general, the fatty acid components of the lipid constituents showed lower iodine values and increased saturation under the influence of oestrogen. These changes were more evident in triglyceride and phospholipid fractions than in the cholesterol ester fraction. Of the nitrogenous bases of phosphoglycerides, serine showed a more marked increase than the other components. The possible significance of these findings is discussed.

329. KAR, AMIYA B., HARISH CHANDRA & DAS, R. P. (Central Drug Research Institute, Lucknow): Induced hyperthyroidism and sexual development in prepuberal male rhesus monkeys, *Indian J. exp. Biol.*, **1** (1963), 172

Administration of graded doses of 3,5,3′-triiodothyronine to rhesus monkeys continuously for 152 days has not been found to disturb the prepuberal status of the testis. The histological features continue to be typical of immature testis but biochemical changes of one type or other take place in the organ. Most of these changes, however, seem to follow the general pattern of metabolic alterations in hyperthyroidism. The gonadotrophin content of the pituitary shows a rise at some dosages although there are no reflections on the status of the testis. No consistent changes have been found to occur in the accessory genital organs except for a reduction in seminal vesicle and prostate weight in the lowest dose group. However, the prostatic acid phosphatase activity decreases uniformly. There is a stimulation of adrenal weight and varying degrees of hypertrophy and hyperplasia of the inner zones. The adrenal cholesterol increases consistently but the ascorbic acid concentration does not register any significant change. The 24-hr urinary 17-ketosteroid levels are somewhat erratic. Any loss of thyroid weight is clear-cut only at the high dose but the histological picture is indicative of varying grades of thyroid inhibition. The serum cholesterol concentration shows a diminished trend.

All the animals have been found to gain body weight during the period of investigation.

612.015 Metabolism

330. MAHENDRA KUMAR & VENKITASUBRAMANIAN, T. A. (Department of Biochemistry, Vallabhbhai Patel Chest Institute, Delhi University, Delhi): Effect of scurvy on lipogenesis in adipose tissue, *Indian J. exp. Biol.*, **1** (1963), 227

Acetate-1-C^{14} incorporation in the fatty acids and cholesterol of epididymal fat of scorbutic guinea-pigs has been investigated. Acetate-1-C^{14} incorporation in fatty acids is significantly decreased while the cholesterol activity is not changed in scurvy. It is suggested that the lowered lipogenesis of adipose tissue could be due to a deranged carbohydrate metabolism in scurvy.

331. MUKERJEE, S. S., SARKAR, A. K. & MUKERJEE, S. K. (Central Drug Research Institute, Lucknow): Studies in experimental obesity: Part III — Observations on certain aspects of fat metabolism, *Ann. Biochem.*, **23** (1963), 405

In order to study the effect of obesity and fat feeding on the lipid metabolism on male obese albino rats, the total lipid, acetone-bodies, total cholesterol, phospholipid levels in blood, and non-esterified fatty acid (NEFA) level in plasma have been investigated. Total lipid, total cholesterol, phospholipid and ratio of dry weight to wet weight of the liver have also been determined. No significant rise in the level of total cholesterol, acetone-bodies and NEFA levels in obese rats compared to the normal ones has been observed. All the constituents of the liver, but not the ratio of their dry to wet weight, were significantly increased. The implication of these findings has been discussed.

612.6 Reproductive System

332. KARKUN, J. N., MUKHERJEE, A. P. & KAR, A. B. (Central Drug Research Institute, Lucknow): Reproduction in thyroidectomized adult male rats, *Ann. Biochem.*, **23** (1963), 401

The reproductive performance of adult male rats has been studied at different time intervals after thyroidectomy. No marked deleterious effect was observed on reproductive capacity or functional potentiality of the testes.

615 Pharmacology

333. GOKHALE, S. D., GULATI, O. D. & JOSHI, N. Y. (Pharmacological Research Unit, Medical College, Baroda): Effect of some blocking drugs on the pressor response to physostigmine in the rat, *Brit. J. Pharmacol.*, **21** (1963), 273

Bretylium and guanethidine have been found to block the pressor effect of physostigmine and potentiated the responses to adrenaline and noradrenaline on the blood pressure of the rat. Morphine and atropine in small doses blocked the pressor effect of physostigmine without interfering with the actions of adrenaline and noradrenaline. Chloropromazine in small doses (0·5-2·5 mg./kg.) blocked the pressor effect of physostigmine and potentiated the responses to noradrenaline while those to adrenaline remained unaltered. 3,6-Di-(3-diethylaminopropoxy) pyridazine di(methiodide) (Win 4981) blocked the pressor effect of physostigmine and, in its early stages, this block was partially reversed by choline chloride. N-Diethylaminoethyl-N-isopentyl-N'N'-diisopropylurea (P-286), in a dose that reduced the effect of dimethylphenyl-piperazinium, had no effect on the pressor response to physostigmine or on the responses to adrenaline and noradrenaline. Hexamethonium, even in large doses (100 mg./kg.), only blocked partially the effect of physostigmine while mecamylamine produced a complete block; the responses to adrenaline and noradrenaline were potentiated in both instances.

615.1 Pharmacy

334. BOSE, P. C., SINGH, R. K. & RAY, G. K. (Central Drug Research Institute, Lucknow): Estimation of inositol in pharmaceutical preparations, *Indian J. Pharm.*, **25** (1963), 419

In a new method developed for its estimation, inositol is heated with periodic acid solution, cooled in ice and then treated with a solution of 2,7-dihydroxy naphthalene in sulphuric acid to develop a pink colour. The colour intensity which is a direct measure of the concentration of inositol is then measured in a spectrophotometer at 535 mμ. The method is also applicable in the estimation of inositol in pharmaceutical preparations with suitable preliminary treatment.

335. MARTIN, D., RIECHE, A. & IYER, R. N. (Central Drug Research Institute, Lucknow): Synthetic mustard oil formers: IV, *Arch. Pharm.*, **296** (1963), 641

The synthesis of substituted thiohydantoic acids, thiohydantoins and related compounds with possible antimicrobial action is described. Some results of biological screening are also given.

336. SARIN, J. P. S., CHAKRAVARTY, R. B., RAY, G. K. & MUKERJI, B. (Central Drug Research Institute, Lucknow): Assay of glycine in amino acetic acid elixir, *Indian J. Pharm.*, **25** (1963), 375

A colorimetric method for the estimation of glycine in amino acetic acid elixir is described. The method is based on the formation of a coloured compound due to the reaction of sodium 1,2-naphthoquinone-4-sulphonate and glycine under specific conditions. The method holds good within the concentration range 100-600 μg. of glycine. The colour intensity has been measured in a Klett-Summerson photoelectric colorimeter at 540 mμ.

337. UPRETY, M. C., BASU, D. K. & MOHAN RAO, V. K. (Central Drug Research Institute, Lucknow): Stabilization of vitamins in pharmaceutical preparations: Part VIII — Effect of shelf

life on the stability of vitamins in oral liquid products, *Indian J. Technol.*, **1** (1963), 397

The relative stabilities on storage at room temperature (15-32°C.) and 37°C. of vitamins present in oral liquid products marketed by eight pharmaceutical firms have been determined. Thiamine has been found to be least stable, particularly at 37°C., the stability falling with temperature, unlike in the case of vitamin A. In half the number of products both ascorbic acid and vitamin A deteriorated to the extent of 30-40 per cent at room temperature. Vitamin B_{12} and pyridoxine are fairly stable, while folic acid exhibits poor stability. Riboflavin and niacinamide are quite stable.

338. UPRETY, M. C., SEN, RAMANUJ, AGRAWAL, D. K. & MOHAN RAO, V. K. (Central Drug Research Institute, Lucknow): Stabilization of vitamins in pharmaceutical preparations: Part VII — Influence of some stabilizers on the stabilities of vitamins B_1 and C, *Indian J. Technol.*, **1** (1963), 391

The influence of eight commonly used stabilizers, viz. thiourea, oxalic acid, cysteine hydrochloride, propyl gallate, ethylene diaminetetraacetate (EDTA), citric acid, ferrous gluconate and sodium chloride, on the stabilities of vitamins B_1.HCl/HNO_3 and C, when present together, has been examined at 37°C. Under all conditions ascorbic acid has been found to be more stable than thiamine. With the exception of oxalic acid, all other stabilizers stabilize thiamine to varying extents. EDTA gives marked protection to both the vitamins and 75 per cent glycerol gives best performance as a vehicle. Though vitamin B_1.HNO_3 is to be preferred to vitamin B_1.HCl in the presence of iron salts, the hydrochloride has often been found to keep better than the nitrate salt, particularly in formulations containing thiourea. In the following combinations of stabilizers and vehicles, the retention of vitamins B_1 and C, after storage for 8 months at 37°C., is over 70 per cent: EDTA + syrup-glycerol-water (2 : 2 : 1): EDTA + sorbitol-glycerol-water (2 : 2 : 1); EDTA + glycerol (75 per cent); thiourea + glycerol (75 per cent); cysteine hydrochloride + glycerol (75 per cent); citric acid-sodium chloride + glycerol (75 per cent); ferrous gluconate + glycerol (75 per cent); sodium chloride + glycerol (75 per cent); and sodium chloride + syrup-glycerol-water (2 : 2 : 1).

615.43 Pharmacognosy

339. BISHT, B. S. (Central Drug Research Institute, Lucknow): Pharmacognosy of 'Piplamul' — The root and stem of *Piper longum* Linn., *Planta Medica*, **11** (1963), 410

The commercial samples of 'Piplamul' obtained from different sources throughout India have been found to consist of the root and stem of *Piper longum* L. The root which is reputed in indigenous medicine to be effective in chronic bronchitis, abdominal pains, diseases of spleen, tumours, etc., constituted proportionately up to one-fourth of the material. The macroscopic and microscopic characters of the root and stem have been described.

615.7 Chemotherapy

340. GHOSH, BINAY KUMAR & BASU, U. P. (Bengal Immunity Research Institute, Calcutta): Chemotherapy of filariasis: Part I — Some isoquinolylpiperazine derivatives, *Indian J. Chem.*, **1** (1963), 528

1-Chloromethyl-3-methyl-isoquinoline has been condensed with different piperazine derivatives to obtain the corresponding (3'-methylisoquinolyl-1')-methylpiperazines. (3'-Methylisoquinolyl-1')-methylpiperazine has been further condensed with ethyl chloroformate, benzyl chloride, benzoyl chloride and *p*-chlorobenzoyl chloride to obtain the corresponding benzyl, benzoyl and *p*-chlorobenzoyl piperazines. None of the derivatives prepared exhibits any antifilarial activity on *L. carinii* infection in albino rats.

62 ENGINEERING

621.3 Electrical Engineering

341. SARKAR, N. (Department of Electrical Engineering, G.S. Technological Institute, Indore): Study of ferroresonant circuits, *J. sci. industr. Res.*, **22** (1963), 448

A modified approach has been attempted towards understanding the pronounced resonance effect observed when the core material of the inductance has idealized B-H characteristic. In the modified analysis the inductor has been assumed to have less idealized B-H characteristic such that it has a finite slope intercepted by two lines of zero slope. The current flow in the circuit due to sinusoidal supply voltage is divided into two parts: (i) presaturation and (ii) saturation periods. During the presaturation period, inductance of the inductor is nearly infinite, the capacitor discharges through its leakage resistance and magnetizing current flows in the circuit. During saturation period, inductance is zero, current flows and the capacitor charges up. The duration of the saturation period depends on the voltage across the capacitor during the presaturation period. The analysis shows that critical firing voltage of the circuit depends on the voltage across the capacitor during the presaturation period. The critical firing voltage of the circuit depends on the value of the capacitor as well as the load resistance and further the equations for design are applicable to a great variety of core materials since less idealized assumptions are used for deriving the formulae.

621.3.047 Electric Commutators

342. DATTA, K. K., CHARI, S. S. & JOGLEKAR, G. D. (Division of Industrial Physics, National Physical Laboratory, New Delhi): Measurement of dynamic elasticity and internal friction of carbon brushes at high frequency, *Indian J. Technol.*, **1** (1963), 409

A method is reported for measuring the internal friction in carbon brushes as a measure of their ability to maintain good contact with the commutator. The method is based on the study of attenuation of sound as it is transmitted and reflected back from the

bottom of the brush medium. For this purpose the patterns of transmitted and reflected echoes obtained using an ultrasonic pulse generator are displayed on a cathode ray oscilloscope as flips. The distance between the flips which is a measure of the time of transmission, on calibration, gives the length of the path in the specimen and is made use of in determining the internal friction.

621.38 Electronics

343. HASHMI, S. Z. R. (Physics Department, M.S. University of Baroda, Baroda): Measurement of lifetime of minority carriers by chronograph technique, *Indian J. pure appl. Phys.*, **1** (1963), 408

The counter chronograph technique has been employed for measuring the effective lifetimes of pulse injected minority carriers in semiconducting silicon. The advantage of the new method is that the effective lifetimes can be directly read off on the scaler. The observed values of effective lifetimes have been found to agree closely with those determined by the photoconductive decay method. Etching of the silicon surface considerably reduces the effective lifetime of the minority carriers.

621.38 : 681 Electronic Devices

344. ACHARYA, G. N. (Central Electronics Engineering Research Institute, Pilani): A transistorized d.c. servo-amplifier with high gain, *J. Instn Telecomm. Engrs*, **9** (1963), 179

A general procedure for the design of a temperature compensated high gain servo-amplifier incorporating a new method of cross-coupled diode feedback is discussed and the results obtained with a typical high gain servo-amplifier are presented.

345. DEWAN, HARDIAL SINGH (Central Electronics Engineering Research Institute, Pilani): Electronic flash tubes, *Res. & Ind.*, **8** (1963), 260

The design, construction and performance characteristics of an electronic flash tube developed and fabricated in the Central Electronics Engineering Research Institute, Pilani, are described. A suitable power supply unit for use with these flash tubes is also described.

346. VAIDYA, N. C. & DAVINDER SINGH (Central Electronics Engineering Research Institute, Pilani): An improved beading technique for electron gun assembly, *J. Instn Telecomm. Engrs*, **9** (1963), 345

An improvement over the RCA beading technique for the construction of electron guns for travelling wave tubes is discussed. The improved technique requires only a simple demountable jig for aligning, supporting and controlling the spacing of the electrodes to a close tolerance. It eliminates the undesirable heating of the entire jig along with the electrodes during the glass-beading, and prevents deformation of the glass rod after softening. The cathode and heater mounting is also such that alterations are possible. A number of special electron tubes built have utilized this technique successfully.

621.51 : 534 Compressor System

347. MURTHY, M. L. R., SOMASHEKAR, B. R., DASANNACHARYA, B. S., COLE, J. R. & ACHARYA, Y. V. G. (National Aeronautical Laboratory, Bangalore): Vibration studies on the NAL compressor foundation structure, *Tech. Note No. TN-AE-22-63* (National Aeronautical Laboratory, Bangalore), 1963

The results of model studies and theoretical analysis of the natural frequencies of vibration of the NAL compressor foundation structure are presented. The design of machine foundations in general and those of rotating machines have been dealt with briefly, including a description of the methods and materials used in isolating the surrounding area from the residual vibrations. It is seen that the natural frequencies of the foundation structure are far removed from the operating frequencies of the machine components they support and there is no likelihood of any resonance.

621.548 Wind Power

348. RAMANATHAN, R. & VISWANATH, S. (National Aeronautical Laboratory, Bangalore): A study of the hourly wind speeds at New Delhi from the point of view of wind power utilization, *Tech. Note No. TN-WP-31-63* (National Aeronautical Laboratory, Bangalore), 1963

Hourly mean wind speed data for the period 1958-60 for New Delhi have been used to estimate the energy and water output of a wind-driven plant. The distribution of wind speed, the diurnal variation of wind speed and spells of low wind have also been studied. The annual mean wind speed at New Delhi is 10 km.p.h. The estimated annual energy output of a wind-driven plant of cut-in speed 8 km.p.h., swept area 30 sq. m. and overall power coefficient 12 per cent is 1361 kWh. The estimated annual water output of a windmill of the WP-2 type is 39,940 kilolitres.

349. RAO, D. V. L. N. & NARASIMHASWAMY, K. N. (National Aeronautical Laboratory, Bangalore): A study of the hourly wind speeds of Gaya from the point of view of wind power utilization, *Tech. Note No. TN-WP-32-63* (National Aeronautical Laboratory, Bangalore), 1963

Analysis of the hourly wind speeds at Gaya for the period 1958-60 showed that electrical energy extractable by using a wind machine of 30 sq. m. swept area and of 12 per cent constant overall power coefficient is 1320 kWh. The average annual quantity of water that would be pumped by a windmill of 13·6 sq. m. swept area (WP-2 type) and of 12 per cent constant overall power coefficient works out to 39,610 kl. (8,714,200 gal.) or 23,870 gal. per day. The number of hours of low wind (assumed to be less than 8 km.p.h.) that occur in a day has been determined, a knowledge of which is necessary to know the power available in the day. The diurnal variation of wind speed has also been discussed.

350. RAO, D. V. L. N. & VENKITESHWARAN, S. P. (National Aeronautical Laboratory, Bangalore):

Performance of the 6-8 kW. Allgaier wind electric generator at Porbandar, *Tech. Note No. TN-WP-33-63* (National Aeronautical Laboratory, Bangalore), 1963

The performance of the Allgaier 6-8 kW. wind electric generator, installed at a site in the Khapat Agricultural Farm at Porbandar, has been examined. The electric energy produced at various wind speeds has been compared with the energy calculated on the basis of the power-speed characteristics of the generator, supplied by the manufacturers. The cost of power has also been estimated. The cost per kWh. works out to 19 nP. without battery and 45 nP. with battery. The cost of pumping 1000 gal. of water works out to 12 nP. as against the cost of 35 nP. for pumping 1000 gal. of water by a 10 h.p. diesel engine working along side the wind electric generator.

621.64 : 536.2 Thermal Ballast System

351. NARAHARI ACHAR, B. N. (National Aeronautical Laboratory, Bangalore): Optimization of tin can thermal ballast requirements of blowdown wind tunnels, *Tech. Note No. TN-AE-21-63* (National Aeronautical Laboratory, Bangalore), 1963

This note presents the results of an investigation undertaken to obtain engineering data regarding the economical use of tin cans as thermal ballast in the air receivers of blowdown wind tunnels. A simple analysis shows that a loading ratio of 2 to 3 would be sufficient to limit the temperature drop to *c.* 20°C. Using tin cans of several sizes to find out the relative importance of dimensional parameters such as diameter and cylinder length, an attempt has been made to determine the average surface area per cubic foot of space occupied by randomly stacked tin cans, as the available surface area is very important for effective heat transfer. The possibility of effecting a compromise between cost and thermal ballast efficiency in optimizing the dimensions of tin cans for a given weight of the ballast is indicated.

622.4 Mining Engineering

352. GURUSWAMY, S., NARASIMHACHAR, V. S. & GOPALAKRISHNAN, N. (Central Mining Research Station, Dhanbad): Standard procedure for the assessment of size and concentration of airborne dust in mines, using dust sampling instruments, *Indian J. Technol.*, **1** (1963), 419

A standard procedure for the estimation of average size and number of particles in a dust deposit which gives reproducible results when followed by two independent observers is described. The procedure has to be modified suitably when several samples from the same source are available for sizing and counting. The number of samples required and the best method of expressing the size and concentration of air-borne dust are discussed considering the practical conditions, and the type of information required, and the limitations of the microscopic method of particle sizing and counting. The method is suitable for ' line ' deposits of dust samples and with modification for ' circular ' deposits.

624.01 Building Engineering

353. KESHAVA RAO, M. N. & RAMAN, N. V. (Central Building Research Institute, Roorkee): Lower bounds for collapse loads of cylindrical shells with edge beams, *Indian Concr. J.*, **37** (1963), 402

Lower bounds for the collapse loads of long cylindrical shells with edge beams have been obtained by the method of limit analysis. Linear approximation to the Von-Mises yield conditions has been used to arrive at the stress inequalities. Longitudinal stresses have been obtained assuming the shell to be a beam, and shell theory has been used to derive other stresses. Results for cylindrical shells with edge beams under uniform vertical pressure are given. These results are more useful than Fialknow's results. Two examples have been worked out to illustrate the method of determining the lower bounds.

354. SHARMA, J. S., CHAND, S. & MIRCHANDANI, H. V. (Central Building Research Institute, Roorkee): Thermal insulation of shell roofs with polystyrene boards, *Indian Concr. J.*, **37** (1963), 343

A method of laying polystyrene boards for thermal protection in conjunction with aluminium foil or bituminous tarfelt as waterproofing on shell roofs is described. This type of treatment has been found to give satisfactory performance.

355. SHARMA, S. P. & GOYAL, B. K. (Central Building Research Institute, Roorkee): The analysis of continuous folded plates, *Indian Concr. J.*, **37** (1963), 448

An extension of Whitney's method for the analysis of continuous folded plates is described. The variables in the equations for compatibility are replaced by a Fourier series. Three end conditions, namely the cantilever, the propped cantilever and fixed ends, are considered and Fourier expansions for plate moments and deflections are derived in each case.

624.2 Structural Engineering

356. CHAULIA, P. B. (Division of Applied Mechanics, National Physical Laboratory, New Delhi): Stress distribution in multiply supported rectangular deep beams, *Indian J. pure appl. Phys.*, **1** (1963), 426

Two-dimensional photoelastic analysis of stress distribution has been made for a square deep beam multiply supported with uniform distribution of reaction and subjected to a concentrated load along the axis of symmetry. A theoretical analysis of the problem based on the numerical solution of the biharmonic equation by the finite difference method has also been undertaken and the distributions of transverse tensile stress in the symmetry section have been evaluated. A good agreement has been observed between the theoretically derived and experimentally observed values. The study has also been extended to rectangular beams of greater depth. An analogy between the square deep beam and the anchor block of a prestressed post-tensioned concrete beam has

also been worked out. This analogy approach has been corroborated by the results obtained from the two-dimensional simplified treatment of the anchor block based on the elastic theory.

625.7 Road Engineering

357. GHOSH, R. K. (Central Road Research Institute, New Delhi): Shear design of flexible WBM overlay over badly cracked concrete pavement, *Civ. Eng. Publ. Wks Rev., Lond.*, (1963), 1401

A theory based on direct shear is proposed for the design of flexible water bound macadam (WBM) overlay over badly cracked concrete pavement. It has been shown that thickness requirement of this type of overlay depends on the condition of the stress of the concrete underlay. A curve for different conditions of the stress has been recommended.

358. GHOSH, R. K. (Central Road Research Institute, New Delhi): Ultimate load analysis of concrete pavement slabs by yield line analysis (Precis), *Struct. Engr, Lond.*, **41** (1963), 326

The ultimate load design by yield line analysis has been applied to pavement slabs. The analysis shows that with a good degree of field control a 6 in. concrete slab laid on a light granular base may be sufficient for 9000 lb. wheel load to give at least 15 years of good serviceability.

359. GHOSH, R. K. & KHANNA, K. K. (Central Road Research Institute, New Delhi): Measurement of moisture differential in concrete pavement slabs, *J. Indian Roads Congr.*, **27** (1963), 591

The variation of moisture contents at various depths of concrete slab has been investigated. The cement mortar electric resistance moisture cells developed in the Central Road Research Institute, due to their greater sensitivity to moisture than plaster of Paris moisture cells, have been found more suitable and accurate.

360. GHOSH, R. K. & SETHI, K. L. (Central Road Research Institute, New Delhi): Minimum time for removal of forms for the construction of cement concrete road pavement, *Trans. Commun. Mon. Rev.* No. 192 (1963), 88

It has been shown that the side forms of concrete road pavement may be safely removed after 12 hr without impairing the strength of concrete pavement.

628 Public Health Engineering

361. BELE, K. N. (Central Public Health Engineering Research Institute, Nagpur): A new method for making moulds for water-closet pans, *Environ. Hlth*, **4** (1963), 331

An inexpensive method for making a mould for casting Indian style water-closet pans with packing case wood is described.

362. BHAKUNI, T. S. & SASTRY, C. A. (Central Public Health Engineering Research Institute, Nagpur): Studies on defluoridation of water using sawdust carbon, *Environ. Hlth*, **4** (1963), 312

Physical, chemical and hydraulic properties of sawdust carbon prepared in this Institute have been studied with a view to determining its suitability for use in large-scale defluoridation units. The efficiency of the carbon for the removal of fluoride from water during successive cycles of operation has also been studied. The other factors studied include flow rate, bed height and presence of other ions in the water on the removal of fluoride by the carbon. The limitations of the carbon are also pointed out.

624 : 691 Building Materials

363. JAIN, L. C. & JAIN, P. C. (Central Building Research Institute, Roorkee): The effect of calcareous constituents of alluvial soils on the physical properties of fired bricks, *J. nat. Build. Org.*, **8** (2) (1963), 1

The effect of additions of calcium salts to alluvial soils on the physical properties of fired bricks has been investigated. Calcium salts decrease the compressive strength and bulk density of fired bricks and increase their water absorption. They also shorten the vitrification range of the soils.

364. RAMACHANDRAN, V. S., AHMAD, F. U. & JAIN, L. C. (Central Building Research Institute, Roorkee): Factors influencing strengths of structural clay products from montmorillonitic clays, *Indian Ceram.*, **10** (5) (1963), 201

A clay containing large proportions of montmorillonitic clay mineral and modular lime is unsuitable for brick making. Bricks made out of such clays exhibit drying cracks, comparatively low fusion temperature, tendency to bloat and lome blowing. Calcium carbonate and sodium chloride have been mixed with the clay for studying their effect on strength development.

66 TECHNOLOGY

66.0 Chemical Technology

365. VASUDEVA RAO, P. V. & UDUPA, H. V. K. (Central Electrochemical Research Institute, Karaikudi): On production of zinc dust from zinc oxide byproduct obtained in chemical reduction processes, *Chem. Ind. News*, **7** (1962), 17

A method of producing zinc powder from byproduct zinc oxide by the direct reduction of solid oxide, similar to the one reported earlier, is described. The power and current efficiency data are presented. Power consumption for zinc powder prepared is about 2·4 kWh./kg. (d.c.) which compares favourably with the value for zinc powder prepared by direct deposition from sodium zincate bath. The powder prepared by this method is finer than that obtained by the deposition method.

661.728 Cellulose

366. CHIPALKATTI, V. B., DESAI, R. M., SATTUR, N. B., VARGHESE, J. & PATEL, J. C. (Shri Ram Institute for Industrial Research, Delhi): Studies in cross-linking reactions of cellulose:

Part I — 1,3-Dichloro-2-propanol and its acetyl propionyl and butyryl esters, *Text. Res. (J.)*, **33** (1963), 282

With a view to studying the effect of bulky substituents in the cross-linking molecule on the physicochemical properties of reacted cellulose, 1,3-dichloro-2-propanol and its acetyl, propionyl and butyryl esters have been reacted with cellulose. Two cotton fabrics have been used: (i) a casement cloth of open structure and (ii) a poplin fabric of closed construction. The presence of cross-links and the retention of the ester groups in the cross-links have been established by the determination of the insolubility of the treated cellulose in cuprammonium hydroxide and the estimation of the ester contents. The effect of the substituent ester groups on the reactivity of these compounds and the resulting changes in the physicochemical properties of the treated fabrics, such as dry and wet crease recovery, tensile strength, tear strength, stiffness as bending length, moisture regain, etc., have been assessed. It has been found that the cross-linking reactivity of these compounds decreases with increase in molecular weight. Besides this, the ester group exerts a distinct influence on the various properties mentioned above. It has been observed that the improved wet crease recovery, increased moisture regain, and stiffness of the fabrics treated with these compounds are inversely related to the increasing molecular weight of the substituent ester group. Similarly the losses in tensile and tear strength and the decrease in dry crease recovery become less as the molecular weight of the substituent ester group increases.

662.3 Propellants

367. MUNJAL, N. L. (Department of Chemistry, University of Gorakhpur, Gorakhpur): Spontaneous ignitability of non-hypergolic propellant under suitable conditions, *J. Amer. Inst. Aeronaut. Astronaut.*, **1** (1963), 1963

The study of spontaneous ignitability of non-hypergolic rocket propellants under suitable conditions has been made. The non-hypergolic fuels like furfural, *m*-cresol, cyclohexanol, anisole, triethanolamine become hypergolic with the addition of certain additives like potassium permanganate in red fuming nitric acid.

662.73 Waste Utilization

368. SASTRY, C. A. (Central Public Health Engineering Research Institute, Nagpur): Studies on cation exchangers prepared from certain organic wastes, *Environ. Hlth*, **4** (1963), 364

Cation-exchange materials have been prepared from wastes like paddy husk, jute wastes, etc., by sulphonation under suitable conditions. The efficiency of these materials in removing calcium from 0·1 per cent calcium chloride solution has been studied. These materials after treatment with sodium carbonate and alum were found to remove fluorides from water efficiently. The possibility of using these materials in the reclamation of sewage effluents has also been studied. The effect of temperature and quantity and quality of sulphuric acid used on the cation-exchange capacity of tea waste carbon has been investigated.

662.74 Coal Technology

369. CHAKRAVARTY, R. K., BANERJEE, S., BASAK, N. G. & LAHIRI, A. (Central Fuel Research Institute, Jealgora): Application of fluidized technique in gas purification, *Indian J. Technol.*, **1** (1963), 423

The removal of hydrogen sulphide from coke oven gas by the fluidized bed technique has been investigated using an iron oxide catalyst developed at the Central Fuel Research Institute, Jealgora. For a unit volume of the catalyst, the capacity of the fluidized bed purification unit has been found to be 9-10 times higher than that of a fixed bed. The optimum conditions for attaining a purification efficiency of *c.* 100 per cent are: particle size of catalyst, −85+120 BSS; length-diameter ratio of the bed, 3:1; and space velocity of the gas, 850-1000 vol. gas/vol. catalyst/hr. By replacing a portion of the used catalyst with fresh catalyst at regular intervals, the process can be run continuously without appreciable fall in efficiency of the bed.

370. GUPTA, S. & GUPTA, A. K. (Central Fuel Research Institute, Jealgora): Properties of bright and dull coals of different ranks, *J. Min. Met. Fuels*, **11** (6) (1963), 12

The properties of dull and bright coal concentrates, prepared from hand picked samples of coals ranging in rank from 75 to 90 per cent carbon have been studied. It has been found that the aromaticity of dull coals is more than that of the corresponding brights. A maximum of 50 per cent of the total oxygen has been observed to be present as reactive oxygen group at a rank of *c.* 80 per cent carbon which falls to *c.* 12 per cent at *c.* 88 per cent carbon. In both the components the hydroxyl (OH) oxygen group constitutes *c.* 90 per cent of the total reactive oxygen present. In the brights the OH groups progressively increase with rank from 90 per cent of the total reactive oxygen groups to 99·6 per cent. No direct relationship between the rank and amount of reactive OH groups has been observed in the dull coals. The only reactive oxygen groups present are OH groups beyond *c.* 82 per cent carbon. A linear relationship between volatiles at 600° and 925°C. indicates the process of pyrolysis at these temperatures to be a specific chemical reaction so far as the ultimate residue is concerned.

371. MENON, M. V. P., DAS, P. K. & DAS GUPTA, N. N. (Central Fuel Research Institute, Jealgora): Some studies on the sampling of coke for physical testing, *J. Min. Met. Fuels*, **11** (9) (1963), 1

The results of an investigation on the influence of the size of coke, its location in the ovens and manner of drawing samples on the physical properties of coke are presented. Based on the results obtained an alternative bias-free method has been suggested for drawing samples for the physical tests. Allowable tolerance limits for the values obtained variously have also been suggested.

372. RAY, A. R., KONAR, B. B., SARKAR, G. G. & LAHIRI, A. (Central Fuel Research Institute, Jealgora): An improved process of coal flotation by use of grids, *Indian J. Technol.*, **1** (1963), 446

The incorporation of a single or a double grid in a subaeration type of flotation cell has been found to bring about marked improvement in the recovery of clean coals from high and low ash coals and washery slurries. In a typical case, the recovery of combustible matter in a cell with single and double grid was 86·1 and 97·2 per cent respectively as compared to 74·3 per cent without a grid. A study of kinetics of flotation indicates increase in the rate of flotation on using grids.

373. SHRIKHANDE, K. Y., CHAKRABARTI, H. C., BHATTACHARYA, H. C. & SINHA, M. P. (Central Fuel Research Institute, Jealgora): Semi-pilot plant studies on low temperature carbonization of some weakly caking coals from Raniganj field, *J. Min. Met. Fuels*, **11** (7) (1963), 7

The results of low temperature carbonization (500°, 550°, 600°C.) studies on different high volatile weakly and semi-coking coals from Raniganj field in laboratory, bench and semi-pilot scale units are presented. In externally heated rotary retort (the Fischer assay), the yield of tar was high, but the quality of coke was poor due to high content of fines produced during carbonization. Correlations have been found to exist between laboratory (Gray-King), bench (Fischer) assays and semi-pilot scale yields. Low temperature carbonization in semi-pilot oven tests required 12-17·5 hr, depending upon the caking properties of the coals. It has been shown that suitable coke can be made from these coals with optimum yields of tar, gas and coke. Correlations have been developed between Gray-King, Fischer and semi-pilot plant yields and those likely to be obtained in full scale narrow, continuous vertical retorts. From these correlations, the yields in large-scale operation can be predicted.

374. SINHA, N. C., MOITRA, A. K. & MAJUMDAR, S. (Central Fuel Research Institute, Jealgora): Some methods for calculating Hardgrove grindability index of coals, *J. Min. Met. Fuels*, **10** (11) (1962), 1

From a study of a large number of determined values of Hardgrove grindability index (HGI) of all major types of Indian coals it has been found that HGI of coals is mainly dependent on two factors: (i) rank of the coal and (ii) the amount of ash in it. It has been established that volatile matter together with the moisture of coals (both reported at 60 per cent RH and at 40°C.) is very closely associated with the carbon content (d.m.f.) which is one of the parameters for measuring the degree of coalification of coals. An equation has been evolved for estimating HGI of coals from a knowledge of their volatile matter plus moisture (R) and ash (A) contents (moisture, ash and volatile matter percentages being reported at 60 per cent RH and at 40°C. basis). The formula $HGI = 105 - R(1{\cdot}16 + 0{\cdot}002R) - 0{\cdot}4A$ may be used for estimating HGI for preliminary selection of coals for pulverized fuel fired furnaces. By an algebraic simplification of the original Hardgrove equation, a formula has been deduced for calculating HGI of coals from the weight of the coal particles above 200 ASTM sieve, left after the specified Hardgrove test (and which is actually weighed), instead of from the weight of the coal particles below 200 ASTM sieve, estimated indirectly. This has also lead to the construction of a standard table which almost eliminates the calculation part of HGI determination.

663 Fermentation

375. GHOSE, T. K. & BASU, S. K. (Biochemical Engineering Laboratory, Division of Food Technology & Biochemical Engineering, Jadavpur University, Calcutta): Bacterial sulphide production in anaerobic packed towers using spent distillery liquor as hydrogen donors, *Indian J. Technol.*, **1** (1963), 434

Sulphide fermentation has been carried out in a flooded packed tower made up of granular gypsum and supported by porcelain raschig rings, using 10 times diluted distillery spent liquor as the source of carbon and hydrogen donors, and sulphate reducers of the type *Desulphovibrio rubentschikii* as the active organisms. Sulphide yields as high as 1025 mg. H_2S/litre of medium have been obtained. Considerable reduction in colour, total solids, c.o.d. value and total carbon has also been achieved.

376. GHOSE, T. K. & PAL, K. D. (Division of Food Technology & Biochemical Engineering, Jadavpur University, Calcutta): Production of vitamin B_{12} in synthetic mineral acetate media, *Indian J. Technol.*, **1** (1963), 401

Vitamin B_{12} has been obtained in a yield of 0·1375-0·1450 γ/ml. by the fermentation of a synthetic medium containing calcium acetate as the only source of carbon employing *Methobacterium söhngenii*, an aerobic methane bacterium, isolated from sewage.

664 Food Technology

377. ANANDASWAMY, B. VIRAKTAMATH, C. S., SUBBARAO, K. R., SURYANARAYANA, B. N., IYENGAR, N. V. R. & SRIVASTAVA, H. C. (Central Food Technological Research Institute, Mysore): Prepackaging of fresh produce : IV — Okra (*Hibiscus esculentus*), *Food Sci.*, **12** (1963), 332

Prepackaging studies on okra have been carried out using 100 and 200 gauge polyethylene and MST (300) cellulose film bags (ventilated/unventilated) under three different conditions of storage (22-28°C., 50-78 per cent RH; 24-26°C., 72-75 per cent RH; and 11-13°C., 85-90 per cent RH). The untreated produce in no vent 100 gauge polyethylene film bag under room temperature conditions and 24-26°C. and 72-75 per cent RH had a shelf life of 7-8 days as against 2-3 days in samples without package. With the same gauge film bags under cold storage conditions the produce kept well for 16-18 days as against 10-12 days in control. Ventilation did not enhance the shelf life of the produce. In all cases, fungicidal

wax emulsion treatment proved distinctly advantageous in extending the shelf life by 2-3 days. Prepackaged okra, treated or untreated, stored under all the above conditions, showed a slight decrease in ascorbic acid content in ventilated bags and there was no significant change in total acidity and reducing sugars or their organoleptic quality before or after cooking.

378. HABEEBUNNISA, PUSHPA, M. C. & SRIVASTAVA, H. C. (Central Food Technological Research Institute, Mysore): Studies on the effect of protective coating on common and refrigerated storage of cucumbers (*Cucumis sativus*), *Indian Fd Packer*, **17** (5) (1963), 4

The physiological losses in weight, spoilage and the rate of respiration in freshly harvested cucumbers treated with sugarcane wax emulsion (refined sugarcane wax, 24 parts; oleic acid, 4 parts; and triethanolamine, 8 parts) and subsequently stored at different temperatures have been determined. The cucumbers were found to keep well for 14 days at 39-42°F., but underwent heavy spoilage at higher temperatures after this period. At lower temperatures, injury occurred to the fruits. Fruits treated with sugarcane wax emulsion containing 8 per cent solids and stored at 39-42°F. showed the lowest percentage of spoilage after the storage period of 20 days. At all temperatures, treated fruits showed beneficial effects in reducing physiological losses, as well as of respiration and extending storage life. Cucumbers treated with 4 per cent sugarcane wax emulsion showed 100 per cent increase in their storage life.

379. SHIVASHANKAR, S. & GOVINDARAJAN, V. S. (Central Food Technological Research Institute, Mysore): Equilibrium relative humidity (ERH) relationships of processed arecanut and whole dried ripe nuts, *Food Sci.*, **12** (1963), 317

Determinations of equilibrium relative humidity, equilibrium moisture content, critical and permissible levels of moisture for three types of processed mature green arecanuts and whole dried arecanut have been made.

380. SRINIVASAN, M., KAPUR, O. P., KRISHNA MURTHY, K. S., IYENGAR, N. V. R., ANANDASWAMY, B. & RAJU, P. V. (Central Food Technological Research Institute, Mysore): Preparation of ready-to-eat, high calorie, light weight, pre-cooked foods, *Res. & Ind.*, **8** (1963), 321

Preparations of pre-cooked composite foods, namely *Sambhar Bhath, Biriani, Pongal*, and a sweet, based on rice or wheat and various pulses, have been made using the principle of drum-drying. The composition of the drum-dried product was adjusted to have an average protein content of 10 per cent and fat up to 20 per cent, with a calorific value of 5 cal./g. In the sweet preparation, adequate amounts of essential vitamins were also incorporated. The briquettes made from the pre-cooked, drum-dried products had good keeping quality; and the consumer acceptability trials were favourable. The possibility of using the above method for producing both vegetarian and non-vegetarian foods in a readily available, compact and energy-rich form suitable for use in picnics, long distance travel and emergency rations is indicated.

381. VENKATESAM, A. V., RAHMAN, A. & SRIHARI, B. R. (Central Food Technological Research Institute, Mysore): An investigation into the effect of the size of orange on the production of canned orange segments, *Food Sci.*, **12** (1963), 275

The effect of size of orange fruit on the yield and waste in the processing of orange segments and the 'optimum' size for canning of segments have been investigated. It has been found that the average weight of fruit and average weight of segments per fruit increase so rapidly that at the peeling and desegmenting stages the work load per worker at those unit operations increases the performance of the operation, thus reducing the cumulative idle time in the repetition of the unit operations during a factory day. There is no difference between the peel proportion (i.e. peel as proportion of the weight of fruit) as the fruit size increases. The peel is *c.* 25 per cent of the weight of the fruit. The peel is so loosely packed in fruits of sizes 2·50-2·75 in. and 2·75-3·0 in. that segments get desegmented even at the time of peeling — with the result that by assigning peeling and desegmenting to the same worker — unlike the present practice — there is every chance of stepping up productivity in the case of the big size fruits. The weight of seed and pomace expressed as a proportion of the weight of segments sent for lyepeeling does not differ for different sizes of the fruit and it is *c.* 4·14 per cent of the weight of segments. As far as the work load assignment for peeling, desegmenting and deseeding is concerned it has been observed that on the average the worker would handle increasing quantities of the material (the input at these stages) per unit operation as the fruit size increases. There is significant reduction in the deployment of workers at those unit operations as the fruit size increases. The diameter between 2·50 and 2·75 in. is the optimum size for production of segments considering its economic returns in the nett addition to the revenue of the company. This size, incidentally, would facilitate doubling the production employing the same number of workers in the peak season as at present.

382. VIRAKTAMATH, C. S. (Central Food Technological Research Institute, Mysore): Packaging and storage studies on scented *supari* (processed arecanuts), *Food Sci.*, **12** (1963), 322

Studies on the packaging characteristics of the commercially produced scented *supari* have shown that it loses its crispness at 10-11 per cent moisture and develops mould growth at 13-14 per cent moisture. Unit packets with an overwrap moisture barrier films considerably enhance the storage period under standard conditions compared to trade packages in kraft paper. However, under accelerated conditions, only polyethylene+MST cellulose film was found useful for storage up to 60 days.

383. VIRAKTAMATH, C. S., ANANDASWAMY, B., SUBBA RAO, K. R., SURYANARAYANA, B. N., IYENGAR, N. V. R. & SRIVASTAVA, H. C. (Central Food

Technological Research Institute, Mysore): Prepackaging studies on fresh produce: III—Brinjal-egg plant (*Solanum melongena*), *Food Sci.*, **12** (1963), 327

Undermature and freshly harvested brinjals of the local green as well as purple varieties have been investigated for their shelf life in bags of low density polyethylene of 100 and 200 gauge and moisture proof heat sealable transparent cellulose film (MST 300) at different temperatures (22-26°C., 40-70 per cent RH; 24-26°C., 72-75 per cent RH; and 8-10°C., 85-90 per cent RH). Some lots of fruits were given 1 min. dip treatment in a 4 per cent sugarcane wax emulsion containing fungicide before storage. Polyethylene 200 gauge and MST (300) without ventilation have been found to be unsuitable for prepackaging of green as well as purple varieties, but 100 gauge polyethylene bags are suitable even without ventilation under all conditions of storage. Shelf life of both the varieties can be increased from 3-4 days to 8-9 days under two conditions, viz. 22-26°C. and 40-70 per cent RH and 24-26°C. and 72-75 per cent RH and from 16-18 days to 30-32 days at 8-10°C. and 85-90 per cent RH by prepackaging the produce in 200 gauge polyethylene bags having 6 or 10 vents corresponding to 0·21 and 0·35 per cent of aeration on the effective area of the bag. Wax treatment extends the shelf life of prepackaged fruits. Physiological breakdown is not noticed if the CO_2 concentration in the bag does not exceed 7 per cent of atmospheric composition. Prepackaging in adequately ventilated bags does not affect the cooking quality, total acidity, reducing sugar and ascorbic acid contents at the end of storage under different conditions.

664.8 Fruit Preservation

384. BHATIA, B. S., MEHTA, G. L. & NAIR, K. G. (Central Food Technological Research Institute, Mysore): Dehydration of litchi (*Litchi chinensis*), *Food Sci.*, **12** (1963), 313

A method has been standardized for the drying of Late Large Red variety of litchi. Litchies pretreated (blanched for 2 min., predried at 105°F. for 30 min., sulphured for 3 hr) and then dried at dry bulb temperature of 155-60°F. and wet bulb temperature of 95-105°F. for 18 hr and sun-dried at 110-14°F. for the same period were found to be acceptable after storage in friction top tins for one year. Fruits pretreated (blanched and predried as in the former case and steeped in 1 per cent potassium metabisulphite solution per 24 hr) and dehydrated dry bulb temperature of 155-60°F. and wet bulb temperature of 95-105°F. for 20 hr were also acceptable after storage in friction top tins. At the peak season the cost of production has been found to be reasonable.

385. MAHANTA, D. & RAO, P. R. (Regional Research Laboratory, Jorhat): Utilization of naga-tenga (*Myrica esculenta*) fruit, *Res. & Ind.*, **8** (1963), 328

An attempt has been made to remove the astringency and to prepare preserved products from the fruit growing wild in Assam, which has not so far found any industrial use.

386. PADMINI, T., NARAYANASWAMY, D. & MURTHY, H. B. N. (Central Food Technological Research Institute, Mysore): Packaging and storage studies on mango cereal flakes, *Food Sci.*, **12** (1963), 315

Studies have been made for the design of a flexible package which would give adequate protection to the extremely hygroscopic mango cereal flakes. It has been found that the use of aluminium foils for overwrapping glassine bags containing the product has decidedly greater advantages over double waxing. The product in the aluminium packages may have a shelf life of *c.* a year in actual practice. Further studies showed that by replacing glassine overwrap by poster paper the efficiency can be increased threefold. Thus, by overwrapping with poster paper and subsequent wax coating the same shelf life as in the case of aluminium foil can be obtained.

387. RODRIGUES, J., DALAL, V. B., MOORTHY, N. V. N. & SRIVASTAVA, H. C. (Central Food Technological Research Institute, Mysore): Effect of post-harvest treatment with plant growth regulators in wax emulsion on storage behaviour of limes [*Citrus aurantifolia* (Christm) Swingle], *Indian Fd Packer*, **17** (5) (1963), 9

Freshly harvested green limes were treated with indole propionic acid (1000 and 2000 p.p.m.) and indole butyric acid (1000 and 2000 p.p.m.) in a wax emulsion containing 12 per cent solids. Untreated fruits and fruits treated with wax emulsion alone were maintained for comparative study. Limes treated with wax emulsion containing 2000 p.p.m. of indole butyric acid and 1000 p.p.m. indole propionic acid showed low physiological losses in weight as compared to the other treated fruits and controls. Samples waxed with indole butyric acid at 2000 p.p.m. had 75 per cent marketable fruits after 17 days of storage, whereas the untreated controls and those only waxed were completely unmarketable. Growth regulators also delayed the colour changes and retarded the rate of respiration.

388. RODRIGUES, J., DALAL, V. B., SUBRAMANYAM, H., AIYAPPA, K. M. & SRIVASTAVA, H. C. (Central Food Technological Research Institute, Mysore): Effect of preharvest sprays of plant growth regulators on Coorg mandarins (*Citrus reticulata* Blanco) and their storage studies with and without wax coating, *Food Sci.*, **12** (1963), 336

The effect of preharvest sprays of different growth regulators on the storage life of Coorg mandarin oranges has been studied. The fruits sprayed with 2,4-D at 100 p.p.m. were found to be small in size but had higher juice content. All other treatments increased fruit size by 6-12 per cent. Appreciable increase in juice content was also noticed in fruits sprayed with 20 p.p.m. of 2,4-D, 20 p.p.m. of 2,4,5-T and 10 p.p.m. of NAA respectively. Wax coating of mandarins was found to increase the marketability and storage life. The fruits sprayed with growth regulators had low sugar and high acid contents. The rate of respiration of these fruits soon after harvest was also high. Marketability of fruits stored at low temperatures was good after 8 weeks of storage.

Physiological losses in weight were low in all waxed fruits irrespective of growth regulator treatments. All fruits showed an increase in total sugars at the end of storage period. Vitamin C decreased in unwaxed and low temperature stored fruits, while retention was good in waxed fruit.

389. SASTRY, L. V. L., CHAKRABORTY, R. N., PRUTHI, J. S. & SIDDAPPA, G. S. (Central Food Technological Research Institute, Mysore): Preservation and storage of cashew apple juice and its blends, *Indian J. Technol.*, **1** (1963), 431

Extraction of cashew apple *Anacardium occidentale* L. juice with a screw type juice extractor yields more juice (66 per cent) than a basket press (38 per cent). The latter, however, requires less gelatin to remove the astringent principles. The loss of ascorbic acid in cashew apple juice or its blends at the end of 32 weeks' storage was found to be 49-66 per cent at 37°C. and 29-54 per cent at room temperature. The colour of cashew apple juice is highly susceptible to heat. Browning during storage is comparatively less in canned than in bottled juice.

390. SRIVAS, S. R., PRUTHI, J. S. & SIDDAPPA, G. S. (Central Food Technological Research Institute, Mysore): Effect of stage of maturity of fruit and storage temperature on the volatile oil and pectin content of fresh limes (*Citrus aurantifolia* Swingle), *Food Sci.*, **12** (1963), 340

The loss in weight of yellow fruits stored at 8-10° and 24-30°C. is greater than that occurring in green fruits. The loss in volatile oil in green as well as yellow fruits is more rapid at room temperature (24-30°C.) than at 8-10°C. At room temperature, there was greater deterioration in jelly grade, jelly units, methoxyl contents, anhydrouronic acid (AVA) contents. The water and oxalate-soluble pectin fractions increased while the acid-soluble pectin fraction decreased. Fully developed green or yellow fruits could be kept at 8-10°C. for *c.* one week only for satisfactory recovery of oil and pectin, for 3-4 weeks at 8-10°C. and for 1-2 weeks at room temperature for the recovery of pectin only.

664.95 Fish Preservation

391. SUBRAHMANYAN, V., LAHIRI, N. L., MOORJANI, M. N., BALAKRISHNAN NAIR, R. & KRISHNASWAMY, M. A. (Central Food Technological Research Institute, Mysore): Ammonia — Possible use for preserving fish, *Science*, **142** (1963), 233

Eviscerated oil sardines (*Sardinella longiceps*) that have been treated with ammonia can be stored at 25-30°C. for more than 2 months without deterioration of their nutritive value. There is no measurable residue of ammonia in the final product.

665.3 Fats & Oils

392. GOVIND RAO, M. K. & RAGHAVENDAR RAO, S. (Regional Research Laboratory, Hyderabad): Determination of trace amounts of nitrogen in vegetable oils, *Indian J. Technol.*, **1** (1963), 464

A modified nesslerization technique has been developed for the estimation of trace amounts of nitrogen (30-100 mg. nitrogen/100 g.) in fats. The technique involves standard acid digestion of 0·1-0·2 g. fatty material in a Kjeldahl flask and estimation of ammonia in the digest colorimetrically with Nessler's reagent. The procedure avoids distillation and is rapid and accurate. It has also been found applicable for the estimation of phospholipids.

393. PHILIP, K. J., VENKATARAO, P. & ACHAYA, K. T. (Regional Research Laboratory, Hyderabad): Isolation and composition of triricinolein and ricinoleic acid from castor oil, *Indian J. Technol.*, **1** (1963), 427

Analysis by gas-liquid chromatography of castor oil, and of the triricinolein and diricinolein compcnents (obtained by resolution with hexane) shows the presence of 89·4, 93·5 and 83·1 per cent (by wt) of ricinoleic acid respectively. The ricinoleic acid obtained by urea-adduction of triricinolein fatty acids contained as impurity only 1·5 per cent of linoleic acid. The best method of obtaining pure ricinoleic acid in 85 per cent yield is by partitioning castor oil acids between 80 per cent methanol and light petroleum. Sharp changes in the immiscibility curves for the castor oil-hexane system occur at 30°C. with commercial hexane and at 39°C. with acid-washed hexane. Using the latter and removing 17 per cent of castor oil glycerides, a product with the low temperature clarity required for use as an aircraft hydraulic brake fluid is obtained.

394. PRAKASA RAO, CH. S., NARASIMHACHARI, P., SARMA, E. L. N., THIRUMALA RAO, S. D. & MURTI, K. S. (Oil Technological Research Institute, Anantapur): Splitting of Indian vegetable oils: Part II — Application of Twitchell process, *Indian J. Technol.*, **1** (1963), 457

Laboratory and pilot plant scale studies on the Twitchell process for the splitting of fats have shown that the efficacy of different Twitchell reagents lies in the following decreasing order: alkylaryl sulphonic acids, petroleum sulphonic acids and conventional type Twitchell reagents. About 90 per cent splitting can be achieved in the case of vegetable oils in 8-9 hr using dodecylbenzene sulphonic acid and alkylnaphthalene sulphonic acid.

666.29 Enamels

395. VERMA, S. S. & UPADHYAYA, V. G. (Central Glass & Ceramic Research Institute, Calcutta): A study of the effects of hydrogen permeability on the enamelling behaviour of metals, *Cent. Glass Ceram. Res. Inst. Bull.*, **10** (1963), 90

The results of a study of hydrogen permeability of copper, aluminium, stainless steel and three types of sheet iron used in enamelling processes are presented. The defects of fish-scaling and reboiling, etc., appearing in enamelled ware, have been correlated with the hydrogen permeability of sheet iron. The effect of oxidation of the surface of sheet iron on hydrogen permeability has also been determined and enamelling behaviour of surface-oxidized sheet iron has

been discussed. Further investigations on the possibility of rendering iron impermeable to hydrogen with a view to eliminating some of the enamelling defects have been suggested.

666.76 Refractories

396. BANERJEE, N. C. & NANDI, D. N. (Central Glass & Ceramic Research Institute, Calcutta): Refractory cements for electrical heating appliances, *Cent. Glass Ceram. Res. Inst. Bull.*, **10** (1963), 82

The results of studies conducted with the object of developing suitable cementing materials for electrical heating appliances are presented. The electrical resistances for talc, calcined magnesite, calcined alumina, silica (quartz), calcined kyanite, sillimanite, calcined china clay grog and calcined fireclay grog with and without bonding material like Cement Fondu, Portland cement, sodium silicate, etc., were measured at different temperatures up to 600° by a small gadget devised at the Institute. The order of decreasing resistivity at temperatures beyond 500° is talc, calcined alumina, calcined magnesite, quartz, calcined kyanite, sillimanite, calcined china clay grog and calcined fireclay grog. But any of the materials tested may be used for immersion heater. Cement Fondu has been found to be the best bonding material both in respect of strength and electrical resistivity. Portland cement is inferior to Cement Fondu. Magnesium oxysulphate appears to be better for calcined magnesite. Sodium silicate is unsuitable for the purpose.

667.6 Paints & Varnishes

397. BARUAH, A. D., BARUAH, J. N. & RAO, P. R. (Regional Research Laboratory, Jorhat): Mahudi fruits kernel oil as a varnish constituent, *Paintindia*, **13** (9) (1963), 36

Mahudi (*Croton joufra* Roxb.) oil has been tried in the preparation of enamels employing phenolic resin. Oil modified alkyds have also been prepared. Coatings from both the types of resins produced hard, flexible and scratch-resistant films.

398. GEORGE, JOSEPH & SINGH, S. M. (Central Building Research Institute, Roorkee): Adhesion of cement paint to old surfaces, *J. Col. Soc.*, **11** (2) (1963), 13

A study has been carried out on the suitability of a few additions to bring about quick hardening and better adhesion of the paint film to old surfaces. The effect of these additives on the mixing and wetting characteristics of dry cement paint powder has also been observed.

399. MOHAMMAD YASEEN, MENON, M. C. & AGGARWAL, J. S. (Regional Research Laboratory, Hyderabad): Studies on water vapour permeability through paint and varnish films: Part I — Observations on the Payne cup procedure, *Indian J. Technol.*, **1** (1963), 382

Six variations of the Payne cup method for the determination of water vapour permeabilities of different varnish films have been studied. The permeability rate has been found to be independent of the nature of the desiccant and the relative position of the desiccant to the water. The method in which anhydrous calcium chloride is kept inside the Payne cup and water in the desiccator has been found to be the best, both with respect to convenience of handling and reliability of results.

400. MOHAMMAD YASEEN, MENON, M. C. & AGGARWAL, J. S. (Regional Research Laboratory, Hyderabad): Studies on water vapour permeability through paint and varnish films: Part II — Effect of temperature on permeability coefficients, *Indian J. Technol.*, **1** (1963), 385

The dependence of permeability coefficients on thickness and temperature has been studied in the case of homogeneous polymeric films and the energy of activation for permeation for the polymers has been calculated. Combining Arrhenius equation and Fick's law, the equation $P = P_0 e^{-E_p/RT}$ (where P is permeability coefficient; R, gas constant; T, temperature; and P_0 and E_p are relative terms) has been derived correlating permeability coefficient and temperature. The permeability coefficient has been found to be independent of the thickness of the film and to increase with increase in temperature.

668.317 Gelatin

401. BARDHAN, P. N., COYAJI, B. & MANSA RAM (National Chemical Laboratory, Poona): Treatment of shock with gelatin as plasma expander, *Indian J. med. Res.*, **51** (1963), 871

Gelatin prepared as a plasma expander by the National Chemical Laboratory, Poona, has been used for the treatment of shock. Of the 50 cases treated, the response in 38 was good, in 6 fair and in 6 poor. The gelatin produced no undesirable reaction nor any complication because of haemodilution. It was safe for intravenous use in all cases. Excretion of gelatin through urine amounted to 23-65 per cent in most cases.

668.44 Resins

402. SINGH, S. M. (Central Building Research Institute, Roorkee): Water absorption by dehydrated castor oil modified alkyd resins, *Paintindia*, **13** (1963), 38

Dehydrated castor oil (DCO) modified alkyd resin films show more whitening when immersed in water compared to linseed oil modified alkyd. The reliability of this test as a measure of water resistance has been investigated. The water absorption of oil modified alkyds containing 20 per cent DCO has been compared with that of linseed oil modified alkyd and it has been found that the resistance to water uptake is greater with DCO modified films.

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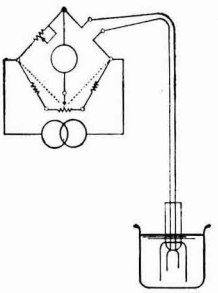

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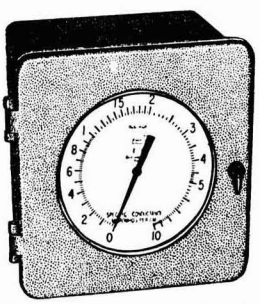

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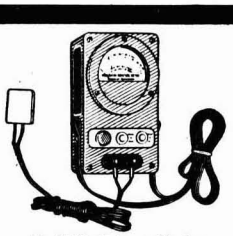

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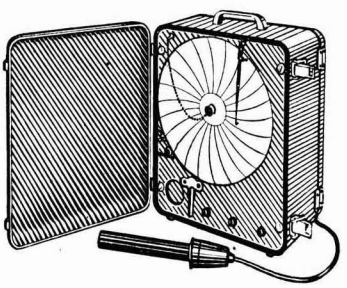

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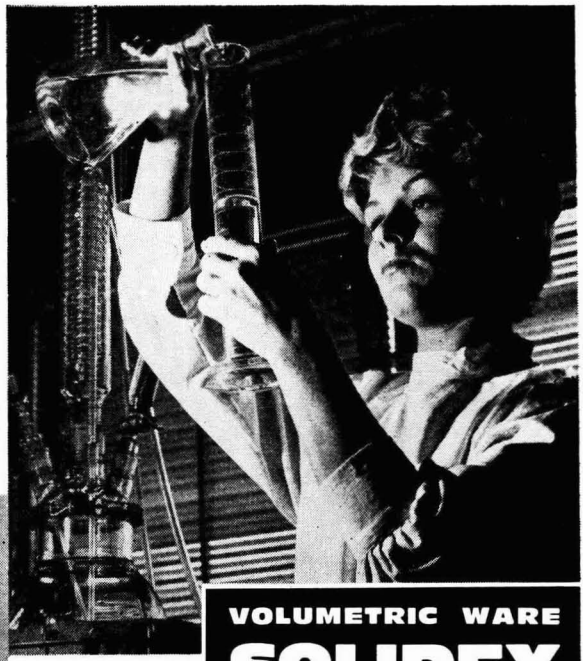

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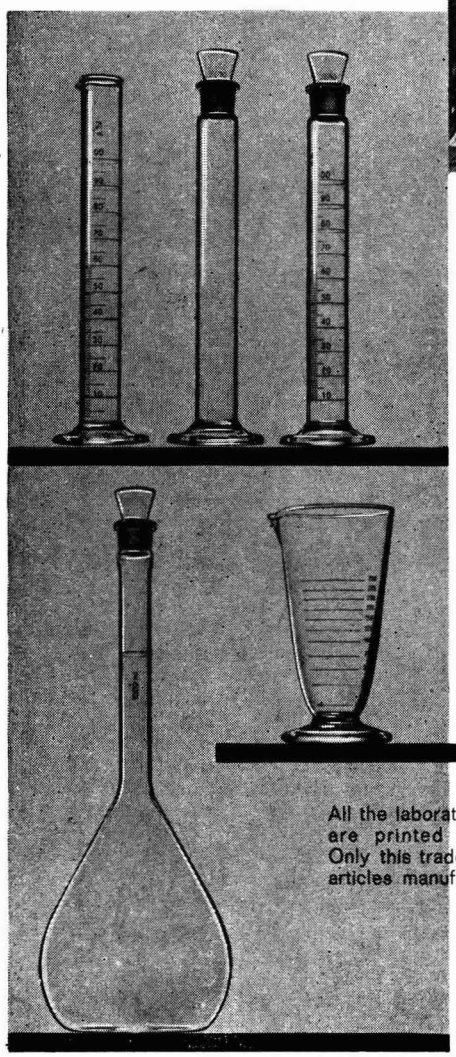

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