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Journal of Scientific & Industrial Research

THIS ISSUE

GENERAL

- Design of transducers
- Microwave radar study of monsoon rain in North-west India
- Recovery of sodium chloride, sulphate and carbonate from Sambhar saltern

BIPHYSICAL SCIENCES

- Restricted dipole orientation in solid dielectrics
- Chemical components of the heartwood of *Morinda tinctoria* Roxb.
- Structure and composition of Nahorkatiya (Assam) gasoline

C. BIOLOGICAL SCIENCES

- Terramycin and growth: Part IV — Studies on rice diets
- Effect of cholesterol on the virulence of *E. histolytica* in rats
- Biogenesis of oil in ripening coconut and arecanut

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SEPTEMBER 1959



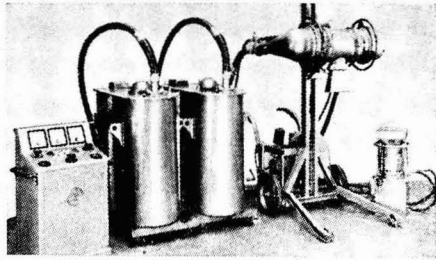
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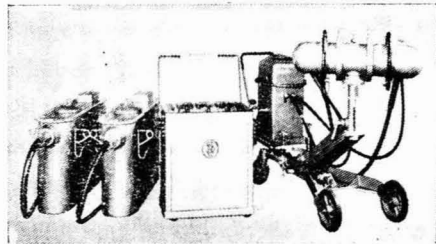
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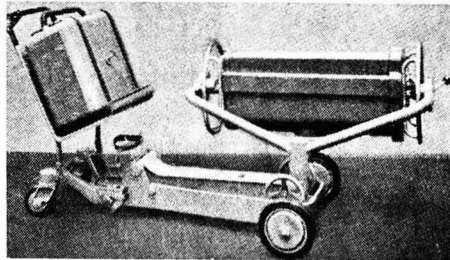
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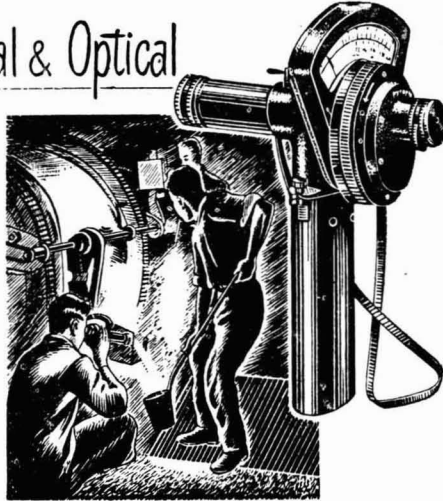
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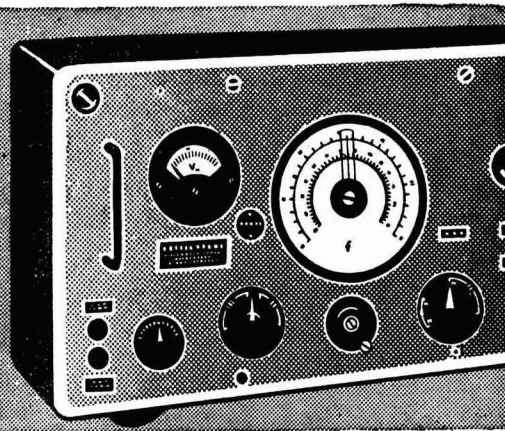
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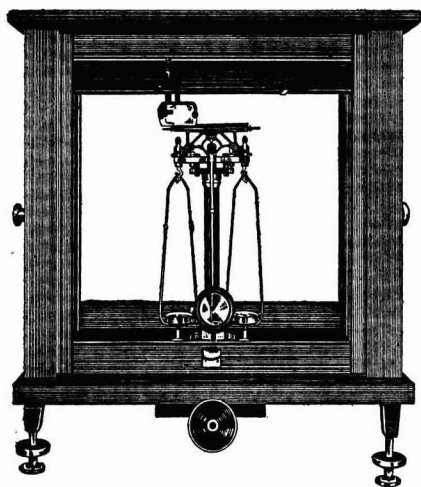
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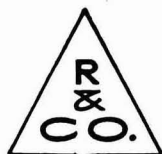
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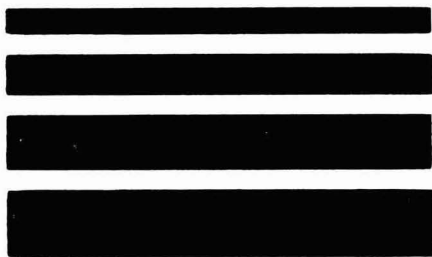
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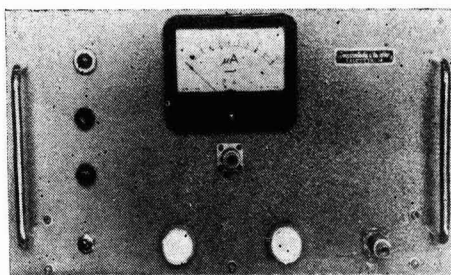
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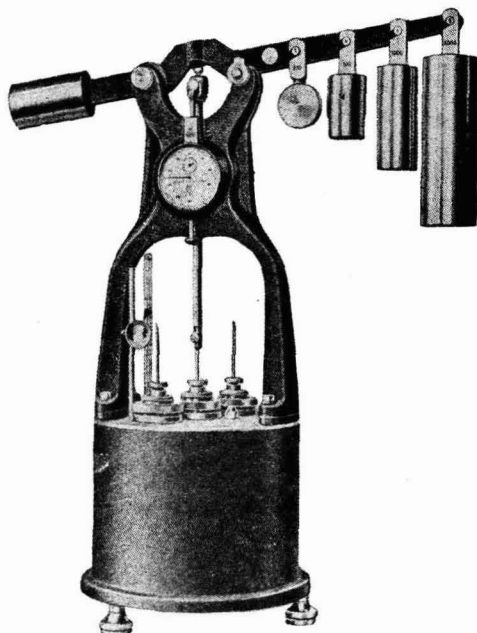
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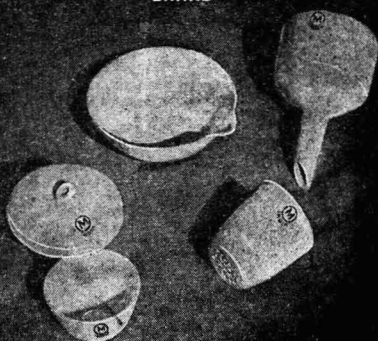
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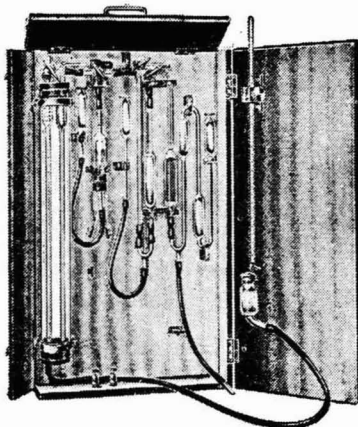


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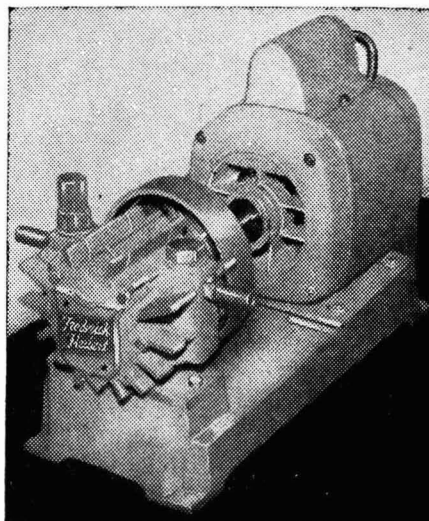
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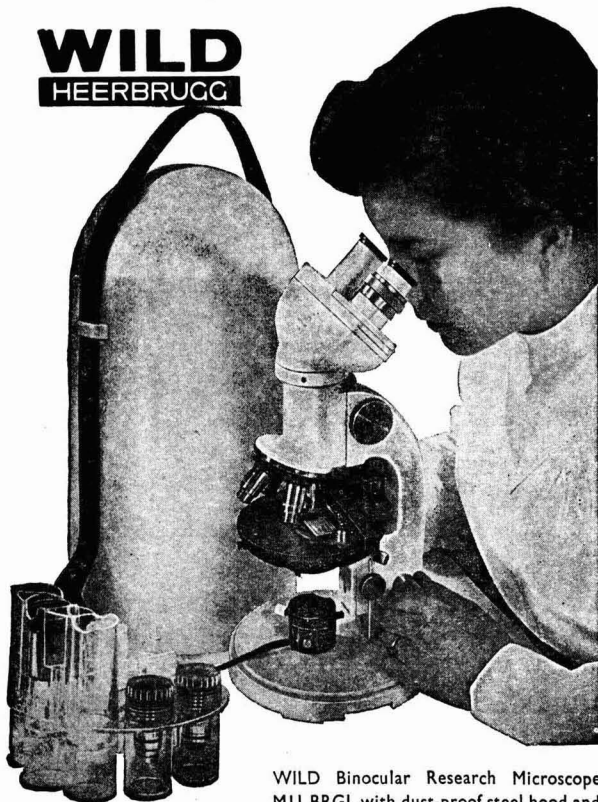
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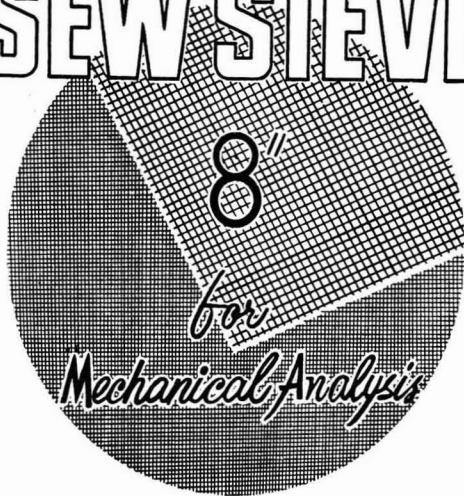
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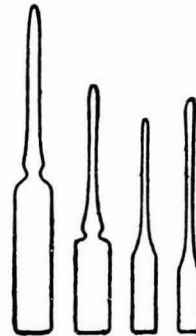
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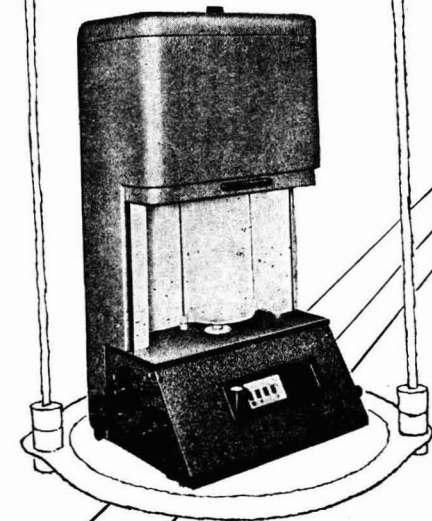
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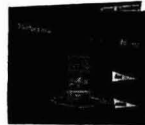
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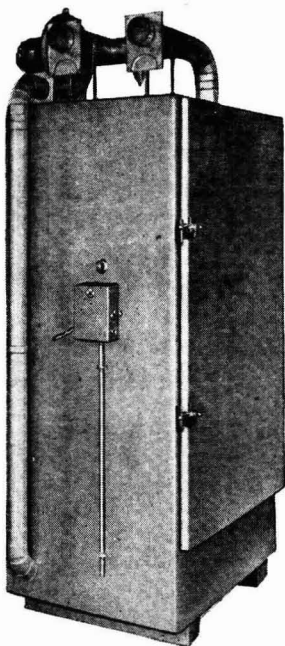
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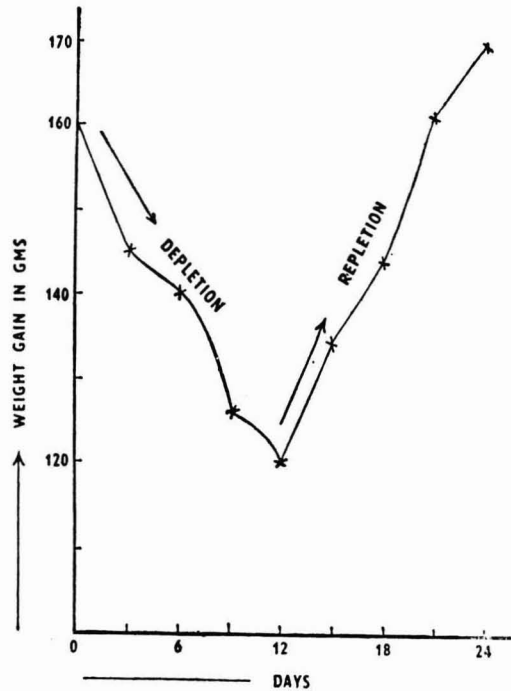
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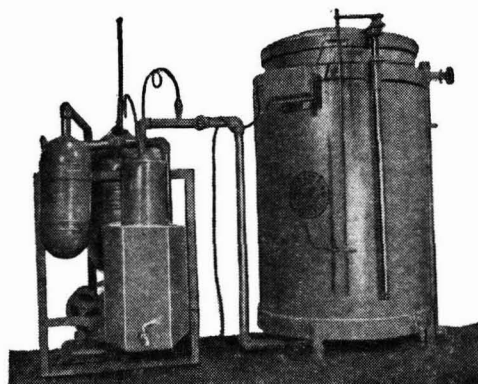
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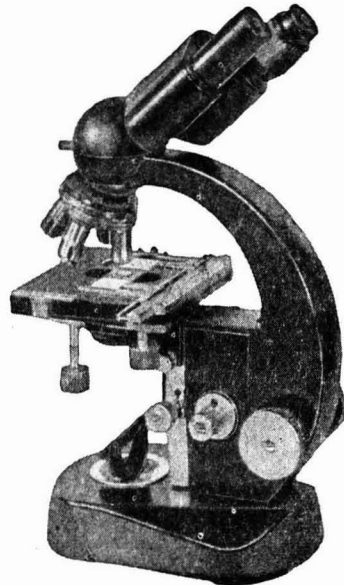
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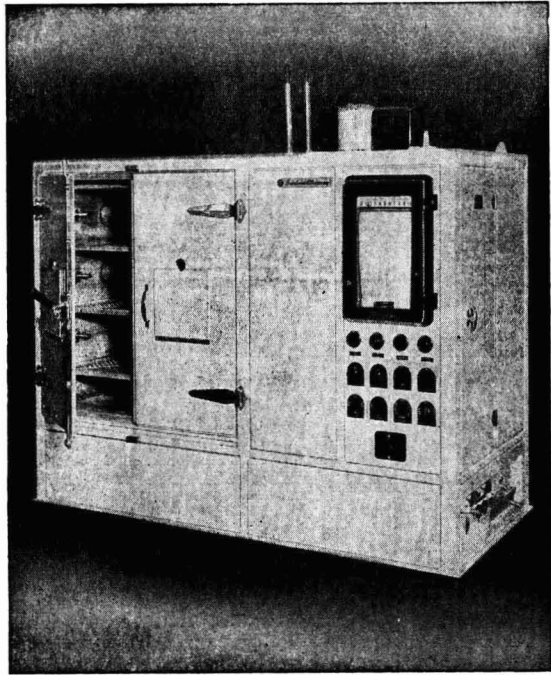
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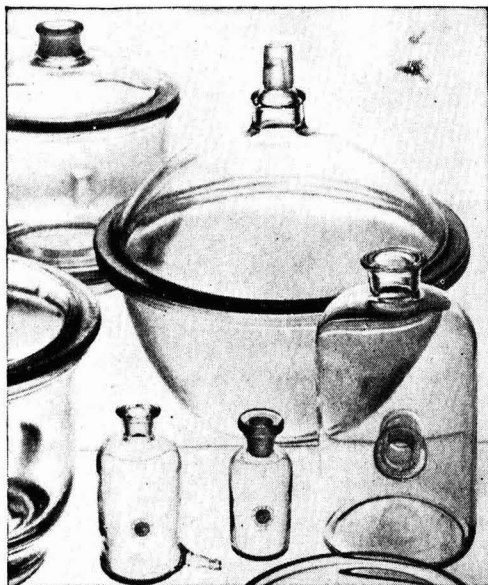
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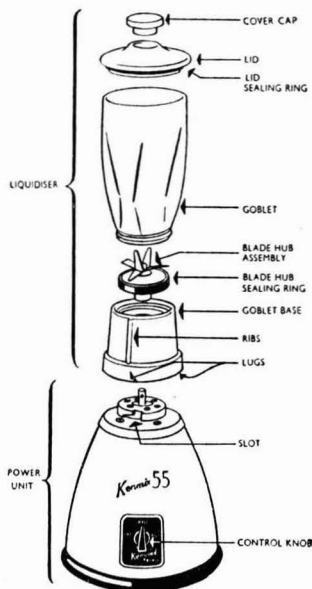
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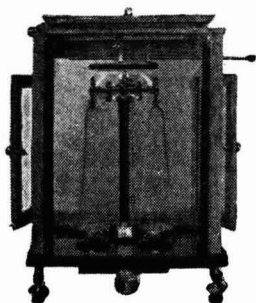
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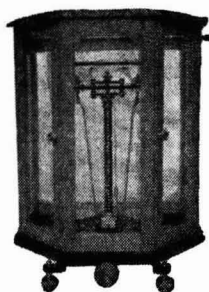
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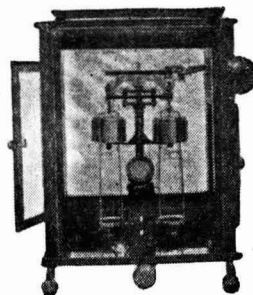
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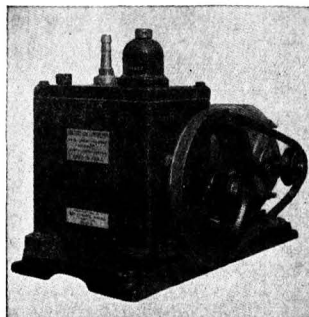
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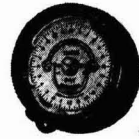
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Current Topics

TRAINING & RESEARCH IN TECHNOLOGY

MUCH ATTENTION HAS BEEN GIVEN IN RECENT YEARS to the promotion of postgraduate studies and research in technology. The planning of large development projects and their implementation under the national five-year plans have imposed new responsibilities on Indian engineers and technologists, and the need for personnel equipped with the knowledge and skills necessary for shouldering the responsibilities has been progressively increasing. Notable expansion in teaching and research facilities in various technologies has been achieved. The number of postgraduate students has increased from less than 100 in 1947-48 to about 500 at present; and there are 70 postgraduate courses in engineering today. A technical teachers' training programme has been instituted and promising engineering graduates who wish to take up teaching as a career are awarded Senior Teaching Fellowships. These are important developments, but the need for scrutiny into the present programmes with a view to further improving them appears to have become necessary and the decision taken by the Ministry of Scientific Research and Cultural Affairs to appoint a high-powered commission to evaluate the progress of postgraduate courses at different centres and suggest measures for their improvement and development will be widely welcomed.

The problem of trained personnel is not one of mere numbers; it is also one of quality, and quality in a variety of fast-developing technologies. The problem has been examined recently by the Working Group for Technical Education of the Planning Commission. What are the measures to be taken, and what are the incentives to be provided, in order to attract the top ten per cent of the students passing out of engineering institutions to take up postgraduate studies and research in different technological disciplines? And what should be done to induce the top five per cent of those who have had the benefit of postgraduate training to take up teaching in technical universities and higher technological institutions? These are crucial questions which the Working Group has formulated

and for which it has sought solutions. The Working Group has emphasized that the establishment of postgraduate departments and provision of facilities for advanced research are essential functions of technical universities and higher technological institutions. The review of the present position of postgraduate studies in various centres, to be undertaken by the commission to be appointed by the Union Ministry of Scientific Research and Cultural Affairs, would help in the selection of centres for instituting new courses of study and research. And concerted efforts should be made to develop such centres of comprehensive training in different specialities. These and other recommendations which have emerged out of the discussions of the Working Group are valuable and it is to be hoped that they would be implemented with a sense of determination and urgency.

FAO SEMINAR

THE POSSIBILITIES WHICH TECHNOLOGY OFFERS FOR the expansion of food production, better utilization of food materials, and processing of new and nutritious foods were discussed at the FAO Regional Seminar held in Mysore last August. This was the first seminar on food technology in Asia and the Far East, and it was appropriately held in the Central Food Technological Research Institute which, during the past ten years of its existence, has contributed substantially to the promotion of food technology in India, particularly its applications to the problems of production, enrichment and utilization of staple, subsidiary and unconventional and less known foods of India.

The region covered by the discussions of the FAO seminar contains the bulk of the world's poorly fed and poorly nourished peoples, and the interest is predominantly in the results of technological developments which will ensure more food and better food. What technology can do is known and the food industries in advanced countries are there to serve as an object lesson; technology has shown that the warning finger of the followers of Malthus can, in fact,

be ignored; food resources can be more effectively tapped; nature's photosynthetic process can be improved upon; chemical farming can raise the yield per acre; a variety of less known food materials can be processed and enriched into palatable, appetizing and nutritious foods; and the control of insect and rodent pests of stored grains can release large quantities of conventional food materials for human consumption. The emphasis in the deliberations of the seminar was, therefore, not on what is possible, but on what has to be done to realize known possibilities. This realism of approach has invested the seminar held at Mysore with particular significance.

The seminar has focussed attention on various aspects of food processing and preservation, including: the place of foods processed by traditional and modern methods in national diets; present status of food industries in the region; availability of raw materials for processing; effects of processing on nutritive value; packaging and transport; storage, hygiene and sanitation; food legislation and additives; protein-rich foods and their importance; technical resources in the region; problems of machinery and dissemination of knowledge.

Much headway has been made in India in the establishment of food processing industries and the Central Food Technological Research Institute, Mysore, has

organized extension services to educate the public on the importance and merits of processed foods. Yet, a great deal remains to be done. The seminar has shown that India is not exploiting her fish resources adequately and the potentialities of food industries in the country have not been fully assessed. In a small country like Japan, there are 30,000 cottage-scale food processing units, employing less than 20 persons and equipped with all modern facilities, for turning out a variety of processed foods and representing over 80 per cent of the food industrial plants. India has only 990 licensed food processing factories. The establishment of small-scale cottage units has obvious advantages and merits consideration. In a country where the people are predominantly cereal consumers, protein-rich and fortified foods are of special significance. Although useful work is being done in India on the utilization of oilseed cakes for this purpose, only the fringe has been touched in this field. It is gratifying to note that the FAO is seized of the importance of this aspect of food technology and has laid special emphasis on extension services and training programmes. The establishment of Co-operative Food Industries Research Associations would not only assist greatly in solving many of the problems of food industries but also help in the fuller utilization of the results of research.

Symposium on Pilot Plants in Metallurgical Research & Development

A SYMPOSIUM ON PILOT PLANTS IN METALLURGICAL Research and Development is to be held at the National Metallurgical Laboratory, Jamshedpur, during February 1960. The object of the symposium is to provide a forum for the exchange of information among scientists and metallurgists from different parts of the world on the development of pilot plant work in the field of metallurgy. The topics scheduled for discussion at the symposium are: (1) Pilot plant projects in relation to laboratory scale investigations and their industrial scale implementation; (2) Importance of pilot plant investigations in assessing the overall economics of processes, production costs, etc., for their industrial scale implementation; (3) Pilot plant projects for metallurgical research in India; (4) Some important pilot plant projects for metallurgical research and development operating in

different parts of the world; (5) Pilot plants dealing with (a) mineral dressing, thermal and chemical beneficiation of low-grade ferrous and non-ferrous ores, (b) pyrometallurgical operations, (c) electrometallurgical operations, (d) production of new refractories, (e) hot and cold working of ferrous and non-ferrous metals, and (f) finishing of metals by anti-corrosive hot dip coating techniques such as aluminizing, decorative-cum-protective chemical treatments, etc.; (6) Materials of construction for metallurgical pilot plants, including equipment, instrumentation and components required and their indigenous availability; and (7) Cost accounting and overall assessment of the economics of applied processes in terms of capital and operational cost, statistical analysis and assessment of pilot plant test data.

Chemistry of Co-ordination Compounds

A SYMPOSIUM on the Chemistry of Co-ordination Compounds, organized by the National Academy of Sciences, was held at the University Buildings, Agra, during 7-8 February 1959. In all 95 papers from India and some foreign countries including those from U.K., U.S.A., U.S.S.R., Japan, Sweden, Hungary, Czechoslovakia and the Netherlands were presented at the symposium. The symposium was divided into seven sections: (I) general survey; (II) valence-bond considerations, stereochemistry and structure; (III) techniques and methods of investigation; (IV) reactions, stability and thermodynamic considerations; (V) stabilization of valence states; (VI) analytical applications; and (VII) miscellaneous. Nearly 150 delegates including those from Czechoslovakia, U.S.S.R. and the Netherlands participated in the proceedings.

In his presidential address, Prof. P. Ray reviewed the recent advances in the chemistry of co-ordination complexes, and discussed different approaches to the problem relating to the nature of the co-ordination bond, structure of co-ordination complexes and their industrial applications. Crystal field theory, a refined form of electrostatic theory, has attracted much attention in recent years and in fact seems to possess some advantages over the valence bond and molecular orbital theories. The crystal field theory, which takes no cognizance of directed covalent or electron pair bonds between the ligands and the central atom, therefore, fails to account for the formation of complexes in which the occurrence of bonding is assumed and also the resolution of asymmetric complexes into their optically active modifications. The concept of polarization and interpretation of the electronic orbits of the ions is often utilized to get over these difficulties. But the main advantage and usefulness of the theory over the other two lie in its ability to offer better quantitative interpretation of many properties of the complex, e.g. magnetic behaviour, colour, structure and stability of co-ordination compounds, and particularly their absorption in the visible region.

Crystal field theory combined with molecular orbital theory, gives a better interpretation of facts and the new theory has been termed as 'ligand field theory'. To date, powerful physical methods for the study of the structure of complexes, based on X-ray and electron diffraction spectra, magnetic moment, Raman and infrared spectra, absorption in the visible and ultraviolet regions, dipole moment, and the recently introduced methods of paramagnetic and nuclear

magnetic resonance, have contributed in a great measure to the elucidation of the finer structure of the complexes and to the determination of the valency of the central metal atom.

Prof. Kazuo Yamasaki of Japan, in his review on the recent researches in co-ordination compounds in Japan, described some new compounds and some new methods of preparation of co-ordination complexes. A new co-ordinating complex of cobalt with three moles of dimethyl glyoxime was reported to have the structure $[\text{Co}(\text{dgH})_3] \cdot 2.5 \text{H}_2\text{O}$. He also reported that crystal structure of a large number of complexes has been elucidated with the help of X-ray analysis.

A paper on partial hybridization and its role in co-ordination chemistry, by G. S. Sharma of Patna University, provided an explanation for the nature of deviations occurring in Pauling *et al.*'s theory of hybridization of bond orbitals when groups or atoms attached to a central atom are not alike. According to the author, deviations in bond angles are more marked as the difference in the nature of the group or atoms co-ordinated to the central atom increases. The nature of deviations can be qualitatively explained by a consideration of the difference in the electronegativities of the atoms concerned. Though the author has not been able to corroborate his conclusions from the available experimental data, yet the structure of certain simple compounds strongly support the conclusion of the author. The phenomenon of partial fulfilment of conditions for perfect hybridization is a case of *partial hybridization* which is likely to play an important role in the study of finer structure of co-ordinated compounds.

Among the various experimental methods described for determining the equilibrium constants for complex formation, two main methods, viz. e.m.f. method and potentiometric method, are available for determining the concentration of ligands and the concentration of the free central ion respectively. Other methods are less universal, e.g. those using solubility, ultracentrifugation and anion exchange, etc.

A well-known and interesting aspect of complex formation is the stabilization of the unusual valence states of the central metal atom through co-ordination. In recent years the preparation and study of stable complexes of several metals in their unusual oxidation states, viz. copper, silver and nickel in their tripositive state, have been reported. The stabilization of the unipositive valency state of cobalt is best illustrated by the preparation of quite stable

diamagnetic complex salts of cobalt (I) with aromatic isonitriles having the formula $[\text{Co}(\text{CNR})_6]\text{X}$.

Some new applications of co-ordination compounds in analytical chemistry were described. 3-Oximino-methyl salicylic acid has been successfully utilized

for the separation of copper from mercury, lead, cadmium, zinc and cobalt in their divalent states. Separation of copper from antimony, bismuth and iron has been effected in the presence of sufficient tartaric acid as the masking agent.

Surface Area of Coal

K. A. KINI & A. LAHIRI

Central Fuel Research Institute, Jealgora, Dhanbad

SURFACE area is an important parameter in the elucidation of the physical structure of coals and hence in understanding their industrial behaviour. It is useful in assessing the suitability of different coals for carbonization and gasification. It provides a measure of the susceptibility of coals towards spontaneous combustion. It is of help in understanding the factors underlying the dewatering of coals. A knowledge of surface area is also of value in the dust-proofing of coals. In this paper, the present position of our knowledge on the surface area of coal is briefly reviewed.

The earliest method to be employed for the measurement of the surface area of coals is the heat of wetting method, developed by workers at the British Coal Utilization Research Association¹. It consists in the determination of the heat evolved when coal is wetted by methanol. Surface area values of 40-200 sq. m./g. were obtained by this method. The validity of the method was questioned by Malherbe² and also by Lecky, Hall and Anderson³, who employed the B.E.T. method using the adsorption of argon or of nitrogen at liquid air temperatures. They obtained values of only 1-9 sq. m./g. These results were confirmed by Zwietering *et al.*⁴, Malherbe² and also Malherbe and Carman⁵ ascribed the high values to imbibition of coal by methanol. Lecky, Hall and Anderson suggested that interaction takes place between methanol and the polar groups in coal.

The heat of wetting method for measuring the surface area of coal has been supported by Maggs^{6,7}, Dryden⁸, Berkowitz and Schein⁹ and Van Krevelen and Zwietering¹⁰. From a study of the adsorption of nitrogen, hydrogen and argon between 77° and 273°K. on coal Maggs observed an anomalous increase of adsorption with increase in temperature which he

attributed to a higher surface area of coal than what is measured by the low temperature B.E.T. method. Zwietering *et al.*, by measuring the adsorption of nitrogen and methane at temperatures of 0° to 50° by a coal with 89.5 per cent carbon (d.a.f.), showed that the coal possessed a surface area of about 90 sq. m./g.

Investigations¹¹⁻¹⁵ carried out at the Central Fuel Research Institute have shown that hydrogen bonding is an important factor in explaining the anomaly of the surface area of coal as measured by the two methods. Evidence in favour of this has come from the studies on the adsorption of polar and non-polar gases, heat of wetting in polar liquids, heat of wetting and B.E.T. measurements on briquetted coal and heat of wetting and moisture relationships on acetylated coals. It has also been shown from a study of mildly oxidized coals¹⁶ that the B.E.T. method using argon does not measure the surface area of a high rank coal due to pores with constricted ends and that the values obtained for low rank coals may not be very different from the true values for these coals. The importance of polarity of the wetting liquid in the heat of wetting determinations has been stressed also by Mertins¹⁷ who indicated its utility in determining the degree of metamorphism of coal. Pampuch¹⁸ examined the mechanism of swelling of low rank coals when treated with polar liquids.

The possible contraction of pores^{19,21-23} and the slow rate of diffusion of nitrogen or argon into the pores¹⁰ of coal at the low temperatures employed has been overlooked in the case of B.E.T. method.

Anderson and co-workers¹⁹ by a study of the sorption of normal and isobutanes at 0°C. and of nitrogen between -195° and 0°C. by coal have shown that the surface area of coals has a value intermediate to

that measured by the heat of wetting method and that by the B.E.T. method using argon or nitrogen. Bond and Spencer²⁰ have concluded from a study of the adsorption of neon at room temperature that heat of wetting gives the correct value for high rank coals and a value lower by a factor of 3 to 4 for low rank coals; the method employed, however, is of doubtful validity. Van Krevelen used an equation for the surface area of coal which gives results varying by a factor of 2 to 3.

The crucial test should be the estimation of B.E.T. surface area using an inert gas or vapour with a boiling point approaching room temperature. Malherbe and Carman⁵ did carry out such an experiment but since the adsorbates used by them had high areas of cross-section, the value for surface area did not show much of an increase. Kini²¹ and also Walker and Geller²⁴ showed that high values are obtained for the surface area of coals using carbon dioxide at -78°C ., but since carbon dioxide has a quadruple moment, it is difficult to accept this result without reservation. Recently Nandi, Kini and Lahiri²⁵ have shown by a study of the adsorption of krypton on coal at -130° and -110°C . that the values obtained for the surface area of coal are intermediate between those given by the B.E.T. and the heat of wetting methods, and this is in agreement with the findings of Anderson *et al.*

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Fifth Congress on Theoretical & Applied Mechanics

THE FIFTH CONGRESS ON THEORETICAL AND APPLIED Mechanics will be held under the Presidentship of Dr A. N. Khosla, Vice-Chancellor, University of Roorkee, from 23 to 26 December 1959 at the University of Roorkee, Roorkee. The topics which will be discussed at the Congress are: (1) Elasticity-plasticity-rheology, (2) Fluid mechanics (Aerodynamics-hydrodynamics), (3) Mechanics of solids (Ballistics-vibration-friction-lubrication), (4) Statistical mechanics-thermodynamics-heat transfer, (5) Mathematics of physics, statistics and computation, and (6) Experimental techniques. There will be invited half-hour addresses on special topics. Papers intended for presentation at the Congress should reach the

Secretary-Treasurer with three copies of their abstracts before 15 October 1959.

The Congress will be preceded by a Symposium on 'Non-linear physical problems'. The topics to be covered will include non-linear problems in elasticity, fluid mechanics, vibration, heat flow and ballistics. The President of the International Union of Theoretical and Applied Mechanics, Prof. F. Odqvist, will be participating in the Symposium.

Further particulars about the Congress and the Symposium can be had from the Secretary-Treasurer of the Indian Society of Theoretical and Applied Mechanics, Indian Institute of Technology, Kharagpur.

Dynamic Mechanical Properties of High Polymers & the Importance of Their Study

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The importance of the study of the dynamic mechanical properties of high polymers, with special reference to textiles, has been emphasized, and the various methods employed in the determination of these properties have been summarized and their limitations have been pointed out. The dependence of dynamic Young's modulus on the static strain applied to the specimen as well as on the dynamic strain-amplitude has been discussed for yarns of different structures with a view to showing the possibility of dynamic determination in solving the problems of yarn geometry which, otherwise, are quite complicated to be solved mathematically. Also, the dependence of dynamic modulus on structural order (orientation and crystallinity) has been shown, and coupled with X-ray diffraction techniques, dynamic modulus determination may provide information about the changes in orientation and crystallinity at different stages of processing of artificial fibres. The relationship between static and dynamic measurements has been discussed, and the fact that dynamic modulus, if determined at high frequency will permit the specimen to undergo only elastic elongation, has been shown to be useful in determining the contribution of the immediate elastic component, primary creep and secondary creep in the total strain when a body is subjected to a particular load under static conditions.

A LARGE amount of information has been collected on the rheological properties of high polymers under static or quasi-static conditions but much less is known about their behaviour in response to time-dependent forces. A knowledge of the dynamic behaviour, which means the mode of response of the material under conditions of loading and unloading at an appreciable rate (from a few cycles to a few hundred kilocycles), must be added to a knowledge of the quasi-static behaviour to establish a complete set of phenomena on which to base a general theory of the rheological behaviour of polymers, whether natural or synthetic. For this purpose, data are required on the relative contributions of the elastic and plastic components of the total strain when a fibre is deformed. At the moderate rates of loading normally employed in static tests, the immediate elastic component cannot be measured, since relaxation or plastic flow will make the stress or strain time-dependent and only by using rates of deformation which are sufficiently high to reduce such relaxation effects to a negligible level is it possible to obtain a more accurate measure of the purely elastic aspects of the mechanism.

In addition to this, distribution of relaxation times and creep behaviour of high polymers have been successfully investigated by studying the relationship between damping and creep behaviour of these materials. Further, materials with high damping have, in general, high impact strength and thus an idea of impact strength, at least qualitatively, can be obtained from dynamic tests by evaluation of the damping factor of the material. The course of the changes in structure such as orientation and crystallinity may, in some cases, be followed by dynamic tests.

From the practical point of view, the importance of dynamic testing can be appreciated for applications, such as flags that flap rapidly in high wind, transmission belts that bend rapidly round the pulley, tyre cords that get bent, stretched and compressed as the tyre rolls and bumps over a road, parachute strings and ropes in a ship's rigging that vibrate in the wind and other important military applications.

The study of dynamic elastic modulus covers a vast field and includes the dependence of dynamic Young's modulus on static strain, on dynamic strain amplitude, on structural order inside the material

and on frequency, temperature and humidity. (This study will give the magnitudes of the molecular energy barriers which must be overcome as the material undergoes a deformation in response to an external force.) Apart from this, the effect upon dynamic Young's modulus of yarn structure, finishing and chemical treatment are still fields having vast potentialities for future research. A study of the relation between dynamic and static modulus of the same material under similar conditions on the one hand, and between dynamic Young's modulus and double refraction on the other, can be of great help from the point of view of basic and fundamental research. In this paper, an attempt has been made to limit the discussion to only a few of the factors, such as the dependence of dynamic Young's modulus on static strain, dynamic strain amplitude, lateral order inside the material and yarn structure of the sample. A comparison of static and dynamic properties is also given.

Methods of measurement

The methods used may be divided into two main groups, namely those measurements where the conditions are such that the inertia of the specimen itself may be neglected and those where its inertia cannot be neglected.

Methods in which inertia of specimen is neglected

These methods usually involved either the direct determination of a stress loop under cyclic loading, or the measurement of resonant frequencies which depend on the inertia of moving parts of the apparatus.

(a) *Direct determination of the stress-strain loop* — Wakeham and Honold¹ have studied Young's modulus and hysteresis effects in cotton, rayon and nylon tyre cords at a frequency of 1 c/s., and more recently, have applied their technique to measurements on the single fibres and filaments which make up the cords. A cyclic load-elongation curve for the sample was deduced from a record of the separate load and elongation tracings of a kymograph, the load being applied by a motor-driven eccentric. Breazeale and Whishnant² used a similar technique, but with electronic recording, to obtain the dynamic stress amplitude (load per unit strain), and cyclical energy losses of tyre cords at 5 c/s.

(b) *Measurement of frequencies of vibration which depend on the inertia of parts of the apparatus* — In such techniques which may be further subdivided into free vibrations and forced resonant vibrations, the motion studied is prescribed by a moving element of the apparatus and the effects on this motion

of the mechanical properties of the attached specimen, acting as a constraint, are measured.

(i) *Free vibrations* — Ballou and Smith³, Nolle⁴ and Lincoln⁵ have all used variants of this method, over a frequency range from 2 to 40 c/s. approximately. Ree, Chen and Eyring⁶, in their experiment on dynamic properties of Saran monofil, used the filament supporting a pendulum weight at the lower end. This weight was displaced from its equilibrium position by about 1 per cent of the filament length and then released to produce damped longitudinal free vibrations. The tension in the filament was measured by means of an electric resistance strain gauge coupled via an amplifier to a pen recorder. From the record of the damped oscillations, the frequency of vibration and the decrease of maximum amplitude with vibration number could be measured. From these the dynamic modulus and logarithmic decrement were calculated. The weight was hung on for two hours before the vibration was applied to allow the extension to reach a steady value. The frequency was varied from 1.75 to 31.5 c/s. by changing the length of filament, using four different weights. The torsion pendulum method⁷⁻¹⁰, the only method so far available for determining the dynamic modulus of rigidity of fibres, also falls into this group, though the frequency of oscillation is generally less than 1 c/s.

(ii) *Forced resonant vibrations* — Methods of this type involve the forcing of the specimen into some mode of forced vibration by electromagnetic excitation of that part of the apparatus to which the specimen is attached. Such techniques have been used by Dillon, Prettyman and Hall¹¹, Lyons and Prettyman¹², Palandri¹³, Dunnel and Dillon¹⁴ and Tipton¹⁵ for various purposes. In all such techniques, a small alternating current of known frequency supplied by means of a variable frequency low range audio-oscillator, is passed through a coil which rests in the field of a strong electromagnet and which is supported coaxially by two equal lengths of the test strings under tension. The passage of the current through the coil causes it to vibrate axially thus providing the loading arrangement by elongating and relaxing each half of the specimen alternately. The amplitude of vibration can be measured by means of a micrometer microscope focussed on a mark on the vibrating system or by a photoelectric arrangement as described by Fujino¹⁶ *et al.* The readings of the vibrating coil current, its frequency, amplitude of vibration at resonance, effective mass of the vibrating system and length and area of cross-section of the specimen provide the necessary data for the dynamic parameters to be calculated by means of the well-known electromagnetic equations.

This instrument, however, is not very suitable on account of the following limitations:

(1) Instrumental energy losses (e.g. dissipative resistance due to leads and supports and the elastic reaction of the leads and the pendulum action of the oscillator unit on account of the path of the motion not being a straight line along the axis of the filament but rather rising above the original plane of the filament at either end of its oscillation) and air damping, though claimed to be fairly small, are somewhat uncertain and tedious to be determined accurately.

(2) The maximum strain-amplitude obtainable is limited by the system becoming unstable and the generation of the transverse vibrations of the specimen in addition to longitudinal ones. A slight increase in the maximum strain-amplitude can, however, be effected by increasing the tension in the specimen.

(3) The mass to be substituted in the electromagnetic equations for calculating dynamic parameters, is the effective mass of the resonant system as a whole. In addition to the mass of the coil assembly, which can be determined by weighing, this effective mass of the resonant system also includes the effective oscillating mass of the specimen and the coil lead in wires. In case of light specimens, although it may be negligible, still it is a source of error.

(4) The method requires the determination of the cross-sectional area of the specimen which is usually determined only indirectly from mass per unit length and density and may not be the correct cross-sectional area of the specimen under vibrating conditions.

(5) There is an upper limit to the frequency in such methods because the inertia of the specimen can be neglected only when the length of the specimen is considerably less than the wavelength of the propagated wave. There is thus a restriction on the maximum length of the sample for a given frequency and as the frequency increases, the specimen length must shorten if errors due to the inertia of the specimen are to be avoided. These methods have, therefore, been normally used only up to the frequency of about 500 c/s.

Methods in which the inertia of the specimen cannot be neglected

These methods involve either the excitation of specimen into one of its own resonant modes of vibration, with the consequent production of standing waves; or alternatively, the use of conditions under which standing waves, produced by end reflections, are avoided or minimized, and direct

measurements of the rate of propagation of stress pulses in the material are made.

(i) *Standing wave method* — This method was first used by Lotmar¹⁷ for determining Young's modulus for textile materials. Later, Ballou and Silverman¹⁸, and Hamburger¹⁹ refined the techniques of loading, load measuring and recording devices. In essence, the apparatus for this method consists of the following parts.

Generating unit — This is a R.C. bridge oscillator of high frequency, high voltage output and great stability.

Transmitter — This receives the output of generator after suitable amplification and by contact transmits them to the specimen, setting up standing, longitudinal, compression waves in the specimen of the same frequency as those of the oscillator output. The transmitter may consist of either a moving coil loudspeaker, piezoelectric crystal or magnetostriction transducer. Generally, piezoelectric crystals are preferred on account of their stability, high frequency generation (depending on crystal material and crystal cut) and ease of mounting and handling. Amongst piezoelectric crystal materials, rochelle salt is given preference over quartz and barium titanate due to its far greater sensitivity, although it is much more fragile and, being a hydrate, is not a perfect insulator. If it is desired to operate the crystal and specimen in atmospheres of varying relative humidities, the stability limits of rochelle salt become important. At room temperature, dehydration occurs at relative humidity below 35 per cent and deliquescence at humidities about 85 per cent for fully exposed crystal. However, on account of protective coatings normally applied to finished crystals by makers the range of relative humidities for safe working is extended from 25 to 80 per cent.

Receiver — The receiver can either be again a rochelle salt crystal or some special type of condenser microphone or suitably mounted strain gauge. Rochelle salt crystal, on account of its having far greater range of frequency response and also high sensitivity, is, however, preferred over the other two for such methods. This receiver is kept in contact with the specimen and is activated into vibration by the vibrating specimen at the same frequency as the oscillator. Further, the receiver crystal can be moved along a graduated bench which allows the distance between the two crystals to be determined at any time during the test.

Recorder — Cathode ray oscilloscope or an ordinary pen recorder can be used for this purpose. But at higher frequencies, generally used in this method, the pen recorder is of no use on account of its high inertial insensitivity.

In case of cathode ray oscilloscope, the waves from both the input and output crystal units are fed to it. These two waves are always of the same frequency but in general they are of different amplitude and are not, except for certain positions of the output crystal relative to the input crystal, in phase with each other. The oscilloscope measures the phase difference between these waves while vacuum tube voltmeter or sound level meter is used to determine the amplitude of the input and output waves.

This experimental set-up enables the velocity of the sound pulse through the specimen to be determined by setting up standing waves in it when a signal of a suitable frequency is sent from the oscillator. Both the input and output waveforms appear on the oscilloscope screen and whenever the two waveforms are an integral number of half wavelength difference in phase, a straight line diagram is produced on the oscilloscope screen. Therefore, while a fixed position of the input crystal is maintained the output crystal is moved along the graduated bench and the readings corresponding to straight line diagrams are recorded. The differences between consecutive readings give values of half wavelengths throughout the sample and the value averaged from them along with the frequency used, gives the velocity of sound wave through the specimen. However, due to imperfect elasticity of textiles and the presence of viscous forces associated with modulus, an additional information regarding the acoustic attenuation is necessary before the correct value of dynamic modulus can be found. For this purpose, the variation of amplitude voltage along the length of the specimen is determined and from this the attenuation factor, α , can be determined as described by Ballou and Smith³ and others. Further, knowing the density of the textile material, the modulus of elasticity and coefficient of internal viscosity can be calculated by the following expressions:

$$E_1 = \rho c^2 \omega^2 (\omega^2 - \alpha^2 c^2) / (\omega^2 + \alpha^2 c^2)^2 \text{ dynes/sq. cm.}$$

$$E_2 = 2\rho \alpha c (\omega c)^2 / (\omega^2 + \alpha^2 c^2)^2 \text{ dynes sec./sq. cm.}$$

where ρ is the density in g./ml.; c , the velocity in cm./sec.; α , the attenuation in nepers/cm. and ω , the angular frequency in radians/sec.

For the case of small damping the above expressions reduce to

$$E_1 = \rho c^2 \text{ dynes/sq. cm.}$$

$$E_2 = 2\rho \alpha c^3 / \omega^2 \text{ dynes sec./sq. cm.}$$

Merits and limitations of standing wave method — This method is superior to those previously discussed because the dimensions, such as area of cross-section, do not appear in the equation and hence the uncertainty arising from their measurements

can be avoided. Another advantage of the standing wave method is that it enables attenuation to be measured with a fair degree of accuracy. In this respect this method is even better than the pulse velocity method which is not well suited for this purpose, particularly if attenuation is low.

This method, however, suffers from some serious limitations mentioned below:

(1) Troubles arise due to end effects resulting from the reflection of waves from the two end fixtures which support the specimen.

(2) Phase shifts occur at unpredictable periods during the test period. These phase shifts are a function of the resonant frequency of the crystals and of the frequency range employed. Since the frequency range necessary for the test is dependent upon the range of modulus values of the material under stress or strain, it is obvious that a preliminary calibration test must be run to eliminate the possibility of such phase shifts and the attendant errors resulting therefrom. The crystal spacings can be modified to permit a dependable range of frequencies to be employed but such a procedure increases the absolute magnitude of acoustical attenuation where crystal separations are increased, and increases the end effects where crystal separations are decreased to eliminate the phase shift.

(3) This method of measurement is limited in frequency range. An upper limit to the frequency range is set due to troubles arising from phase shifts while at sufficiently low frequencies the sample length becomes smaller than the half wavelength of the transmitted sound wave thus making velocity measurements impossible. The range of this method is, therefore, from about 1 to 30 kc/s.

(ii) *Pulse velocity method* — This method differs from the standing wave method in that while the latter determines the wavelength of the standing wave set up in the specimen in order to calculate the velocity of the sound wave through it, the former uses a constant length of the specimen and determines the time of travel of a sound pulse of short duration and fixed frequency through the specimen.

For this purpose a pulse propagation meter, which sends pulses of less than a microsecond duration, is used and their times of arrival at the receiving crystal are individually and precisely measured, the technique being similar to that employed for recording echo pulses in radar systems. These pulses are transmitted at a slow rate of about 160/sec. and since this rate of transmission is sufficiently low to allow the amplitude of each pulse to decay to zero before the initiation of the next succeeding pulse, the standing waves do not get the chance to be set up in the specimen.

As regards textile materials, Hamburger¹⁹ seems to have been the first to use this pulse velocity method as an alternative to the standing wave technique. Chaikin and Chamberlain²⁰, while refuting the claim of Hamburger to have carried out measurements of dynamic Young's modulus at 100 kc/s., have themselves developed an excellent instrument based on the direct pulse velocity propagation technique and by means of this instrument, of which they have given a very detailed description, they have been able to record the dynamic elastic moduli of single fibres at a frequency of approximately 100 kc/s. thus representing a considerable increase in frequency over any previously recorded work.

Very recently, Fujino *et al.*¹⁶ have described an instrument suitable from high audio to supersonic ranges (from 2×10^3 to 2×10^5 c/s.) and employing the principles of both longitudinal wave resonance and longitudinal wave propagation methods by a little alteration. The apparatus of these authors differs from the conventional one in being of the vertical type similar to that used by Kawai and Tohita. The conventional horizontal apparatus was not used because it has an unavoidable defect that the contact condition between sample strip and wave detector is hardly kept constant during observation and consequently higher accuracy of determination of attenuation constant is not expected.

Merits and limitations of pulse velocity method — This method is free from the troubles arising due to end reflections and sudden phase shifts. The end effects are not developed because the time of arrival of each pulse at the receiving crystal is measured separately; and because standing waves are not set up in the specimen and frequencies are not involved, phase shifts difficulty is not a consideration at all. Apart from the fact that the area of cross-section of the specimen is not required, this method is further advantageous in that the crystal can be spaced any desired distance apart, depending upon the available specimen length, its attenuation constant and the range of time units most convenient for plotting because the time of propagation of the pulse through the specimen is the only quantity measured by the instrument. Although this method seems to be by far the best, it is not without limitations which are pointed out below.

(1) This method is not suitable for measurements below 10 or 20 kc/s. and the upper limit is set by the limitations of sensitivity and stability of the generating unit and also by the fact that the largest cross-sectional dimension of the sample must be kept small in comparison with the wavelength of the propagated wave.

(2) This method is not suitable for the accurate measurement of attenuation constant, especially if it is low. The vertical type apparatus of Fujino¹⁶, although better than the horizontal type in this respect, is not so accurate for this purpose as the resonance method.

(3) The circuit of the timing unit for the measurement of the time of travel of the sound pulse is very complicated on account of the high accuracy required in the measurement of this quantity.

Elastic modulus and internal friction

As discussed by Eyring and co-workers²¹, Alfrey²² and Meredith²³, the strain developed in a textile material lags behind, in phase, the applied stress on account of time-dependent viscous forces and the concept of Young's modulus (E), therefore, leads to a complex Young's modulus consisting of two parts E_1 and E_2 as defined below:

$$E_1 = \frac{\text{component of stress in phase with strain}}{\text{strain}}$$

$$E_2 = \frac{\text{component of stress } 90^\circ \text{ out of phase with strain}}{\text{strain}}$$

or

$$E = E_1 + iE_2$$

E_1 represents the purely elastic property of the material and is the quantity usually referred to as dynamic Young's modulus while the imaginary part E_2 , known as loss modulus, arises on account of viscous forces inside the material.

It can further be shown that $E_2 = \omega\eta$ where η is the coefficient of internal friction of the material and $\omega/2\pi$ the frequency of the sinusoidally applied stress.

Also $\frac{E_2}{E_1} = \tan \delta$, where δ is the phase angle

between the stress and strain and is known as the loss angle tangent.

Different ways of expressing loss angle tangent —

There are several ways of expressing the loss angle tangent in terms of directly measured quantities, provided that it is not too great.

(i) In the case of forced vibration experiment, loss tangent, $\delta = \frac{\Delta f}{f_0}$ where f_0 is the resonance frequency and Δf the change in impressed frequency between the two points on resonance curve where the amplitude is $\frac{1}{\sqrt{2}}$ of its maximum value.

(ii) In the case of damping capacity determination, $\delta = \frac{1}{2\pi} \tan^{-1} \left(\frac{\Delta W}{W} \right)$ where $\frac{\Delta W}{W}$ is the specific damping

capacity and is the ratio of the energy dissipated per cycle of vibration and the strain energy when the strain is maximum.

(iii) In the case of free vibration, $\delta = \frac{1}{\pi} \tan^{-1} (\lambda)$

where λ is the logarithmic decrement and is defined as the natural logarithm of the ratio of the amplitudes of successive oscillations.

Dependence of dynamic properties on static strains and dynamic strain amplitude

As reported by various workers, it is seen that, in general, E_1 increases with an increase in static strain but it decreases with the increase in dynamic strain amplitude. On the other hand, loss modulus E_2 may decrease or increase with increase in static strain but it increases with dynamic strain amplitude. Further, the relative change in loss modulus is greater than that in the dynamic Young's modulus with the change in dynamic strain amplitude while with the change in static strain this relative change is reversed being greater for E_1 than for E_2 . It will, therefore, be

clear that the loss angle tangent, which is equal to $\frac{E_2}{E_1}$,

always increases with dynamic strain amplitude while with only a few exceptions under conditions of low static strain and low dynamic strain amplitude it decreases with static strain at any particular dynamic strain amplitude.

In Fig. 1 are shown the curves obtained by Tipton¹⁵ for similar yarn structures of some of the specimens and it gives an indication of the range of variation of dynamic Young's modulus with static strain and also the types of behaviour shown by different materials at limitingly low dynamic strain amplitude.

However, since the yarn structures were not identical, the curves do not offer an exact comparison between the various materials. It will be clear from the graph that the variation of dynamic modulus with static strain is greater for the more highly oriented materials such as linen and least for the more extensible material like cellulose acetate rayon and wool.

These changes in the nominal moduli have been attributed by Tipton due to mainly two factors: the

change in the shape factor $\frac{L}{A}$ (on account of the tightening up of yarn structure and elongation in its length) as the yarn is strained and which was constant in calculating nominal values, and changes in actual moduli of yarn material on account of the increase in molecular orientation of the filament material with strain.

It was further shown by Tipton that if the curves are plotted as relative values of E_1 and $\tan \delta$ against

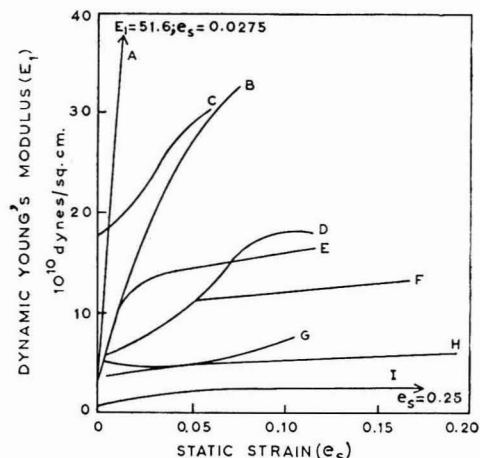


FIG. 1.—RELATION BETWEEN DYNAMIC YOUNG'S MODULUS AND STATIC STRAIN IN THE CASE OF DIFFERENT YARNS [(A) Linen, (B) cotton, (C) Terylene, (D) nylon, (E) silk, (F) viscose, (G) nylon, (H) acetate rayon and (I) worsted wool]

dynamic strain, that is, $\frac{E_1}{E_{10}}$ and $\frac{\tan \delta}{\tan \delta_0}$ (where the

subscript '0' denotes the values at zero dynamic strain amplitude) the relative changes in E_1 and $\tan \delta$ are found to be practically independent of static strain (which means that the various curves at different static strains will be very close to a single curve) for all the low twist continuous filaments (nylon, viscose rayon, cellulose acetate rayon, Terylene, etc.), but not for the specimens of more complex yarn structure.

Effect of yarn structure on the dependence of dynamic Young's modulus on static strains

By taking yarns of different complexities (single yarn, folded or ply yarn and cabled yarns) for various materials (viscose rayon, cellulose acetate, nylon, silk, casein, Terylene, cotton, etc.), Tipton¹⁵ showed that, in general, because the average angle between the axes of individual fibres and the yarn axis will be greater in the case of more complex yarn structures and also because the filaments are highly anisotropic, the dynamic Young's modulus measured in the direction of the yarn axis will be lower in yarns of more complex structures. The effect of yarn structure is most apparent at low static strains when the structure is slack. Thus, as shown in Fig. 2, the structures of specimens F, G and H which are of ordinary viscose increase in complexity in the order F, H and G; F is a single yarn, H folded and G cabled. The graph shows a low modulus at zero strains which rises rapidly as the structure tightens up and at static strains of 0.02 for the folded yarn H

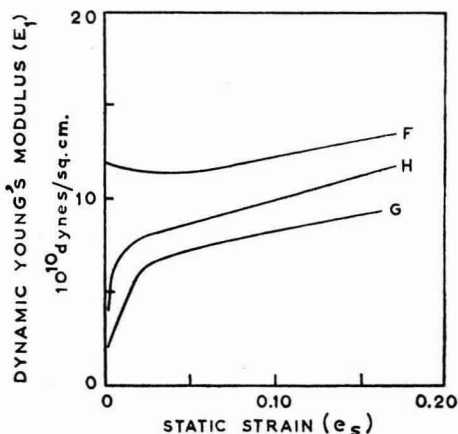


FIG. 2 — EFFECT OF YARN STRUCTURE ON THE DEPENDENCE OF DYNAMIC YOUNG'S MODULUS ON STATIC STRAIN AMPLITUDE [F, H and G represent single, folded and cabled viscose rayon yarn samples]

and 0.04 for the cabled yarn G the structure has become fully compacted and the behaviour then follows that of the single yarn F.

Effect of yarn structure on the dependence of dynamic Young's modulus on dynamic strain amplitude

The effects of yarn structure on the dependence of dynamic Young's modulus on dynamic strain amplitude has been reported by Tipton who studied the behaviour of single continuous filaments, cabled continuous filaments and cabled staple viscose rayon yarns. It was found that the greater the fall of E_1 and rise of $\tan \delta$ with dynamic strain, the more complex the yarn structure at all static strains, but these effects are greatest at the lowest static strains. The changes in loss angle tangent are more pronounced and the relative magnitudes of the changes with dynamic strain amplitude decrease with increasing static strain. For static strain greater than 0.04, Tipton noted that the relative changes of both E_1 and $\tan \delta$ became approximately independent of the static strain, as for the single yarns.

The effects observed are consistent with those to be expected from inter-fibre friction. At high static strains, the lateral forces in a twisted yarn are high and the normal forces between adjacent fibre segments, which will have a variety of orientations to the yarn axis, are also high. For low dynamic strain amplitudes the yarn will behave as a continuous material, that is there will be no relative movement of adjacent fibre segments. As the dynamic strain is increased the forces along the surface of contact of the various adjacent fibre segments will increase and

tend to cause movement of an increasing number of them, depending upon the normal force between the segments and upon the elastic restraint of the fibres themselves. The effect of slipping segments is to cause a reduction in the stiffness of the yarn, that is, a reduction in its dynamic Young's modulus and an increase in its loss angle tangent since a further energy dissipation mechanism has been introduced. These effects play a negligible part in the behaviour of the low twist singles continuous filament yarn where the filaments are practically parallel to the directions of the yarn but they become increasingly important as the complexity of the yarn structure increases.

An estimate of the fractions of the energy dissipated by internal friction in the fibre material and by the inter-fibre friction can be made by comparing the values of $\tan \delta$ for the continuous filament singles yarn with the difference in the values of $\tan \delta$ for the more complex yarn and for the continuous filament yarn.

It may be mentioned here that the effects of yarn structure in case of natural staple fibres in relation to those of individual fibres do not seem to have been studied so far and may be a fruitful field for future study.

Effect of varying structural order on dynamic Young's modulus

By means of pulse propagation technique, Work²⁴ has made the measurements of moduli of elasticity of the various yarns (from both cellulose acetate and cellulose regenerated from cellulose acetate) of varying degrees of structural order, i.e. orientation and crystallinity) under conditions of continuously increasing stress up to the point of failure. In Figs. 3 and 4 are shown the curves for cellulose acetate and regene-

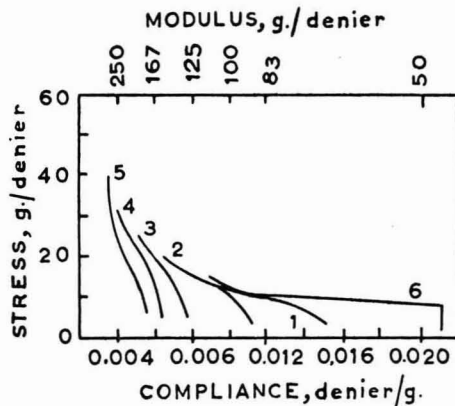


FIG. 3 — RELATION BETWEEN STRESS AND COMPLIANCE IN THE CASE OF CELLULOSE ACETATE YARN OF VARYING DEGREES OF ORIENTATION [Curves 1-5 refer to yarns with increasing orientation, and curve 6 refers to unoriented yarn]

rated cellulose respectively, the numbers (1) to (5) indicating increasing orientation in each case. By extrapolating the compliance curves of the yarns to zero stress, Work found that the ratio of the compliance of the unoriented material to that of the most completely oriented one in both the above cases is of the order of 3.5 to 1.0. Stretching decreases the compliance, the effect being considerably greater with the unoriented parent material and the yarns of lower original orientation than with more oriented members in both the above cases. Also, there is a tendency for the curves to overlap each other although the yarns of the unoriented or less oriented material, depicted on the right, are seen to fail before their compliance reaches that of the more oriented materials.

In Fig. 5 are given the curves where the compliances at breaking stress of each member of these two families of curves are connected and plotted on a single graph. It can be seen from the graph that the moduli at failure for the series of cellulose yarns are higher throughout the range of orientation studied, thus illustrating the effect of changing the structural order by increasing the crystallinity.

From a basic standpoint, the increase of modulus with both orientation and crystallinity is expected because with increasing order, the adjacent atoms and molecular segments are held in their positions by greater forces and hence the modulus of elasticity, that is the force required to move them relative to each other and so produce a given elastic defor-

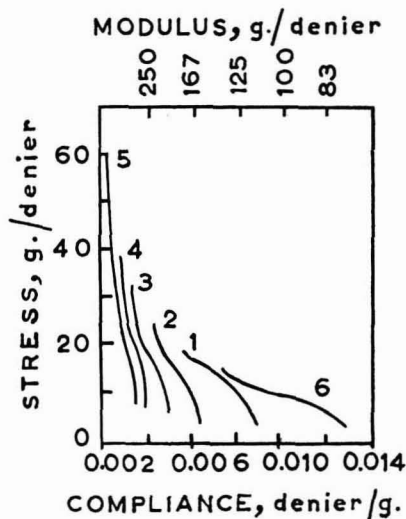


FIG. 4.—RELATION BETWEEN STRESS AND COMPLIANCE IN THE CASE OF REGENERATED CELLULOSE YARNS OF VARYING DEGREES OF ORIENTATION [Curves 1-5 refer to cellulose yarn with increasing degree of orientation and curve 6 to unoriented yarn]

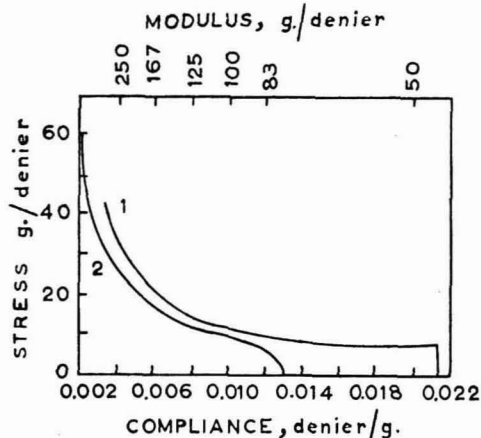


FIG. 5.—LIMITING COMPLIANCES OF CELLULOSE ACETATE AND CELLULOSE YARNS [(1) Cellulose yarn and (2) cellulose acetate yarn]

mation, will continuously increase with corresponding increase in the order of the material to a limit till the degree of order becomes more perfect by either increasing the orientation or crystallinity.

It may be mentioned here that up to this time X-ray diffraction techniques have been used to study this phenomenon of changes in the structural order of the material. However, the sonic moduli measurements appear to be more sensitive to the variation in orientation and possibly in crystallinity. It may, nevertheless, be pointed out that the determination of the changes of crystallinity or orientation by means of sonic moduli technique should be taken only with reservation because, as pointed out by Fujino *et al.*²⁵, the improvement of molecular orientation due to drawing is attended by the development of crystallization as well as of lateral bonding between chain molecules in the amorphous region, while the development of crystallization due to heat treatment is also attended by that of lateral bonding, so long as ordinary crystalline polymers of good spatial symmetry and of strong chain interaction are employed. In view of this fact, it appears that the changes in sonic moduli cannot be strictly ascribed separately to either the improvement of molecular orientation, or the development of crystallization or of lateral bonding between the chains in the amorphous regions. On the other hand, these changes in sonic moduli seem to be brought about as a result of the integrated effect of all the above three factors.

Comparison of dynamic and static properties

Lyons²⁶ carried out some measurements—dynamic stretch moduli, dynamic energy loss per unit strain

amplitude, the dynamic energy loss per unit stress amplitude, etc. — on filaments, yarns and cords. Similar quantities, i.e. static moduli and static energy loss under both the conditions (per unit stress and per unit strain) were determined by him on the same materials from the mean slope of the loading and unloading curves obtained on a Scott inclined-plane serigraph and from the hysteresis loop respectively.

It was found that for all samples studied, except steel monofil, the ratio of dynamic to static modulus is substantially greater than unity. This may be interpreted as indicating that during the slow static loading the elongation is not purely elastic but is much more due to plastic yielding on account of primary and secondary creeps. Therefore, the entire observed elongation corresponding to a given load is much more and hence the computed static modulus is smaller than it would be, were these contributions absent. In a dynamic test there is not sufficient time for the flow and orientation of the molecules of the filament or for the rearrangement and shift of the fibres and filaments of yarns and cords before the applied force is reversed. The more plastic the material, the greater the ratio of dynamic to static modulus. Thus for the steel monofil, for which, in the static test, there was little opportunity for plastic flow, this ratio was minimum while for the new synthetic organic filaments, Fibre A, Vinyon N and Velon, which exhibit pronounced elongation in standard creep experiments, the maximum ratios were found. It may not be out of place to mention here that, assuming the deformation of purely elastic type in dynamic tests, Hamburger¹⁹ separated these three deformations — elastic deflection, primary creep and secondary creep — with the help of dynamic measurements coupled with the static ones.

As regards the energy losses, it was found that not only are the dynamic and static energy losses (both per unit stress and per unit strain amplitude), in general, of different orders of magnitude but that they also assume different relative proportions. With the exception of those of one or two samples, the data for dynamic and static energy losses based on unit stress amplitude show a tendency to correlate between the groups of low values and those of high values. In general, however, the static energy losses are not reliable indicators of relative dynamic losses, and hence where the material is used under dynamic conditions, it is necessary to evaluate its suitability by carrying out the dynamic measurements.

Conclusion

In this paper, the importance of the study of dynamic mechanical properties has been indicated

and the various methods of measurements have been discussed. The dependence of dynamic properties on static and dynamic strain amplitudes as well as on the structural order of the material has been pointed out, and a comparison of dynamic and static measurements has been made.

There is still a vast scope for research in this field and more specific investigations remain to be made regarding the correlation between dynamic properties of constituent fibres and the staple yarn structure, the variation of dynamic properties with surface finish of the fibres and also the variation with frequency of the changes in the dynamic properties which are due to material, yarn structure effects and also due to form factors such as cloth weave, etc. It is hoped that the measurements of dynamic Young's modulus would be useful in problems of yarn geometry which are difficult to solve mathematically (such as the determination of the average orientation of the fibres in a yarn), apart from being helpful in studying the variations in orientation and perhaps crystallinity also, at different stages of processing, in the case of artificial fibres.

Work is being undertaken in this laboratory to fabricate a suitable instrument for determining the dynamic Young's modulus and energy loss, and to study the effect of various finishes, the effect of decrystallization and ionizing radiations, etc., on these properties as well as on the recovery behaviour of textile fibres and yarns (mainly cotton). The three components of elongation (i.e. immediate elastic recovery, delayed elongation or primary creep, and permanent set or secondary creep) are proposed to be separated along the lines suggested by Hamburger¹⁹.

Acknowledgement

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Design of Transducers

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The transducers, extensively used in both heavy and light current engineering, have some definite advantages over the corresponding electronic circuits which make them particularly suitable for control equipment and servomechanisms. The paper describes the design and performance of transducers and their application in electrical instrumentation practice, viz. (1) a conventional magnetic amplifier having an output of about 0.5 watt for operating a recording instrument, (2) a pair of transducers used as a current transformer for d.c. circuit, (3) a second harmonic type magnetic inverter, and (4) a typical transducer control relay.

THE name transductor^{1,2} has been derived from the terms transformer and inductor respectively. Its core laminations and mechanical construction closely resemble those of a transformer while its electrical characteristics are similar to an inductor, the impedance of which can be varied by saturating the core. The device is based upon the process of magnetizing the core by a periodically varying magnetomotive force applied to the 'gate' winding and by a unidirectional magnetomotive force applied to the 'control' winding — both forces being applied independently and simultaneously. The variation of direct current in the control winding causes a change in the time at which the core saturates during each cycle of the gate winding voltage. So the effective impedance of the transducer changes. The impedance of the gate winding is made considerably large compared to the load placed in series with it, so that the whole supply voltage appears on the gate winding leaving very little across the load, when the core is unsaturated.

Another advantage of high impedance gate winding is the minimization of the standing magnetizing current in the load. However, the impedance of the transducer should be considerably low in comparison with the load when the core saturates and then the whole supply voltage appears on the load. The impedance variation of the transducer caused by the variation of the control current gives rise to a corresponding change in the load current which may be rectified for d.c. operation. This change follows the equal ampere turns law as in transformers. Thus, neglecting the small magnetizing current, the single phase transducer holds the relation, $I_L N_L = I_c N_c$. The control characteristic of a transducer, plotted according to the above relation, is primarily independent of the a.c. supply frequency. Secondary effects, of course, arise due to eddy currents and hysteresis losses in the cores and due to rectifier capacitances.

Magnetic amplifiers based on the above transducer principles have recently replaced many elec-

tronic circuits in typical applications, where ruggedness of construction and reliability in operation are sought. They can withstand heavier shocks, and are much more efficient than valves and require no heating power and warming up period. The devices are also much less liable to errors due to ageing. Magnetic amplifiers, unlike electronic circuits, require no d.c. power supply and are very compact in size, particularly at supply frequencies of 400 c/s. or above, which are common in aircraft operation. They have low input and output impedances, of the order of a few hundred ohms, and so are readily applicable to the circuits of low impedances.

The main disadvantage of the conventional magnetic amplifier is its high time constant. The other disadvantage of the magnetic amplifier is its frequency limitation due to the losses in the core of the inductor. So far, with best magnetic core materials, supply frequencies up to 20 kc/s. have been reached and with this an input signal of a maximum frequency of 1 kc/s. can be handled with reasonable power gain.

The present paper describes the design of transducers and other associated circuits for both light and heavy current applications. In the light current field, a two-stage conventional magnetic amplifier has been designed to operate a recording meter, recording directly the variation of the intensity of light over a prolonged period. The instrument can be used in industry in measuring the variation of colours or temperatures. The light or 'colour' is received on the face of a barrier-layer photocell which feeds the control winding. The recording meter is connected as the load of the amplifier, a thermocouple instead of the photocell being used for measuring the variation of temperature.

A second harmonic type magnetic inverter³⁻⁵ has also been designed for using it as a first stage of a magnetic amplifier to render the amplifier more sensitive. The zero stability of this inverter is very good. The complete amplifier can easily be used in measuring extremely low signals, viz. earth's magnetic field, etc.

Regarding the heavy current application of transducers, a d.c. current transformer has been designed to measure a heavy direct current on a low current moving coil meter without using a shunt. The heavy current is passed through the control winding and the meter is placed as the load. The control winding to gate winding turns ratio is adjusted so as to have a step down of current following the equal ampere turns law of the transducer.

A transducer-controlled relay has also been designed to operate a heavy current circuit. The unstable condition arising due to the over-compensating

feedback, to be discussed later, has been exploited in this design. A very small change in the control current causes an abrupt large change in the load current thus operating the relay. Thus a 'danger limit' in any control current can be maintained and the relay is restored automatically when the control current falls back to a safe value.

Transducer theory

The transducer is excited by an alternating voltage which can magnetize the core just short of saturation. The d.c. control voltage is applied to the control winding. The core now saturates when the flux due to the alternating voltage added with the d.c. flux reaches the saturation flux level. Thus the average value of the load current depends on the time at which either core saturates during each half cycle, which in turn depends on the magnitude

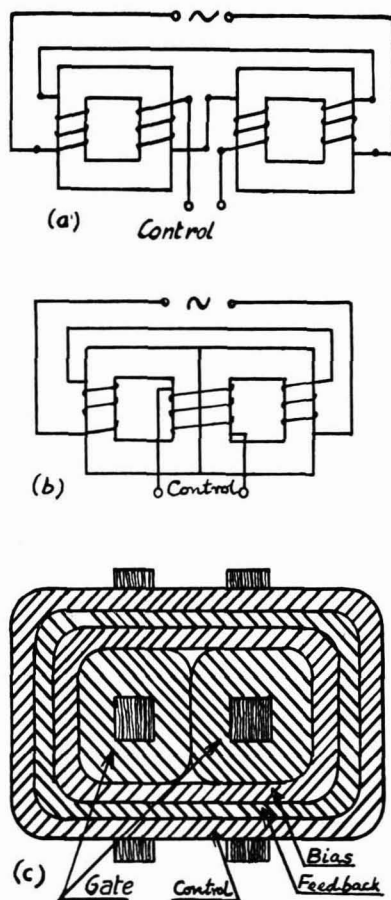


FIG. 1 — BASIC TRANSDUCER CIRCUIT [(a) illustrating electric neutralization of transformer effect; (b) illustrating magnetic neutralization of transformer effect; and (c) typical cross-section of core and winding]

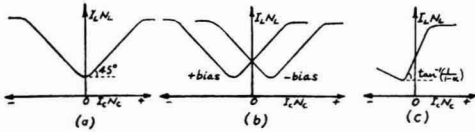


FIG. 2—CONTROL CHARACTERISTICS OF THE TRANSDUCTOR [(a) without bias and feedback; (b) with positive and negative bias; and (c) with feedback]

of the d.c. voltage. To avoid any circulatory current in the control winding due to the voltage transformed from the load winding, an arrangement should be made such that the control winding is not affected by transformer interaction with the load winding.

It is evident from Fig. 1(a) that the net induced voltage across the control winding is zero as the two e.m.f.s are equal and in opposite directions. The two cores can be assembled into one as illustrated in Fig. 1(b) where the flux lines due to two equal a.c. winding excitations move in opposite directions in the control limbs and hence the voltage induced across the control winding is zero. In the present investigation the winding scheme as illustrated in Fig. 1(c) is followed. Here the gate windings (i.e. a.c. windings) are connected in opposite directions such that the flux lines in one central core move downwards and in the other upwards. The net voltage induced on the control winding embracing the two cores is evidently zero. In all cases, only the fundamental components of the load voltage balance each other on the control winding. In most cases, a low resistance choke is connected in series with the control winding to limit the second harmonic current, though the introduction of the choke makes the time constant larger.

With the increase of control current, the load current increases following the equal ampere turns law. The control characteristic is shown in Fig. 2(a) which can be shifted to any convenient position as shown in Fig. 2(b) by applying a fixed bias to the transductor. The bias winding is placed magnetically parallel to the control winding [Fig. 1(c)] and a fixed direct current through it shifts the characteristic in either direction, depending on the polarity of bias voltage with respect to that of the control voltage.

It has been stated earlier that the current gain of the transducers is equal to $I_L/I_c = N_c/N_L$. This turns ratio cannot be made very high due to the practical difficulties in windings, high response time, lower power gain, etc. But the current gain of the equipment can be raised to a very high value by employing feedback which can be of two types, viz. the self-excitation and auto-excitation. In case of self-excitation feedback the load current is passed through a bridge rectifier. The rectified load current

is fed through a separate winding, called the feedback winding, wound magnetically parallel to the control winding [Fig. 1(c)]. If the feedback current is passed in the direction assisting the control current (Fig. 3) providing additional control excitation, the current gain of the device rises. In case of auto-excitation feedback the load winding itself acts as a feedback winding by introducing half wave rectifiers in series with it. Auto-excitation saves copper but cannot provide the means for adjusting the feedback energy.

The characteristic of the amplifier with positive feedback (self-excitation) is shown in Fig. 2(c). As the rectified magnetizing current provides some d.c. excitation, a negative value of control current is necessary to reduce the net d.c. excitation to zero to obtain minimum output. If the control current is increased further in the negative direction, a region of reduced gain occurs due to the opposing nature of control and feedback currents. Now for positive feedback current $N_L I_L = I_c N_c + I_f N_f$, neglecting the effects of the magnetizing current. From this

$$G = \frac{I_L}{I_c} = \frac{N_c}{N_L} \cdot \frac{1}{1-\alpha}$$

considering the rectifiers as 100 per cent efficient, i.e. $I_L = I_f$.

In practice, however, the current gain is much less even though N_f is made equal to N_L in which case ideally G should have been infinite. The deficiency is due to the fact that commercial metal rectifiers available for this purpose have finite reverse resistance and are hence less efficient. The current gain has been stepped up in the present design by increasing the number of turns of the feedback winding above N_L and a judicious adjustment was necessary because, in this region, when N_f is made larger than N_L , a slight increase in N_L causes an unstable condition. Again, the current gain depends on the ratio N_c/N_L , but the decrease of this ratio is an added advantage if the resulting decrease in

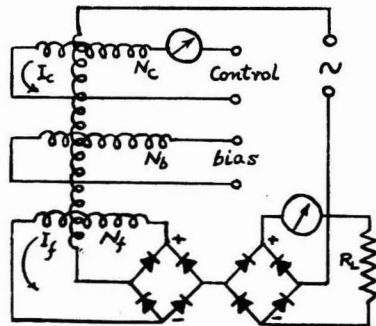


FIG. 3—CIRCUIT DIAGRAM OF MAGNETIC AMPLIFIER

current gain is compensated by increasing N_f because the decrease in the control winding turns means a decrease in the input resistance and a better power gain is obtained thereby. These considerations have been taken into account in the actual design of the amplifier.

The magnetic amplifier has a high time constant. The response time for 100 per cent change in output to occur after a step change of input voltage is normally about 2 to 100 cycles of the supply frequency. The delay is mainly due to the slow build-up of the control current. With positive feedback, the rate of change of feedback current induces a voltage in the control circuit in opposition to the direction of control voltage change, and thus the effective inductance of the control circuit becomes greater. Hence, with increased gain, the response time is higher. When the amplifier feeds d.c. inductive loads, the response time also largely increases. With the increase of frequency and N_c/N_L ratio, the response time increases. By putting a smoothing condenser across the load, the time constant can be improved by a factor of 2 or 3, when $C > \frac{1}{8fR_L}$. In our device an 8 mfd. condenser was used for this purpose.

Basic principles of the different types of transductor

The basic principles involved in the four types of transductor applications are given below in greater detail.

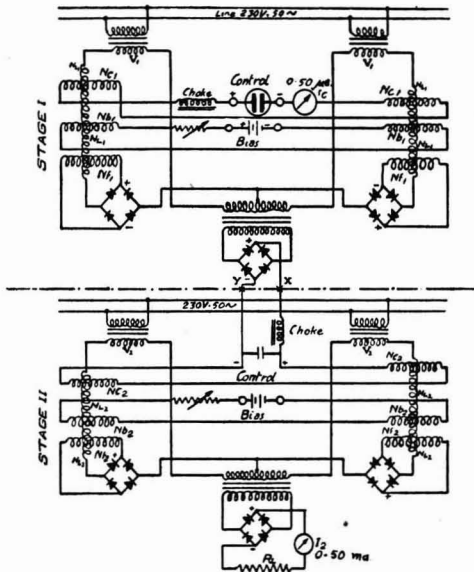


FIG. 4 — CIRCUIT DIAGRAM OF CONVENTIONAL MAGNETIC AMPLIFIER

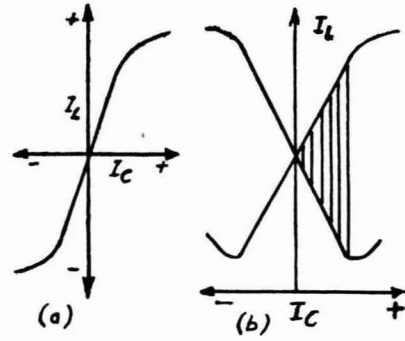


FIG. 5 — CONTROL CURRENT-LOAD CURRENT CHARACTERISTICS FOR A PUSH-PULL CIRCUIT [(a) net output; and (b) individual control characteristics. The shaded portion in (b) indicates the region of linear operation]

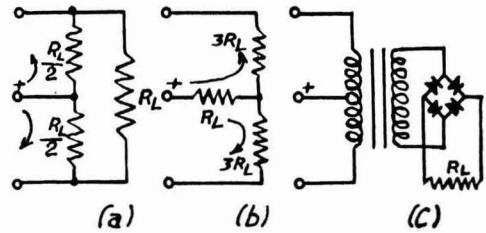


FIG. 6 — RESISTIVE AND INDUCTIVE SUMMING CIRCUITS [(a) and (b), resistive; and (c) inductive]

Conventional magnetic amplifier — The conventional magnetic amplifier was arranged in push-pull as shown in stage I of Fig. 4 where the load in series with a meter may be connected across XY (with stage II removed). Here two similar transductors are connected with their control windings back-to-back and their excitations are supplied from separate transformer windings. The outputs of the transductors are summed up such that only the out-of-balance current appears on the load (Fig. 5). Initially the transductors are biased to the middle of the characteristics such that the net output at zero signal is zero. On application of a control signal the output current of one transductor rises while that of the other falls; the difference voltage appears on the load circuit (Fig. 5). Generally, resistance summing circuits as shown in Fig. 6(a) or 6(b) are employed. But the efficiency of the system goes down to as low as 20 per cent due to the heavy bleeding action of the two resistors $R_L/2$ in Fig. 6(a). In an amplifier where the maximum power output is an essential requirement and a somewhat higher time constant is not harmful, as is in the present case, an inductively coupled summing circuit as shown in Fig. 6(c) gives much better results. The push-pull circuit has some advantages: the two initial currents of individual transductors are balanced

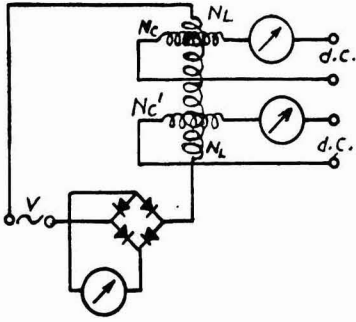


FIG. 7 — CIRCUIT DIAGRAM OF CURRENT TRANSFORMER

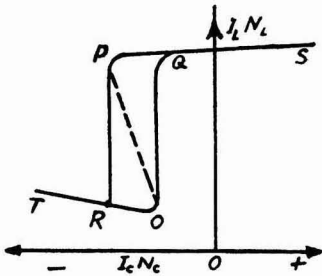


FIG. 8 — CHARACTERISTIC FOR OVER-COMPENSATION

to give zero output at zero signal. The instrument can discriminate the direction of flow of current, and the current gain is doubled. Besides, push-pull circuits give a high order of stability against mains voltage variation, any change in supply voltage appearing equally in both transducers and effectively cancelling out.

Direct current transformer — For measuring high direct currents, a d.c. current transformer has been designed which requires less space than the equivalent shunt installation and avoids the losses in the shunt. Besides, the transformer isolates the indicating instrument from the high voltage busbar. The operation of the d.c. transformer is also based on the law of equal ampere turns. The control winding consists of a few turns of thick copper strip to carry the heavy current. The moving coil meter of low current range is placed across a bridge rectifier in series with the gate winding (Fig. 7). For measuring very high currents, the control winding is simply a busbar passing through the gate windings. The response of the d.c. transformer is instantaneous which is a further advantage in closed loop control systems.

Transducer control relay — It has been shown previously that the current gain assumes an infinite value when the number of turns in the feedback winding equals that of the control winding; the operating portion of the characteristic shown in Fig. 2(c) becomes perfectly vertical. In case of over-

compensation, the curve assumes a peculiar shape (Fig. 8). Actually, the curve follows the path TROPQS, but the change in load current at O and P is so sudden that this appears to follow the path TROQS while moving upwards and the path SQPRT while going downwards. This property has been utilized in obtaining a trigger circuit by using a relay as the load of this transducer. A very small increase in the control current at O causes a large increase in load current and thus operates the relay. The load current jumps from P to R suddenly when the control current falls back to R, and the relay restores to normal position. The width of the loop, i.e. the separation between R and O, increases with the increase in feedback winding turns and vice versa. The operating point O can be shifted to any desired value of control current by applying the necessary bias.

The only drawback is that the operating point suffers from occasional drifts, chiefly because the reverse resistance of the commercial rectifiers does not remain constant for prolonged periods.

Second harmonic magnetic inverter — The output of the inverter is obtained not from current in the a.c. circuit but from the even harmonics of the m.m.f. which appear in the cores when they are polarized. The out-of-balance appears only when the cores are polarized by a d.c. signal and so with no d.c. signal the output is zero. The control and gate windings are wound in a way similar to those of a transducer described before, and a separate pick-off winding is wound magnetically parallel to the control winding and the load is connected across it as shown in Fig. 9. The control coil has an L-C filter circuit to prevent any even harmonic current from flowing; these harmonics then tend to be confined only to the pick-off winding. The inverter is operated mostly in the

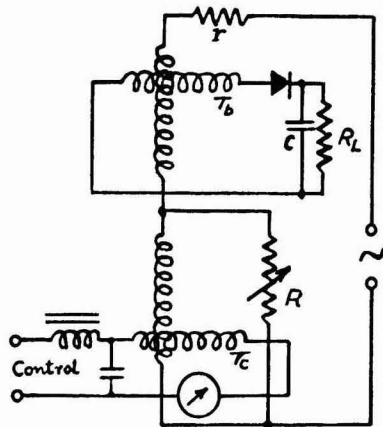


FIG. 9 — CIRCUIT DIAGRAM OF INVERTER

saturation region and thus, to have a constant current gain, the supply voltage applied has to be about four times the saturation voltage. A small resistor in series with the gate winding limits the excessive saturation current. The time constant of the inverter itself is negligible; still the system has a larger time constant than that of the conventional magnetic amplifier due to the presence of high impedance in series with the control circuit.

Both cores are driven well beyond saturation by making the supply voltage very large. When the cores are not polarized, both cores will remain unsaturated during a small part of the half cycle and both will be saturated during the remaining portion. If the cores are polarized by passing a direct current through the control winding, the total m.m.f. in core I will be $F_a + F_c$ while in core II it will be $F_a - F_c$ (in both cases $F_b = 0$), where F_a , F_b and F_c are the m.m.f.s in the a.c. winding, pick-off winding and control winding respectively. Now when switched on, F_a gradually increases and core I saturates first at time t_1 (Fig. 10), while core II is unsaturated by the amount $2F_c$. At time t_2 , core II saturates and both cores remain saturated between t_2 and π/ω . During the interval between t_1 and t_2 when core I alone is saturated, a current i_b flows in the pick-off circuit and supplies the reverse m.m.f., F_b ; this current is permitted to flow by the rectifier. The capacitor C is charged during the period between t_1 and t_2 and discharges through R between t_2 and $(\pi/\omega + t_1)$. If the capacity of the condenser is large enough, the discharge will be small and the average load current will be large. Thus the introduction of the condenser increases the current gain of the system, though at the expense of linearity. The load current also depends on the conducting period between t_1 and t_2 which is a function of the control m.m.f. F_c . When the desaturation occurs, a small negative voltage pulse is induced across T_b but the current is not allowed to flow by the rectifier.

Frostsmith⁵ has shown that the current gain of the inverter can be expressed by $G = \beta/R_b$, where

$$\beta = \frac{16\pi T_c T_b \mu a f}{l} \cdot 10^{-9}$$

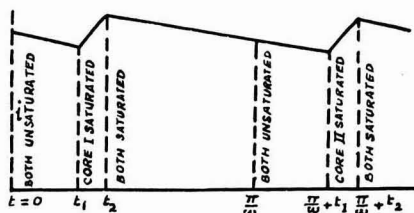


FIG. 10 — INSTANTANEOUS LOAD CURRENT IN INVERTER

Thus, to have a good current gain, R_b should be as small as possible. Though the gain is higher with higher frequencies, the frequency is limited to 500 c/s. above which the balancing of the cores becomes a difficult task. The most difficult problem in an inverter is the perfect balancing of the two transducers; for this purpose the two transducers have been made identical and for balance adjustment, a variable high resistance is connected across the a.c. winding of one transducer on which the voltage is slightly more (if there is any discrepancy). The earth's magnetic field (about 0.5 oersted) is sufficient to cause considerable polarization of the inverter cores. For this reason the unit was well shielded by a high permeability material.

This type of inverter is particularly useful at low signal levels as the zero drift of this device is 10^{-12} watts under normal operating conditions over a period of several days at least. The corresponding figure of a push-pull magnetic amplifier is about 10^{-9} watts only.

Materials

The fundamental considerations concerning the design and construction of saturable reactors are closely linked with the properties⁶⁻⁸ of special magnetic core materials. For optimum performance the core materials should have the following magnetic properties:

(i) Hysteresis and eddy current losses should be minimum (high resistivity, low coercive force and ability to be made in thin laminations or tapes).

(ii) High saturation flux density, to obtain large power handling capacity for a given weight of core materials.

(iii) The general shape of the magnetization curve should be a rectangular hysteresis loop with a region of very high permeability (ideally infinite), followed by a well-defined saturation point and a region of zero permeability. (Low grade core, not having a sharp knee, causes a non-linear output characteristic, and post-saturation reactance prevents the full supply voltage from being developed across the load.)

(iv) Stability of magnetic characteristics under changing temperature and mechanical strain and shock conditions.

From the requirements detailed above, the most suitable materials for use are nickel-iron alloys, particularly the grain-oriented rectangular hysteresis loop materials (Permenorm 5000-z alloy, Orthonol, Delta-max, etc.). But in many cases, specially for higher power outputs (up to 100 W.), cores of cold-rolled silicon steel tapes are used. The saturation flux density values of the high permeability materials (Mu-metal, Permalloy C, 1040 Alloy, etc.), which are

extensively used in low level input stage circuits are much lower than those of the rectangular hysteresis loop materials, which have proved to be most suitable for output stage circuits and in which maximum flux density occurs close to the saturation flux density, thus increasing substantially the power handling capacity for a given weight of core material. The structure of the cores should be such that the effective air gap is as small as possible. Core materials used in the present investigation include Mu-metal and HCR — a heavily cold-rolled nickel-iron alloy.

Design details and practical applications

Conventional magnetic amplifier — For maximum power output for a given size and weight of core, the entire winding space is generally utilized and special attention is paid to secure minimum leakage effect. The load resistance and current determine the necessary supply voltage (considering the probable gate winding resistance and the rectifier resistances). With a given sample of material, the required gate winding turns are calculated just as in a transformer. The number of turns in the feedback winding corresponds to that in the gate winding with several additional turns provided with intermediate tapings.

The control winding is wound such that the ratio N_c/N_L is not excessively high, for the reasons discussed before. The respective currents in the coils determine the gauges of the wires to be selected.

Ideally, to have a high power gain, the control winding should have a low coil resistance as compared to that of the load. Actually, in this case, the barrier layer photocell required several hundred ohms across it to ensure a safe value of current. The resistance of the control winding placed across the photocell was designed accordingly. The gate winding resistance was kept low to get the maximum power across the load. The diameter of the wires selected was such that the resistance is low and thus any temperature effect which would cause a non-linearity in the output is avoided.

With these considerations in view, the two stages of the conventional magnetic amplifier have been designed. The first stage consists of E and I cores of Mu-metal, the saturation flux density of which is about 6000 gauss. The second stage is made up of E-shaped HCR stampings, the saturation flux density of which is about 14,000 gauss. The windings are placed as illustrated in Fig. 1(c). The winding data are given below:

First stage: a.c. winding (gate winding), 500 turns on each core, s.w.g. No. 34; d.c. winding (control winding), 1000 turns, s.w.g. No. 40 (resistance, 180 ohms); feedback winding, 540 turns, s.w.g. No. 34 (tappings at each fifth turn after 520 turns); and bias winding, 200 turns, s.w.g. No. 34.

Second stage: a.c. winding (gate winding), 100 turns on each core, s.w.g. No. 32; d.c. winding (control winding), 1000 turns on each core, s.w.g. No. 42 (resistance, 200 ohms); feedback winding, 1050 turns, s.w.g. No. 32 (tappings at each fifth turn after 1020 turns); and bias winding, 200 turns, s.w.g. No. 32.

Each stage consisted of two identical transductors connected in push-pull and properly biased. The two stages are inductively coupled. The individual characteristics of the two stages are given in Fig. 11 [curves (A) and (B)]. The whole set-up and connections are shown in Fig. 4. By varying the amount of incident light on the face of the photocell, the input power is varied and with this variation of control current, the readings of the output current in the 500 ohms load, simulating the recording meter, are taken. The result is shown in Fig. 11 [curve (C)]. The push-pull connections ensure constant output though the mains voltage fluctuates by up to ± 15 per cent. This is shown in Fig. 12. The instrument was found to be capable of indicating the polarity of signal.

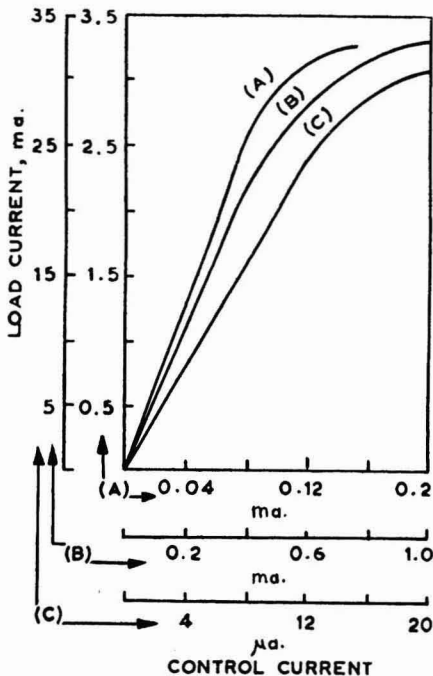


FIG. 11 — PUSH-PULL CHARACTERISTICS OF MAGNETIC AMPLIFIER [(A) stage I: a.c. input voltage = 15 V., 50 c/s., $R_L = 400$ ohms, $N_L = 500$ on each core, $N_c = 1000$, $N_f = 530$; (B) stage II: a.c. input voltage = 70 V., 50 c/s., $R_L = 500$ ohms, $N_L = 1000$ on each core, $N_c = 1000$, $N_f = 1040$; and (C) stage I and stage II coupled together]

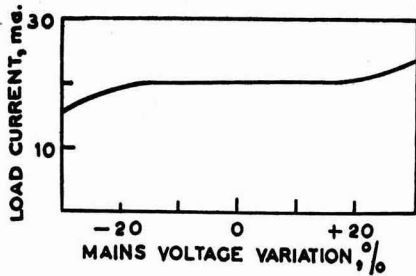


FIG. 12 — STABILITY OF LOAD CURRENT AGAINST MAINS VOLTAGE VARIATION

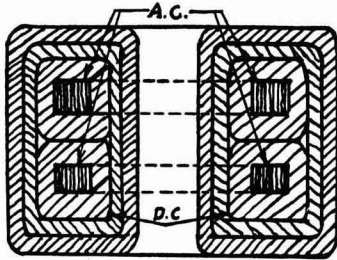


FIG. 13 — TOROIDAL CORE WINDINGS

From the above characteristics it is evident that the amplifier can deliver a power of about 0.45 W. on a fairly linear scale with a gross power gain of about 4×10^6 . As a typical recording meter takes only 0.25 W. in 500 ohms, the power gain of this amplifier in this region is about 6×10^6 .

The d.c. current transformer has been wound on a toroidal spiral core of Mu-metal, the windings on which are shown in Fig. 13. The gate windings are wound on each core separately and then the control winding is wound embracing the two coils. The winding data are as follows: a.c. winding (gate winding), 350 turns (s.w.g. No. 24) on each core; and d.c. winding, (a) 20 turns (s.w.g. No. 12) and (b) 2 turns of thick copper strip to carry a current of 300 amp.

The equipment connected as shown in Fig. 7 is able to measure 25 and 250 amp. full scale. The calibration curve (which is almost the same for both ranges) for these two scales is given in Fig. 14. In the range 250 amp. full scale, tests over 150 amp. could not be performed due to non-availability of a higher d.c. current source. Depending on the equal ampere turns law, it is expected that the curve for the higher range will follow the same path after 150 amp.

The transducer control relay was tried with the first stage of the amplifier connected as in Fig. 3. An extra winding of 500 turns (tappings at 250 and 450 turns) was added to the feedback winding for over-compensation. A 300-ohm relay was connected

instead of R_L . The operating characteristic is shown in Fig. 15.

Second harmonic magnetic inverter — In the design of an inverter, it is reasonable to allocate half of the winding space for the pick-off winding and the rest equally for the control and a.c. windings. The series choke in the control circuit should have about four times the inductance of the control winding and its resistance shall approximately be equal to that of the control winding. Where the source impedance is given, the value of R_c is fixed, and is determined by the condition for the maximum power transfer. If the load resistance is fixed, R_b is calculated taking $R/R_b = 15$ (approximately). If the forward resistance of the rectifier and r_b are known, T_b is wound utilizing the maximum space. The degree of saturation is taken to be about 4 and from the supply voltage T_a is calculated as in the case of a transformer. The value of C will be such that $RC > 1/2f$. Considering these factors, the inverter has been designed with the following constants: a.c. winding (gate winding), 500 turns on each core; d.c. winding (control winding), 1000 turns; and pick-off winding, 2000 turns.

The coils are wound on a toroidal spiral core of Mu-metal as shown in Fig. 13. The characteristic of

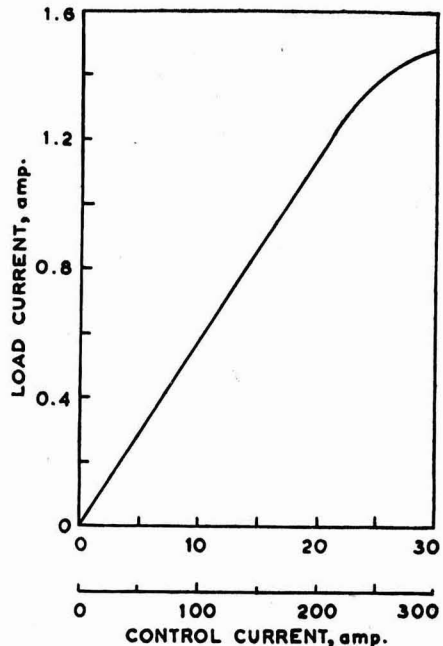


FIG. 14 — CHARACTERISTICS OF CURRENT TRANSFORMER [Full scale, 25 amp.: a.c. input voltage = 15 V., 50 c/s., $N_c = 20$ and $N_L = 350$ on each core; and full scale, 250 amp.: a.c. input voltage = 15 V., 50 c/s., $N_c = 2$ and $N_L = 350$ on each core]

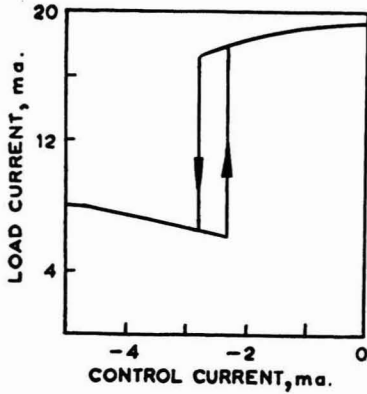


FIG. 15 — CHARACTERISTIC OF TRANSDUCTOR CONTROL RELAY [a.c. input voltage = 15 V., 50 c/s., relay = 300 ohms, $N_L = 500$ on each core, $N_c = 1000$ and $N_f = 750$]

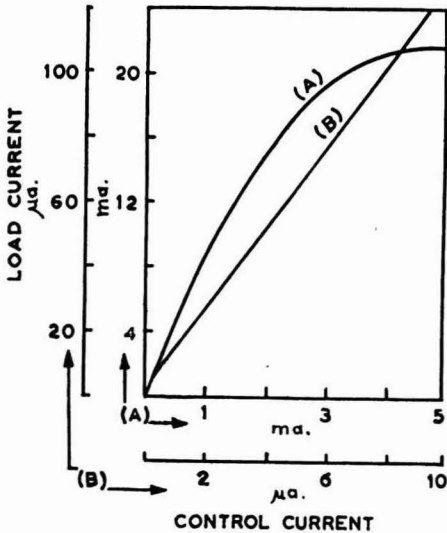


FIG. 16 — INVERTER CHARACTERISTICS [a.c. input voltage = 70 V., 50 c/s., $R = 500$ ohms, $N_L = 500$ on each core, $T_b = 2000$, $T_c = 1000$ and $C = 25 \mu F.$]

the inverter, connected as in Fig. 9, is shown in Fig. 16. The inverter has a fairly linear response up to a load current of 18 ma. The high input stability and a faithful operation with low control current are remarkable.

The four classes of transducers designed by us and described here are only some typical examples of the

devices applied in the field of electrical measurements. These four types are by no means exhaustive in the design and application of increasing varieties of devices operating on the transducer principles and more and more are being added to the field every year.

Nomenclature

- R_L = load resistance
- N_L = number of turns in the gate winding (a.c. winding)
- N_c = number of turns in the control winding
- N_f = number of turns in the feedback winding
- I_L = average load current after rectification
- I_c = average control current
- α = feedback factor = N_f/N_L
- G = current gain = I_L/I_c
- r_b = pick-off winding resistance in inverter
- r_B = forward resistance of the rectifier in inverter
- $R_b = r_b + r_B$
- T_a = number of turns in the a.c. winding in inverter
- T_b = number of turns in the pick-off winding in inverter
- T_c = number of turns in the control winding in inverter
- F_a = m.m.f. in the a.c. winding in inverter
- F_b = m.m.f. in the pick-off winding in inverter
- F_c = m.m.f. in the control winding in inverter
- μ = permeability of the core
- a = area of cross-section of the core
- b = length of the magnetic path
- f = supply frequency

Acknowledgement

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Certain Aspects of Monsoon Rain in North-west India, Based on Studies by Microwave Radar

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A study has been made, during one monsoon season, of radar echo characteristics of rain cells in and around Delhi in North-west India. Certain interesting features observed, which may help to throw light on rain processes in clouds in different meteorological situations, are presented.

THE importance of centimetric radar in meteorological studies lies in its ability in portraying the structural details of rain cells, even as these lie a considerable distance away beyond our range of vision. Rapid development in technique of construction of high power meteorological radars, and growing experience in detailed interpretation of echo patterns associated with precipitation of various types, have helped greatly to extend further the scope of the use of radar use in recent years for a more thorough probe into the details of the processes accompanying rain development in clouds. A clear and complete knowledge of the mechanisms of natural rain is essential not only for ultimate success in evolving a really fruitful technique of artificial inducement of rain in clouds, but also is of value in proper scientific planning of rainmaking trials by presently contemplated methods of cloud seeding.

According to our present knowledge, there are two main processes by which natural rain occurs — one operating in supercooled clouds, and the other in what are now commonly termed 'warm' clouds. While rain in temperate latitudes is seen to occur chiefly from clouds of the first type, there is by now enough evidence to show that rain in tropical maritime areas falls frequently from warm clouds in which Bergeron mechanism is not applicable. Adequate quantitative information is, however, still lacking as to how frequent is such warm rain in the tropics, especially in its continental interiors, and what proportion of total rain is received from warm clouds. By enabling such observations as the cloud level from where precipitation echo is first received by a radar, how the echo level later extends to other layers above and below, what the relative intensities of the echoes are at different heights, and how these get oriented with progressive development of rain,

radar study of precipitating clouds helps to throw useful light on the above question, and also to provide valuable data relating to many of the interesting details about rain occurrences in clouds in different meteorological situations.

For conducting systematic census of clouds relative to their precipitation features during different seasons in the north-western part of India where natural rain is somewhat deficient, a high power meteorological radar (peak output, 250 kW.; wavelength, 3.2 cm.) has been installed and brought into use by the Rain & Cloud Physics Research Unit, National Physical Laboratory, New Delhi, since June 1958. The equipment used has pulse width, 1 microsecond; pulse repetition frequency, 300 c/s.; beam width, 1°; and I.F. gain, 110 db. Besides the conventional plan position indicator (PPI), range height indicator (RHI), and A-scope, the radar is provided with one more useful display, range elevation indicator (REI), enabling depiction of vertical section of an extensive field of precipitation occurring from clouds overhead to those near the horizon, with ranges and heights shown in true proportions.

The principal objective of studies undertaken with the help of the radar has been collection of adequate data, to help provide answers as far as possible to the following questions:

1. How often do clouds of adequate depth develop over the area, but fail to reach the stage of precipitation?
2. What is the frequency of occasions when precipitation echo develops at a certain height in the cloud, but does not extend to the ground?
3. How often does natural rain occur from a 'warm' cloud, i.e. a cloud which lies wholly below the freezing level? Compared to this, what is the frequency of occasions of 'cold' cloud rain?

4. What is the relative contribution of rain from warm and cold clouds to the season's total rainfall?

5. Is rain from all cold clouds the result invariably of Bergeron mechanism? If not, under which circumstances and in what percentage of cases rain from cold clouds occurs without the intervention of ice crystal process?

6. How does the intensity of echo at the melting band level compare with that at heights above and below it?

7. What are the general meteorological situations and commonly occurring physical features in clouds as are seen to be associated with warm rain?

8. At which level does the precipitation echo commonly develop in a convective type cloud, and how does this extend progressively in the vertical direction?

9. What is the rate of vertical development of precipitation echo from large cumulus clouds?

Besides, study of upper and lower bands under circumstances when these are seen to occur, quantitative estimates to the extent possible of echo intensity from different parts of precipitation cells, etc., would help to furnish useful information about details of the processes governing natural rain showers.

The echo characteristics as shown on the radar of a number of cloud cells within 250 km. around Delhi, at various stages of precipitation development within them, have been studied during the monsoon season of 1958. A paper giving full details of investigations made and data collected is under preparation. Certain interesting findings about relative incidence of rain from cold and warm clouds, and how frequently rain initiation in clouds of the latter type is governed by ice crystal growth in their top layers are summarized in this note.

'Cold' versus 'warm' rain

Out of 275 rain cells studied, 183 gave precipitation echo with top reaching 6 km. and above, that is, well above the mean freezing level of the season at about 5 km. (cold cloud rain), while in 92 other cases the echo top was confined below this level (warm rain).

Of the precipitating cold cloud cells, 130 were surveyed in detail, to see if the associated radar echo showed a well-defined bright band just below the freezing height — a feature which is suggestive of melting snow flakes aiding the process of rain, as postulated by Bergeron. Of the 130 cells thus examined, 94 showed such a band (Fig. 1), and the remaining 36 did not (Fig. 2).

Thus, while in the majority of cases of rain occurrences from cold clouds during monsoon season in the area under study precipitation appears to be of

ice origin, there are instances in which this mechanism apparently either does not operate, or is at least not the predominating factor governing rain formation in such clouds. The finding is in conformity with observations in other areas also¹, showing that in certain situations rain from very tall and highly supercooled convective clouds is seemingly an 'all water' process, without the intervention of ice crystal mechanism.

Warm rain appears to be more frequent on occasions when radar echoes from precipitating cold clouds in adjoining localities fail to show melting band characteristics. In association with 36 cases of cold rain of this type, there were 34 instances of rain from warm cloud (Fig. 3). On the other hand, in situations of cold cloud rain giving echoes with definite melting band characteristics (there were 94 such instances), rain from warm clouds was seen to occur in 12 cases only.

In the majority of situations of cold cloud rain giving echoes without any melting band, the precipitation cells as seen on the radar are typically of a convective character. This fact, and the observed higher frequency of warm rain in situations when cold precipitation cells fail to show melting band characteristics, appear to suggest that, as expected also on theoretical grounds, one important factor governing warm rain is a certain degree of atmospheric instability giving rise to an optimum rate of updraft in the growing cumulus cloud. Small vertical wind shear and an adequate depth of moist air are other important meteorological elements favouring rain development in warm clouds.

Relative contribution of rain from cold and warm clouds

A critical study of relative contribution to the season's rain over an area from these two types of clouds requires a careful estimate being made of rates of precipitation from distant clouds, based on measurements of radar echo intensities. A suitable simple technique for such measurements is being developed. Meanwhile, from general studies made till now it has been observed that the radar echo from a warm cloud often fades out quickly on relatively small reduction of receiver gain, indicating that intensity of rain from such clouds is usually rather weak compared with that associated with cold clouds. The following also provide an indirect evidence in support of such a conclusion.

1. On 'A' type days, that is on days when cold precipitation cells reveal distinct melting band characteristics, rain is usually of a widespread and steady character. The average daily total rainfall recorded at 27 stations within 15 miles from Delhi

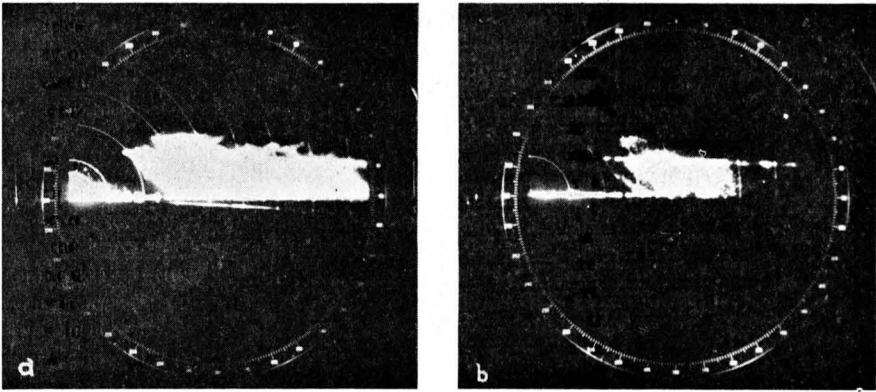


FIG. 1 — REI PICTURES OF A RAINING COLD CLOUD, RADAR ECHO FROM WHICH IS ASSOCIATED WITH WELL-MARKED BRIGHT BAND AT MELTING LEVEL AT 5 KM. RANGE MARKERS, 5 KM. APART, INDICATE DISTANCE AND HEIGHT OF RAIN CELL. MAXIMUM HEIGHT OF ECHO TOP IN (a), TAKEN AT HIGH RECEIVER GAIN, IS ABOUT 10 KM. MELTING BAND CHARACTERISTIC IS BROUGHT OUT MORE PROMINENTLY IN (b) TAKEN AT REDUCED RECEIVER GAIN

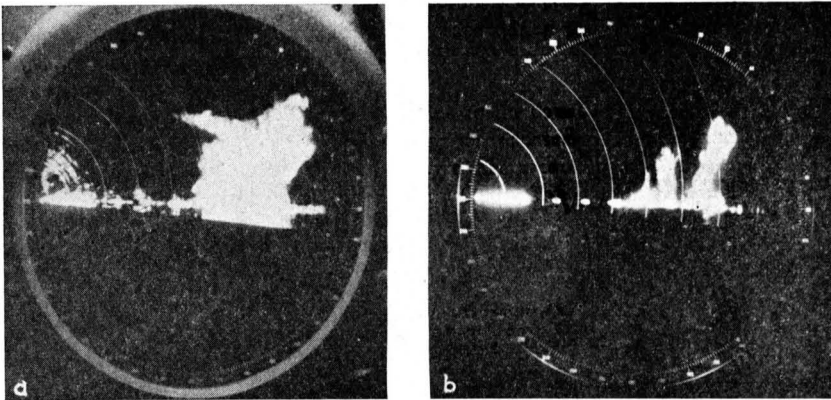


FIG. 2 — AN EXAMPLE OF PRECIPITATING COLD CLOUD WHICH DOES NOT SHOW THE MELTING BAND FEATURE. SEPARATION BETWEEN RANGE MARKERS IN THIS CASE IS 2.5 KM. MAXIMUM HEIGHT OF ECHO TOP IN PICTURE (a) IS MORE THAN 8 KM. PICTURE (b) TAKEN AT REDUCED GAIN SHOWS SHRINKING OF THE PRECIPITATION CELL, BUT NO BRIGHT BAND AT THE MELTING LEVEL

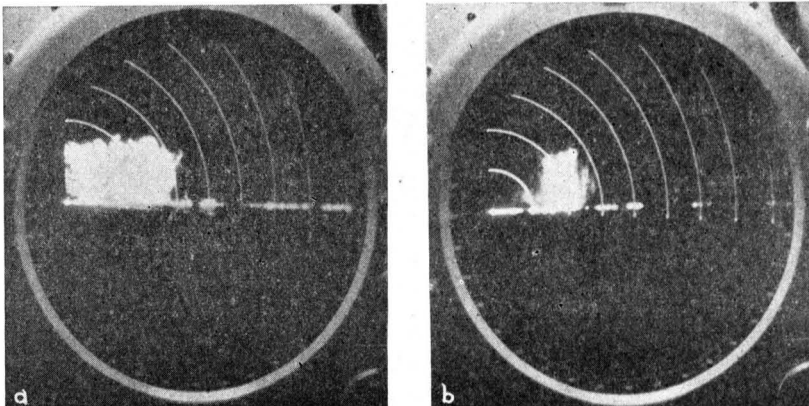


FIG. 3 — PHOTOGRAPHS ILLUSTRATING RAIN FROM A WARM CLOUD. PICTURE (a) SHOWS THAT THE ECHO TOP IS CONFINED TO BELOW 5 KM. PICTURE (b) TAKEN AT REDUCED GAIN SHOWS A MUCH MORE RESTRICTED PRECIPITATION FIELD AND SUGGESTS ALSO A LOW RATE OF RAINFALL. SEPARATION BETWEEN SUCCESSIVE RANGE MARKERS IS 2.5 KM.

on such days during the season in question is found to be 239 mm.

2. On 'B' type days when echoes from cold clouds show no melting band, rain is mostly of a showery character. The average total rainfall per day in these situations comes to 157 mm.

3. On 'C' type days (4 in all) when no cold precipitation cells were detected by the radar and rain was found to be restricted to a few warm clouds only, precipitation was in the nature of short-lived showers occurring from isolated or widely scattered rain cells. Average daily total of rain at 27 stations around Delhi on these days is 28 mm.

A general survey, as above, of monsoon rain cells during one season has furnished useful information on questions 3 to 5 in regard to the broad mechanisms of rain initiation in clouds in different meteorological situations, and also their relative importance in contributing to the season's rain in the area under study. A fuller appreciation of the position in this regard, helping a plausible estimate of potentialities of the present contemplated techniques of cloud modification for artificial augmentation of rain over an area under prevailing meteorological conditions, would require further critical and, to the extent possible, quantitative examination of the details of radar echo features associated with rain of various types. A beginning in this direction was made in the last monsoon season with studies such as (a) intensity structures of rain cells at various stages of their growth, based on examination of echo contours shown on the radar scope by progressive adjustment of receiver gain, (b) development of upper bands of types discussed by Bowen¹ and Browne² a few kilometers above the freezing height in certain cold rain situations, (c) height at which the first precipitation echo develops in a convective type cloud and the rate at which the echo top and base extend in the vertical directions, and (d) association of well-marked intensity gradient in the vertical leading to distinct band-like structure at heights well below melting level in certain situations, showing effects of strong vertical currents holding up raindrops below a certain size. Details of data collected in regard to these studies are being included in the fuller paper referred to earlier.

In relation to the finding that the major contribution of monsoon rain in and around Delhi comes from cold clouds which show melting band features, suggesting that ice crystal process apparently plays a notable part in rain development during this season, it is important to ascertain how far the formation of these ice crystals is conditioned by the presence, originally, of freezing nuclei in adequate concentration in the cloud air, and how far this is helped by the freezing of a few supercooled drops of relatively large size formed by pure collision-coalescence mechanism. Observation by Ludlam³, namely that thorough infection of the top layers of Cb clouds with ice crystals sometimes appears to follow the shower release, is of interest in this connection. Also, the results of study of drop size distribution in monsoon rain in India by Ramana Murty and Gupta⁴, bringing out certain striking differences in the characteristics of distribution curves from those pertaining to typical cold rain in temperate latitudes, appear to show that, side by side with the ice process, coalescence mechanism serves as an important contributory factor in helping initiation of raindrop growth in clouds in this season.

One obvious limitation of the radar method of study of the probability of precipitation from, or 'rainability' of, a cloud is that location by radar of a distant cloud cell becomes possible only after a certain stage of growth of precipitation elements within it has been reached. To get full and effective answers to questions 1, 2 and 7, which are important in assessing how far rain augmentation in an area might be effected by present cloud modification techniques, it is essential to carry out, for a time, a systematic survey of clouds, raining as well as non-raining, by carrying out aircraft observations and measurements in individual clouds.

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Studies on the Waveforms of Atmospherics during the Regular World Days & the World Meteorological Intervals

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Some of the features of the waveforms of the atmospherics recorded at Banaras during the Regular World Days and the World Meteorological Intervals from June to October 1957 are discussed, and the automatic atmospherics recorder employed during the investigations is described. It has been observed that the general character of the waveforms from near and distant sources changes only slightly during the Regular World Days with or without unusual meteoric activity, and also during the World Meteorological Intervals.

EXPERIMENTAL studies on the waveforms of atmospherics were undertaken at the Banaras Hindu University as part of the programme for the International Geophysical Year during 1957-58. A large number of waveform records of atmospherics were taken with the help of an automatic atmospherics waveform recorder constructed in the laboratory. The present paper deals with the waveform records taken during the Regular World Days and the World Meteorological Intervals of the IGY Calendar from June to October 1957, and discusses some of the features of the waveforms of the atmospherics recorded during these days. It has been found that the general character of the waveforms of atmospherics from near and distant sources changes only slightly during the Regular World Days with or without unusual meteoric activity and during the World Meteorological Intervals. In this paper, the changes observed are described and interpreted along with a brief description of the automatic atmospherics waveform recorder employed during the investigations.

Experimental arrangement

The different parts of the automatic atmospherics recorder and their working have already been published^{1,2}. Only those component parts of the equipment used for the automatic recording of the various waveforms of atmospherics are described here.

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Aerial unit— A suitable damped antenna consisting of a long open-air horizontal wire was employed, the time-constant of the antenna being small compared with the duration of the atmospheric pulses.

Main amplifier— A wide-band linear voltage amplifier of the resistance-capacitance type, having a flat frequency response characteristic from 100 c/s. to 100 kc/s., was constructed and used.

Square-wave trigger— The intensity modulation of the cathode ray oscillograph required for making it operative only at the incidence of the atmospherics was effected with the help of a positive square-wave trigger. The entire triggering circuit was arranged to have a quiescent time of suitable duration after each triggering pulse, so that overlapping of oscillograms due to subsequent atmospherics was avoided.

Low-frequency tuned amplifier— A tuned amplifier was constructed and used, when necessary, for triggering the square-wave pulse generator.

Delay-line unit— As a square-wave pulse generator would require a positive voltage of predetermined value, there should be a definite time lapse between the arrival of the atmospheric pulse and the restoration of the brilliancy of the cathode ray beam, the magnitude of this time delay depending upon the initial rise-time of the waveform of an atmospheric pulse. In order to restore the initial portion of the waveform lost in the oscillographic record before triggering, it was, therefore, necessary to delay the signal by about 60 μ sec., whereas the undelayed signal was used for triggering the square-wave pulse

generator. A suitable impedance-matching amplifier was inserted between the main amplifier and the delay line.

Oscillograph unit—The intensity modulated cathode ray oscillograph was used to delineate the waveforms which were photographed.

Automatic film-moving unit—With the help of this unit, it was possible to move forward the exposed film to the receiving cassette after each exposure.

Raster arrangement—In this unit there was a thyratron linear time base followed by a two-stage R/C-coupled amplifier. The linear time base of the cathode ray oscillograph was applied to the horizontal deflector plates, while the raster linear time base with a period which was an integral multiple of that of the horizontal sweep was applied simultaneously to the vertical deflector plates. Several horizontal lines were thus swept out and exhibited on the fluorescent screen of the oscillograph one above the other. Since the output from the main amplifier was applied to the same vertical deflector plates of the oscillograph through the delay-line unit, any electrical field change due to an atmospheric discharge produced a corresponding vertical deflection on the raster lines.

Classification of the waveforms of atmospherics

In discussing the changes in the waveforms of atmospherics recorded at Banaras during the Regular World Days and the World Meteorological Intervals and which have been classified³, it would be useful to consider the following different types of waveform patterns:

- Type I* — 'Aperiodics', N-type pulses and 'quasi-periodics'
- Type II* — Slow components
- Type III* — 'Hook' components
- Type IV* — Ionospheric reflection types: (a) peaked repeaters, (b) smooth quasi-sinusoidal type, and (c) long and short wave trains on the slow component
- Type V* — 'Predischarges': (a) 'predischarges' followed by the return stroke, (b) 'predischarges' of the isolated type, and (c) 'stepped' pulses from the initial leader
- Type VI* — Cloud-to-cloud discharges having all the characteristics of the cloud-to-ground discharges

Observations

The waveform records taken during the Regular World Days and the World Meteorological Intervals of the IGY Calendar did not appear to show preference

to any particular type of waveform. There are, however, certain features observed in these records, which are described below.

1. In some of the waveform records taken during the Regular World Days and the World Meteorological Intervals, the successive ionospheric reflections of an atmospheric pulse from a distant source, superimposed on the c-field change of another atmospheric pulse of relatively near origin, indicated, at times, a reflection height of 75-85 km., which was slightly lower than the usual value lying between 85 and 90 km.

2. In some of the waveform patterns, the 'predischarges' or the 'stepped' pulses from a lightning source, superimposed on the c-field change of another discharge of relatively near origin, were found to have a quasi-frequency of 8-10 kc/s., which was lower than the usual average value of about 20 kc/s., indicating that the 'steps' were of slightly longer duration during the observations.

3. The waveform records seem to indicate conditions favourable for the 'hook' field changes during a lightning discharge.

4. The waveform recorded on one of the Regular World Days with unusual meteoric activity showed closely spaced regular pulses on the c-field change of a relatively near atmospheric pulse, which could be due to successive ionospheric reflections from a height of 50 km.

5. In the various waveform records taken, the successive ionospheric reflections on the c-field changes of the waveform patterns gave an average value of the reflection coefficient of about 0.85, which is of the usual order.

The waveform records taken on a Regular World Day (26 July 1957) at 2120 hrs IST are shown in Fig. 1A. The time intervals between successive ionospheric reflections on the c-field change of the waveform pattern gave the ionospheric reflection height (h) as 75 km. and the distance of the lightning discharge as 3318 km. A similar record taken at 2015 hrs IST on the last day (24 September 1957) of a World Meteorological Interval (which was also a Regular World Day) is shown in Fig. 1B, where the ionospheric reflection height was found to be 81 km. and the estimated distance of the lightning discharge was only 180 km. In each case the reflection height was slightly lower than the usual value on normal days. Similar records taken at about 2110 hrs IST on the seventh day (19 September 1957) of the same World Meteorological Interval and shown in Fig. 2 (A and B) did not, however, show such reduction, the estimated ionospheric reflection heights and the distances of the lightning discharges being 91 and 90 km. and 300 and 1400 km. respectively. In

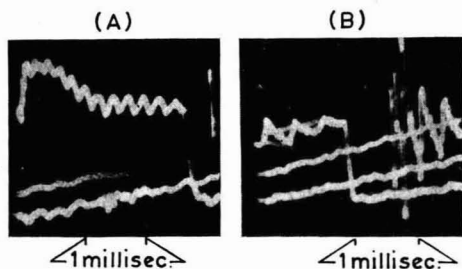


FIG. 1 — IONOSPHERIC REFLECTIONS [(A) On the c-field change during Regular World Day (26 July 1957; 2120 hrs IST; $h = 75$ km.); and (B) World Meteorological Interval (24 September 1957; 2015 hrs IST; $h = 81$ km.)]

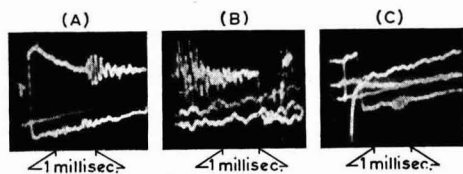


FIG. 2 — IONOSPHERIC REFLECTIONS [(A) World Meteorological Interval (19 September 1957; 2110 hrs IST; $h = 91$ km.); (B) World Meteorological Interval (19 September 1957; 2110 hrs IST; $h = 90$ km.); and (C) on the c-field change during Regular World Day with unusual meteoric activity (27 July 1957 night; $h = 50$ km.)]

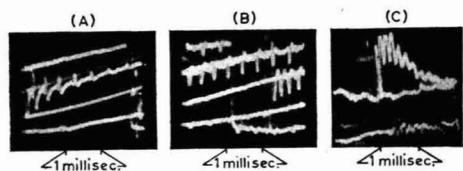


FIG. 3 — PREDISCHARGES AND 'HOOK' FIELD CHANGES [(A) 'Predischarges' on the c-field change during Regular World Day (26 July 1957; 2120 hrs IST); (B) 'predischarges' of the isolated type during World Meteorological Interval (24 September 1957; 2015 hrs IST); and (C) 'hook' field changes during World Meteorological Interval (24 September 1957 night)]

Fig. 2C is shown the waveform recorded at night on one of the Regular World Days (27 July 1957) with unusual meteoric activity. If the closely spaced regular pulses could be regarded as successive ionospheric reflections, the reflection height would be 50 km., which is rather low. The average reflection coefficient, as estimated from the relative amplitudes of the successive ionospheric reflections, in Fig. 2 (A and B), was of the usual order of 0.85, whereas the reflection coefficient determined in the same way from Fig. 1A was found to be as low as 0.6.

The waveform recorded on a Regular World Day (26 July 1957) at 2120 hrs IST (Fig. 3A) reveals 'predischarges' or 'stepped' pulses from a distant discharge superimposed on the c-field change of a

relatively near lightning discharge, the noteworthy feature being the comparatively low value of their *quasi*-frequency, viz. 8-10 kc/s. The waveform recorded on 24 September 1957 during the World Meteorological Interval at about 2015 hrs IST (Fig. 3B) reveals isolated 'predischarges' of about the same order of *quasi*-frequency, viz. 10 kc/s. The waveform recorded on the same day at about the same time and shown in Fig. 3C illustrates 'hook' field changes in the slow component 12 millisecc. after the main discharge.

Discussion

The Regular World Days of the IGY Calendar are selected on the basis of meteoric activity. The ten consecutive days during the equinoxes and the solstices constitute the World Meteorological Intervals. From the published list of the magnetically quiet and disturbed days, it can be seen that during the days the waveform records under consideration were taken, the average value for the three-hour index K_p is about 3. This low value indicates that the days on which these observations were made were magnetically 'normal', except for a few days of which 23 September 1957 is an example.

During meteoric activity, there is ample experimental evidence of a large increase of the E-region ionization. If the E-region ionization is increased considerably, it is evident that, when a radio wave is directed upwards vertically, the height at which reflection should take place will be at a lower level. The lowering of the ionospheric reflection height, which was at times observed during the Regular World Days, can thus be explained. Such lowering of the height of the ionospheric reflection is not, however, usually expected during the World Meteorological Intervals. With regard to the very low value of the ionospheric reflection height (50 km.) observed once during the intense meteoric activity, it may be noted⁴ that, of the two levels for the disappearance of the meteors, the lower one is at 48 km.

The two processes by which a thunder-cloud may cause increased ionization in the region immediately below the E region are well known. In the first process, the 'run-away' electrons envisaged in Wilson's theory⁵ of separation of charges in a cloud, positive in its upper and negative in its lower part, move upwards in the intense field within the cloud and when they go beyond the positive upper part, they are retarded by it. When a spark discharge, however, takes place, the retarding field is destroyed and the 'run-away' electrons move upwards with extremely high velocity and are likely to reach the E region causing extra ionization. In the second

process, it has been shown⁸, from the estimated electric moment of a thunder-cloud, that the electric field in the lower boundary of the E region is intense enough to accelerate free electrons, if they are present at that height, and cause ionization of the oxygen and nitrogen molecules.

With regard to the first process, it is likely that even the normal magnetic field of the earth may deflect the 'run-away' electrons under suitable conditions*. An increase in the E-region ionization is, therefore, possible when the electric field between the upper positive and the lower negative charges within the cloud is comparatively high. In the second process also, an appreciable electric moment of the cloud would produce a perceptible increase in the E-region ionization. Such an increase in ionization is also expected during the post-magnetic perturbation when there is sudden depression in the average value of the horizontal component of the earth's magnetic field.

It may be mentioned that the conditions favourable for the 'run-away' electrons to be deflected back under normal or higher magnetic field of the earth may lead to certain observable effects. The electrons coming down to the lower regions may cause an upward movement of the upper positive charge of the bipolar cloud. The electric field within the cloud may thus be decreased, increasing thereby the effective field between the lower negative charge of the cloud and the ground. As a consequence, the steps of the initial leader should be longer and the quasi-frequency of the 'pre-discharges' or of the 'stepped' pulses should be of a lower value. The increase in

*The calculations of Bowen^{7,8} regarding the trajectories of the 'run-away' electrons of energies from 0.5×10^9 to 2×10^9 V. projected vertically upwards from a storm in both equatorial and non-equatorial planes in the presence of a uniform magnetic field of 0.5 gauss showed that the electrons could be deflected down to a region between the ground and a height of 20 km.

the effective field between the negative cloud and the ground should also increase the possibility of the 'hook' field changes. The waveform records on 24 September 1957 and on other magnetically active days seem to indicate such possibilities. Later observations will be reported in due course.

It is well known that there is considerable increase in ionization in regions as low as 60-70 km. during the solar flares. This may be due to L_γ -radiation of hydrogen emitted during the solar flares. Recent rocket experiments seem to indicate that this is more likely due to hard X-rays and L_α -radiation. Due to the increase in the ionization in the lower regions of the ionosphere, there will be a consequent lowering of ionospheric reflection height. It is to be noted that the average lowering of the ionospheric reflection height as determined from the sudden-phase-anomaly during a solar flare is 4 km. for 16 kc/s. waves, and may even be 15 km. This has yet to be substantiated from the records of waveforms of atmospherics recorded during the solar flares.

Acknowledgement

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A Process for the Recovery of Sodium Chloride, Sodium Sulphate & Sodium Carbonate from Sambhar Bittern

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A process has been developed for the separation of sodium chloride, sodium sulphate and sodium carbonate from the waste bittern of Sambhar Lake. The process consists in adjusting the concentration of the bittern suitably and treating it at 100°C., whereby burkeite, a double salt of sodium sulphate and sodium carbonate, is thrown out from the solution and is separated. The mother liquor is subjected to solar evaporation to recover good quality common salt. Burkeite is processed further for the recovery of sodium sulphate and sodium carbonate by a suitable modification of the Trona process.

The process has been worked out successfully on a bench pilot plant and the study indicates its suitability for the economic exploitation of Sambhar bittern.

THE brine from Sambhar Lake contains, besides sodium chloride, small amounts of sodium sulphate and sodium carbonate. Common salt is produced in large quantities at the salt works at Sambhar Lake by solar evaporation of the brine. The mother liquor, i.e. bittern, containing the unrecovered salt and most of the sodium sulphate and sodium carbonate present in the brine, is discarded. The composition of the Sambhar bittern varies, within the limits given below, depending on the season in which it is collected and a sample of the bittern (29°Bé) analyses to: NaCl, 25 ± 1 ; Na_2SO_4 , 6 ± 1 ; and Na_2CO_3 , 5 ± 1 g./100 ml. of bittern. The sodium carbonate content of the bittern is higher during winter and lower during summer.

Work has been in progress at this Institute to evolve methods for the efficient utilization of Sambhar Lake bittern. As a result, a process has been developed whereby sodium chloride, sodium sulphate and sodium carbonate can be separated from the bittern, in a fairly pure state. The process has been successfully worked out on a bench pilot plant and the preliminary estimates indicate the possibility of its economic exploitation.

The process may be broadly divided into two parts: (1) separation of burkeite, a double salt of sodium sulphate and sodium carbonate, from the mixture of the three salts and (2) separation of sodium sulphate and sodium carbonate from burkeite.

Separation of burkeite from the mixture of salts

Formation of burkeite — On raising the temperature of a saturated solution containing sodium chloride, sodium sulphate and sodium carbonate beyond 25°C., sodium carbonate and sodium sulphate are thrown out as the double salt burkeite ($\text{Na}_2\text{CO}_3 \cdot 2\text{Na}_2\text{SO}_4$), provided the sodium chloride saturation at that higher temperature is maintained. The higher the temperature of the solution, the larger the amounts of sodium carbonate and sodium sulphate thrown out as burkeite. The equilibrium concentrations¹ (expressed in g./100 g. water) of the system NaCl- Na_2SO_4 - Na_2CO_3 - H_2O at 100°C.¹ are given below:

EQUILIBRIUM No.	NaCl	Na_2SO_4	Na_2CO_3	SOLID PHASE
1	33.1	0.9	14.9	NaCl + $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ + burkeite
2	37.2	6.7	1.2	NaCl + Na_2SO_4 + burkeite

It may be seen from the data for equilibrium No. 2 (Fig. 1) that at 100°C. the solution retains the least amount of sodium carbonate, if it is saturated with respect to the other two salts. If Sambhar bittern is made to follow equilibrium No. 2 by making up the deficiency in sodium chloride and sodium sulphate, much of the sodium carbonate will be thrown out as burkeite along with some sodium sulphate and

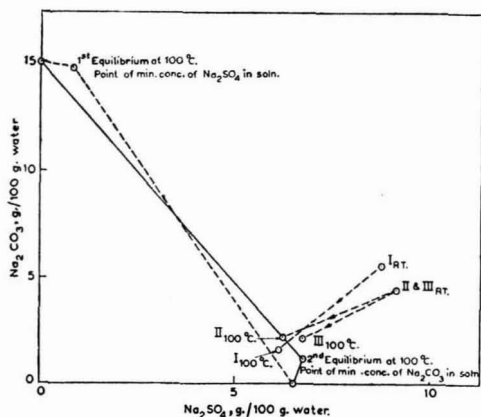


FIG. 1—SOLUBILITY OF SODIUM CARBONATE AND SODIUM SULPHATE AT 100°C. IN SOLUTION SATURATED WITH SODIUM CHLORIDE [I RT, II RT and III RT represent the compositions of starting solutions for batches No. I, II and III at room temperature and I₁₀₀, II₁₀₀ and III₁₀₀ the corresponding compositions of the solutions at 100°C.]

sodium chloride. As the original sodium sulphate concentration in the bittern is never sufficient for maximum sodium carbonate extraction, additional sodium sulphate has to be introduced in the system. The exact equilibrium is attainable only after a prolonged contact between the salts and the solution, but in practice optimum conditions for yield and quality of burkeite have to be determined experimentally. With this equilibrium system in view, a large number of experiments were carried out on artificial compositions and the conditions thus worked out were verified with Sambhar bittern.

The temperature of 100°C. was selected as it is more favourable for maximum separation of the salts and also because the equilibrium is attained much faster at that temperature, as has been found experimentally.

Process—For burkeite formation, two procedures have been worked out. Procedure 1 is applicable to bittern with sodium carbonate concentration of 5 g. and above per 100 ml. of solution. Procedure 2 is a modification of procedure 1 and has been worked out for bittern with sodium carbonate concentration of 4.5 g. per 100 ml. of solution. Bittern with a lower sodium carbonate concentration is not workable as the burkeite obtained is of very poor quality.

Procedure No. 1—To a measured volume of the bittern was added a calculated quantity of sodium chloride and sodium sulphate and the mixture was heated to 100°C. with efficient stirring. Impure salt containing up to 20 per cent of sodium sulphate, obtained at second stage of solar evaporation of the mother liquor (described later), is used for this

purpose and extra sodium sulphate added if necessary. Evaporation is prevented by covering the reaction vessel. Optimum time for the reaction is 30 min.

Procedure No. 2—In this, no addition of sodium chloride was made. Bittern with the requisite amount of sodium sulphate added was evaporated with stirring at 100°C. till the sodium chloride concentration reached the equilibrium value. The approximate extent of evaporation to be effected was calculated on the basis of the difference between the initial sodium chloride concentration in the bittern and the equilibrium concentration at 100°C. (equilibrium No. 2); this works out to about one-fifth of the volume of the bittern treated. The progress of evaporation was checked by analysing for sodium chloride in the solid phase. Evaporation was stopped when sodium chloride began to crystallize out from the solution. Further evaporation was prevented by covering the reaction vessel and the mixture is maintained at 100°C. for 30 min.

At the end of the operation, the burkeite formed was allowed to settle and the mother liquor decanted off. The burkeite crystals were centrifuged and washed with hot water.

The mother liquor and burkeite washings are mixed and subjected to solar evaporation. The liquid contains about 1.4-1.9 g. of sodium carbonate. During evaporation of this liquid up to half the initial volume, a large crop of sodium chloride of 97-99 per cent purity was thrown out and was recovered. Evaporation was continued further till the sodium carbonate concentration reached the maximum possible in the season. During the second stage of solar evaporation the salt thrown out was gradually contaminated with more and more sodium sulphate and a little burkeite. This impure salt was used for addition to the bittern as mentioned in procedure No. 1. The mother liquor, concentrated with respect to sodium carbonate, was recycled to the process.

Typical experimental run—Data for a typical experimental run in the case of an artificial bittern composition (batch No. I) and Sambhar Lake bittern compositions (batches No. II and III) are given in Tables 1 and 2. The compositions of the bittern samples, at start and after treatment, and of burkeite obtained in the three batches are given in Table 2.

Products: Quality and recovery—As mentioned earlier, sodium chloride recovered in the process is 97-99 per cent pure and is of edible quality. Sodium carbonate and sodium sulphate are recovered as burkeite which analyses to 85-90 per cent of Na₂CO₃. 2Na₂SO₄, the remaining 10-15 per cent being mostly sodium sulphate. The small amount of sodium

TABLE 1 — PROCESS DATA

PARTICULARS	BATCH No. I*	BATCH No. II†	BATCH No. III†
Procedure followed for the treatment of bittern	No. 1	No. 2	No. 2
Volume of bittern treated, litres	10	50	50
Additions			
NaCl, kg.	0.62	nil	nil
Na ₂ SO ₄ , kg.	0.89	3.0	3.0
Burkeite obtained, kg.	1.5	5.67	5.57
Vol. of mother liquor after treatment, litres	9.2	40	40
Sodium chloride (99.97%) recovered at stage of solar evaporation of the mother liquor, kg.	—	6	6
Recovery of Na ₂ CO ₃ †, %	69.3	60	60
Recovery of Na ₂ SO ₄ †, %	30.5	33.5	29
Recovery of NaCl†, %	—	c. 58	c. 58

*Artificial composition.

†Sambhar bittern.

‡Calculated on an unrecycled basis.

TABLE 2 — COMPOSITION OF BITTERN BEFORE AND AFTER TREATMENT AND OF BURKEITE

(Values expressed as g./100 ml. of solution)

PARTICULARS	NaCl	Na ₂ SO ₄	Na ₂ CO ₃	TOTAL
Starting bittern (sp. gr. 1.25-1.26)				
Batch No. I	26.05	7.43	4.95	38.43
Batch No. II	26.05	7.85	4.28*	38.18
Batch No. III	26.05	7.85	4.28*	38.18
Bittern after treatment at 100°C.†				
Batch No. I	28.66	5.31	1.41	35.38
Batch No. II	28.09	5.42	1.93	35.44
Batch No. III	28.09	5.83	1.90	35.82
Burkeite				
Batch No. I	2.90	74.46	22.64	100.00
Batch No. II	1.20	76.17	22.58	99.95
Batch No. III	2.50	74.35	23.08	99.93

*The figures include NaHCO₃.

†Bittern was analysed at room temperature; sp. gr. was 1.23.

chloride contamination in the burkeite is got rid of by centrifugal washing.

The yield of burkeite depends on the initial sodium carbonate concentration in the bittern. For every gram of sodium carbonate about 1.5-1.8 g. per 100 ml. of bittern, 4.5-4 g. of burkeite are obtained. For actual plant practice, it is recommended to start with bittern having high initial concentration of sodium carbonate and sodium sulphate. If dried bittern rich in these two salts is available, it may be used to raise the initial concentrations of the salts in fresh bittern. Impure sodium sulphate can also be used. The recoveries given in Table 1 are on an unrecycled basis and if the mother liquor from

burkeite formation and after solar evaporation is recycled, maximum recoveries can be obtained.

Separation of sodium sulphate and sodium carbonate from burkeite

The separation of sodium sulphate and sodium carbonate from burkeite by the Trona process is based primarily on the transition point of burkeite in solution and the different solubilities of its constituent salts in the presence of sodium chloride. The Trona process consists in (i) cooling of burkeite solution to 22°C. for the separation of part of the Na₂SO₄·10H₂O, (ii) heating the mother liquor to 50-70°C. with the addition of sodium chloride for the separation of the remaining sodium sulphate as burkeite and (iii) chilling the final solution to 5°C. for the separation of Na₂CO₃·10H₂O. The decahydrates on dehydration yield the respective pure anhydrous salts.

The process employed in the present study is a slight modification of the Trona process with regard to the temperatures employed in certain operations. Although the normal composition of burkeite is represented by the formula Na₂CO₃·2Na₂SO₄, it is known that variations in the sulphate-carbonate ratios occur as a result of co-precipitation of either excess of sodium carbonate or sodium sulphate, depending upon the composition of the bittern. The burkeite separating from Sambhar bittern contains excess of sulphate, which is definitely advantageous from the viewpoint of sulphate recovery. The modifications effected in the Trona process are: (i) cooling of burkeite solution to 20-22°C. instead of 22°C. as the solution contains less of sodium carbonate and (ii) removal of the remaining sodium sulphate as burkeite at 75°C. instead of at 50° or 70°C. These modifications have resulted in better separation of sodium sulphate as decahydrate and higher concentrations of carbonate in the mother liquors.

Process—The burkeite obtained from Sambhar bittern was calcined at about 500°C. in suitable equipment whereby the complex organic colouring matter is carbonized². The calcined burkeite, dirty black in colour, when dissolved in water gives a solution with the carbonaceous matter in suspension. The solution can be filtered easily and gives a clear filtrate free from any colloidal organic matter and yields pure, white products on processing.

Calcined burkeite was dissolved in water with stirring, the temperature being maintained near 27°C. On standing, most of the carbonaceous matter floated at the top and was skimmed off. The solution was then filtered and the carbonaceous mud discarded. The clear filtrate (sp. gr. 1.36) was an almost saturated solution containing 35 g. of Na₂SO₄ and 10 g.

of Na_2CO_3 per 100 ml. solution. The solution was then processed in four stages for the separation of the two salts as described below.

Stage 1: Crystallization of sodium sulphate at 20°C. and dehydration — Burkeite solution was cooled to 20°C. whereby about 75 per cent of the sodium sulphate crystallizes out in the form of the decahydrate. The resulting thick slurry was centrifuged, the crystals were given a wash in the centrifuge with cold water (10-15°C.). The mother liquor (M.L. 1) and wash liquid were collected separately. The latter was used to dissolve the burkeite thrown out in stage 2 and the solution thus obtained was recycled in the next batch at stage 1.

The sodium sulphate decahydrate crystals were dehydrated by adding salt and heating to 50°C. with stirring. Sodium chloride went into solution and most of the sodium sulphate was thrown out in the form of fine anhydrous crystals. The slurry was centrifuged, the crystals washed with hot water and finally dried at 130°C.

Impure salt, containing up to 20 per cent sodium sulphate, obtained during the second stage of solar evaporation of the mother liquor after burkeite separation from the Sambhar bittern was used. In this way, besides finding a use for the impure salt, the recovery of anhydrous sodium sulphate can be raised to 90 per cent and above.

Stage 2: Removal of residual sodium sulphate as burkeite at 75°C. — The mother liquor (M.L. 1) was mixed with the mother liquor (M.L. 3) from stage 3 and the combined solution was evaporated to raise the sodium carbonate concentration. Solid sodium chloride was added when necessary and the system was maintained at 75°C. with stirring for 30 min. The burkeite thrown out was separated and recycled in the next batch as mentioned in stage 1.

For plant practice it is recommended that M.L. 3 be evaporated to dryness by solar or waste heat and the resulting mixture of salts be added instead of adding M.L. 3 as such. This procedure will result in smaller volumes of solutions for further treatment and consequently better recovery of sodium carbonate.

Stage 3: Separation of sodium carbonate as decahydrate at 5°C. — The mother liquor from stage 2 containing mostly sodium chloride, sodium carbonate and very little sodium sulphate was allowed to cool to 25-30°C. Some sodium chloride, thrown out at this stage, was removed. The solution was then chilled at 5°C. when sodium carbonate crystallized out as the decahydrate. The slurry of the decahydrate crystals was centrifuged and the crystals washed with ice-cold water. The mother liquor plus decahydrate washings (M.L. 3) were recycled at stage 2 in the next batch.

TABLE 3 — COMPOSITION OF BITTERN SAMPLES AFTER DIFFERENT TREATMENTS, MOTHER LIQUORS AND OF THE PRODUCTS OBTAINED

(Values expressed as g./100 ml. in the case of solutions and percentage wt/wt in the case of solids)

PARTICULARS	BATCH No. I			BATCH No. II			BATCH No. III			BATCH No. IV		
	Na_2SO_4	Na_2CO_3	NaCl	Na_2SO_4	Na_2CO_3	NaCl	Na_2SO_4	Na_2CO_3	NaCl	Na_2SO_4	Na_2CO_3	NaCl
Starting solution	34.94	10.16	0.50	33.40	11.21	0.78	28.80	12.80	1.97	27.50	12.74	1.42
Solution after cooling to 20°C. (M.L. 1)	13.17	15.38	1.07	12.32	16.44	1.25	12.42	16.37	2.98	12.80	15.57	1.88
Solution after treatment at 75°C. (M.L. 2)	1.87	18.08	21.69	1.35	14.98	24.12	1.72	15.57	23.58	1.87	14.78	23.84
Solution after chilling at 5°C. (M.L. 3)	2.27	6.00	27.76	1.47	6.00	26.01	1.90	5.67	27.57	1.99	6.60	27.20
Solution left after crystallization of $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ + its washings	2.57	37.87	3.98	—	—	—	—	—	—	2.96	23.75	17.98
Washings of $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	13.61	7.79	Traces	—	—	—	—	—	—	11.91	6.00	0.77
Burkeite obtained at 75°C.	65.38	30.50	4.12	47.17	39.59	1.32	57.41	37.93	4.66	62.40	32.07	5.53
$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}^*$	97.27	2.70	Traces	—	—	—	—	—	—	—	—	—
$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}^*$	3.92	93.35	2.50	1.00	95.40	3.54	0.20	93.80	6.04	4.34	83.71	11.95
Purity of anhydrous Na_2CO_3	—	—	—	—	—	—	—	—	—	—	—	—
Crop 1	—	99.72	—	—	99.79	—	—	99.72	—	—	99.38	—
Crop 2	—	98.83	—	—	98.65	—	—	—	—	—	—	—
Purity of anhydrous Na_2SO_4 (all four batches dehydrated together)	99.50	—	—	—	—	—	—	—	—	—	—	—

* Anhydrous salt basis.

TABLE 4—AVERAGE COMPOSITIONS OF SOLUTIONS AND PRODUCTS AT DIFFERENT STAGES

(Values expressed as g./100 ml. in all cases except in the case of burkeite which are expressed as percentage wt/wt)

PARTICULARS	Na ₂ SO ₄	Na ₂ CO ₃	NaCl	TOTAL
Starting burkeite solution (sp. gr. 1.35-1.36)	28-35	10-12.8	0.5-2	41-45
Solution after cooling to 20°C. (M.L. 1; sp. gr. 1.24)	12.5-13	15-16	1-2	29.5-32
Solution after treatment at 75°C. (M.L. 2; sp. gr. 1.29-1.3)	1.3-2	15-18	24-22	40-42
Solution after chilling at 5°C. (M.L. 3; sp. gr. 1.24-1.25)	2-2.5	5.5-6.5	26.5-27.5	34-36
Burkeite obtained at 75°C.	62-70	29-32	5-8	—
Na ₂ SO ₄ ·10H ₂ O washings	10-13	6-10	Traces	—

Stage 4: Dehydration of sodium carbonate decahydrate—The sodium carbonate decahydrate crystals were heated to 100°C. when they dissolved in their water of crystallization. The resulting solution was evaporated at a slightly higher temperature when Na₂CO₃·H₂O separated out. Evaporation was continued until the solid, on testing, showed the presence of a sodium chloride separation. The treatment was stopped at this stage and the slurry centrifuged and the crystals washed with water. The mother liquor plus the monohydrate washings (M.L. 4) were recycled in stage 3 of the next batch. The monohydrate was finally dried at 130°C. to give anhydrous sodium carbonate.

Typical experimental run—Twenty-eight litres of saturated solution of burkeite were processed for the separation in four batches. The process was tried out on a recycling basis. The detailed analytical data of the various samples and of the average compositions of solutions and products are presented in Tables 3 and 4.

Fig. 2 shows the path followed by burkeite solution of batches No. 1 and 3 during stages 1, 2 and 3 of the process, and its deviation from the corresponding points according to Teeple¹ and Robertson³.

Products: Quality and recovery—Sodium sulphate and sodium carbonate recovered by the above process were in the form of fine, white, anhydrous crystals of purity 99.5-99.8 per cent. Sodium carbonate obtained was in the form of dense soda ash which has a special demand in the glass industry.

The actual recoveries for sodium sulphate and sodium carbonate obtained were 80 and 50 per cent

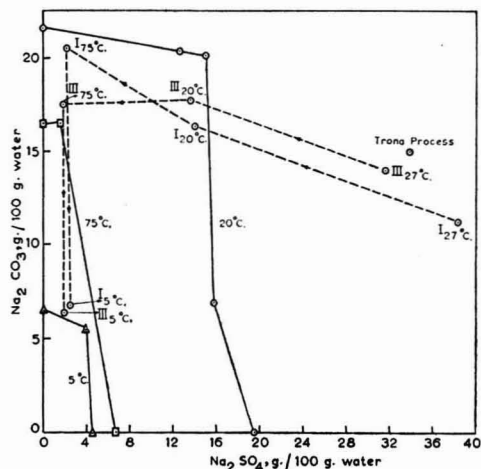


FIG. 2—SOLUBILITY OF SODIUM SULPHATE AND SODIUM CARBONATE AT 5°, 20° AND 75°C. [The curves for 5° and 75°C. are obtained with solutions saturated with sodium chloride; dotted lines show the path followed by burkeite solution of batches No. I and III during the separation of sodium sulphate and sodium carbonate]

respectively. The unrecovered portion of the sodium sulphate and sodium carbonate was left in the burkeite and in the end liquors of the fourth cycle. It was found that the recovery of components from burkeite increases with each cycle, reaching 90 per cent in the case of sodium sulphate from second cycle onwards and 85 per cent for sodium carbonate in the fourth cycle.

The entire process is basically cyclic in operation. At many stages salts and solutions have to be recycled in the process to attain maximum efficiency. After a few cycles balance is established with respect to the waste products recycled and the concentrations of solutions in the process. Once such balance is established and with the incorporation of the suggested improvements, the process will be economically operating at an efficiency of 90-95 per cent.

Acknowledgement

The authors desire to express their thanks to Dr A. N. Kappanna and Dr D. J. Mehta for their kind help in this work.

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REVIEWS

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

This elementary work surveys the field of neutron physics, a fundamental knowledge of which is essential for all those engaged in research in nuclear power and development. Starting with experimentally demonstrated facts, the author effectively and lucidly presents the subject in a manner which can be easily grasped not only by workers who are actually engaged in industry but also by students.

In the first chapter the properties of neutron are introduced with a description of relevant experiments. The second chapter is devoted to the subject of neutron interactions with nuclei. The minimum of theory is introduced with respect to experiments leading to an understanding of the structure of the nucleus. The chapter on neutron sources is elaborate and describes the available methods of producing neutrons in the laboratory. The next chapter discusses the advantages of various detectors and their energy sensitivities. The succeeding two chapters are devoted to experimental methods in neutron physics especially with pile neutrons and their application to problems in the physics of solid state. The chapter on calibrations and standards is rather elaborate in relation to the treatment of subjects in the rest of the book. The last chapter deals with the problems of neutron shielding and protection against health hazards to the personnel.

The book is well written with numerous illustrative sketches, and only very necessary mathematical formulae are introduced. The development of the subject in various chapters is well conceived. The book should serve as a useful treatise for beginners and makes easy reading for nuclear engineers.

P. K. IYENGAR

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

Proteins are the basic components of human diet like other essential nutrients. Vitamins have held the field for a fairly long time, and adequate attention to protein nutrition has been paid only during recent years in view of the wide prevalence of protein malnutrition in many parts of the world. The importance of vegetable proteins in combating

protein malnutrition has now come to the forefront. So, from the practical nutrition point of view, compilation, under one cover, of widely scattered data on proteins in different foodstuffs and their amino acid composition is a welcome feature.

The monograph contains 13 chapters each covering generally one class of foodstuffs with short notes on some important aspects like protein contents, amino acid composition, nutritive value, supplementary value, effects of processing on quality of proteins, etc. The nutritive value and the essential amino acids composition of protein in foodstuffs are given separately in two tables in each chapter followed by relevant references.

The information presented in the monograph will be very useful and time saving to workers in the field of nutrition, particularly dietitians in preparing suitable protein-rich menus and other therapeutic diets.

Although brief mention has been made in the introduction regarding the role of proteins in nutrition, it would have been more useful and would have enhanced the value of the monograph if a comprehensive chapter on this subject had been included in it.

M.V.R. & S.M.P.

FINE PARTICLE MEASUREMENT—SIZE, SURFACE & PORE VOLUME by Clyde Orr, Jr & J. M. Dalla Valle (The Macmillan Co., New York), 1959. Pp. xiv + 353. Price \$ 10.00

The book is bound to interest scientists, technologists and engineers working in entirely different fields. Those concerned with the production and use of matter in a finely divided form (e.g. cement) will be interested in reliable methods which would be useful to control the quality of their products. Others (e.g. mining engineers and health physicists) are concerned with particle size measurements as applied to diseases and explosions due to dust.

The authors have brought in one volume information from literature on the different methods of fine particle measurement. The references given in the bibliography are very helpful in guiding the individual worker to select the most satisfactory method for his problem. However, not all the methods discussed in the book will be useful in a laboratory with normal facilities. Microscopy, sieve analysis, sedimentation, elutriation and permeability are the more useful methods for routine purposes. Others are essentially research methods.

The value of the book would have increased considerably if the authors had critically analysed the usefulness of (i) optical methods for the measurement of particle size; (ii) surface area measurement by liquid phase sorption and other methods and (iii) methods for the measurement of pore size and pore-size distribution.

The book will serve as a useful introduction to the subject of fine particle measurement.

S. GURUSWAMY

DIFFERENTIAL THERMAL ANALYSIS (AS APPLIED TO BUILDING RESEARCH) — AN ANNOTATED BIBLIOGRAPHY by V. S. Ramachandran & S. P. Garg (Central Building Research Institute, Roorkee), 1959. Pp. vii + 182. Price Rs 5.00

The authors, with their considerable acquaintance in the field of Differential Thermal Analysis (D.T.A.) have rendered a commendable service in compiling this handy volume of annotated bibliography on the application of D.T.A. to building materials.

The D.T.A. technique, its theoretical considerations and its applications in diverse fields of research are described in the introductory chapter. The bibliography following, presents in six different sections, references to: (i) various modified experimental techniques; (ii) theoretical considerations involved in the measurement of the heat of reaction; (iii) application to the qualitative and quantitative estimation of clay minerals; (iv) building limes, plasters and cements; (v) accessory minerals usually associated with clays and (vi) general articles on D.T.A. and its application in different fields.

This bibliography, inasmuch as it contains references from 1940 onwards, is a valuable complementary volume to text-books now available on D.T.A. and is strongly recommended to all those who are interested in this branch of study. The usefulness of this volume will be greatly enhanced if the authors can bring out periodically such bibliographies surveying the growing volume of work in this field, either as an appendix in subsequent editions of this volume or as a note in scientific journals.

S. K. BHATTACHARYYA

COLORIMETRIC DETERMINATION OF TRACES OF METALS by E. B. Sandell (Interscience Publishers Inc., New York), Third Revised & Enlarged Edition, 1959. Pp. xxii + 1032. Price \$ 24.00

Judging from the outstanding popularity of this volume and the rapid, unabated flow of new colorimetric methods in chemical analysis, a new edition of the book was expected and indeed was being looked forward to. The author's bland preface to the new edition stating that "the aims and general

plan of treatment of the subject remain the same in the third edition as in the earlier editions" is, of course, true but it does not truly reflect the admirable effort he has put into the work of revising the treatise and making it up to date. Even small but significant changes, e.g. "by the colours of the rare earth ions in aqueous solution" to "by light absorption of the rare earth ions, etc." (p.744), recasting the table on metal dithizonates, pruning the controversial table on visual sensitivities of some important colour reactions and bringing it back to its original place in Chapter III, etc., have received his careful attention.

Of special value and interest are the addition of a chapter on procedures for the determination of traces of thorium, and the shifting of the chapter on 'Columbium and Tantalum', after considerable revision and enlargement, to its due place under 'Niobium and Tantalum'. Emphasis on ion-exchange and chromatographic methods is also a welcome new feature of the current edition.

Though the size of the book is 50 per cent larger than the second edition, it still retains its handy, useful character because of the essentially simple pattern of treatment that has remained unchanged through the editions. The book will doubtless continue to maintain its usefulness and wide popularity among chemists engaged in the determination of traces of metals in organic and biological materials.

J. GUPTA

PHOSPHORUS AND ITS COMPOUNDS: Vol. I — CHEMISTRY by John R. Van Wazer (Interscience Publishers Inc., New York), 1958. Pp. xiii + 954. Price \$ 27.50

To all chemists of modern thinking, the classification of chemistry into organic, inorganic and physical chemistry is becoming increasingly meaningless, and new chemistries such as boron chemistry, actinide chemistry, etc., are making their appearance as more meaningful categorizations. The author, a senior scientist in a front-rank industrial chemical company of U.S.A., has produced in the first volume (Vol. I) of his *magnum opus* evidence of a growing subject called phosphorus chemistry. This covers atomic structure and bond characteristics of phosphorus, the element and the metal phosphides, the preparative and structural chemistry of its hydrides, halides, pseudo-halides (inorganic and organic), oxides, sulphides, nitrides and their derivatives (inorganic and organic), oxyacids, simple and derived (their salts and esters), and condensed phosphoric acid and phosphates. The perfectly natural way in which the author's discussions on the preparative organic-inorganic chemistry have often merged into considerations of their structures and other physical properties is

absorbingly interesting reading, and does credit to his conviction that a new chemistry with new ideas is in the process of emergence.

Considering the variety of items brought into the self-imposed wide scope of the book, the treatment is really very good and factually rich. Chapters 8-12 on orthophosphates and condensed phosphates (pyro-, tripoly-, tetrapoly-, pentapoly-, Kurrol's and Maddrell's salts, metaphosphates and phosphate glasses) are extremely well written and up to date.

Though the book will have a second volume dealing with technology, functions and applications of phosphorus and its compounds, the first volume is fairly complete in itself and should find immediate place in all libraries as an authoritative treatise on the subject, and among reference books it is one of the most attractively readable ones from beginning to end.

It is somewhat queer that the author, after all his magnificent exposition of the subject, should have thought it fit to compare the current emergence of new chemistries with the frightful writings on the wall 'mer.ē mer.ē tekel upharsin' at Belshazzar's feast (Daniel, 5, 25). It would be just as correct, perhaps, to say that chemistry is finding itself in new ways, lest one good customary way of thinking (inorganic-organic-physical) should corrupt the minds of its votaries.

J. GUPTA

ADVANCES IN PEST CONTROL RESEARCH, Vol. 1, edited by R. L. Metcalf (Interscience Publishers Inc., New York), 1957. Pp. vii + 514. Price \$ 11.00

On the dust cover the scope of this series has been explained as: "Pests can be anything from fungi to rodents, and the control of pests engages a number of sciences, from physiology to engineering. This series offers a medium for publication of reviews and critical evaluations of all the branches of this complex field of applied sciences."

Pest control research presently occupies the attention of a significant portion of the world's scientific manpower and their research endeavours are often responsible for enriching the literature under the purview of various disciplines, viz. plant pathology, microbiology, entomology, economic botany, zoology and parasitology. The application of the experimental findings of pest control research is dependent on the ancillary disciplines of chemistry, physics, ecology and pharmacology. The present volume embraces the broad-based requirements of research workers, teachers and students engaged in the field. The wide and connected subjects selected for reviews in the publication are:

(i) Control of health hazards associated with the use of pesticides by J. M. Barnes; (ii) The chemistry and mode of action of herbicides by A. S. Crafts; (iii) Uses of radioisotopes in pesticide research by Paul A. Dahm; (iv) The chemistry and action of organic phosphorus insecticides by T. R. Fukute; (v) Mechanisms of fungitoxicity by James G. Horsfall; (vi) Recent advances in control of soil fungi by J. B. Kendrick (Jr) and G. A. Zentmyer; (vii) Repellents for biting arthropods by G. F. Shambaugh, R. F. Brown and J. J. Pratt (Jr); (viii) The status of systemic insecticides in pest control practices by W. E. Ripper; (ix) Chemical analysis of pesticide residues by Milton S. Schechter and Irwin Hornstein; and (x) Bioassay of pesticide residues by Yun-Pei Sun.

The significance of the subjects reviewed hardly requires any emphasis for any one engaged in pest control research. However, attention is drawn to the intrinsic merit of the subjects listed above as (i), (iv), (v), (vii), (viii) and (x). All these reviews have a pharmacological bearing and stimulate research on the development of agents of specific toxicity for use against pests without affecting other organisms and endangering human health. A large number of reviews deal with the chemistry and modes of actions of the pesticides. Although, the review on Radioisotopes in Pesticide Research is exhaustive, it requires some critical processing of the undigested list of references for the benefit of the readers. The author has expressed a very significant critical view on the subject of pest control by radiation, contrary to the opinion of overenthusiastic workers in the field. He states: "More versatile radiation sources used in connection with plant breeding may contribute to new methods of pest control. However, in the long run, natural evolution with plant breeding may contribute to new methods of pest control. However, in the long run, natural evolution of new diseases and insect varieties may catch up with the new types of plants created through radiation effects." This statement has a significant bearing on the future research in the field of pesticides.

The objectives set by the editor have been realized and the volume will continue to provide stimulating reading to those engaged in pest control research. Workers in the field will look forward with interest for the subsequent volumes in this series.

S. K. MAJUMDER

ADHESIVE BONDING OF REINFORCED PLASTICS by Henry Alexander Perry (McGraw-Hill Book Co. Inc., New York), 1959. Pp. xi + 275. Price \$ 8.75
An attempt has been made in this book to demonstrate how the principles and theories of high polymer science can be effectively utilized in realizing material

of practical importance. An approach designed to bring out the usefulness of polymer science in the design and assembly of many useful products and even engineering structures based primarily on adhesive bonding is rather new in outlook. Special reference has been made to glass fibre reinforced plastics. A purely chemical approach nowadays is an inadequate basis for research and development in this field and due attention has, therefore, been paid by the author to the physico-chemical, rheological and structural principles to make the book useful to engineers and technologists alike. The treatment of the subject in passing from the theoretical to the applied is lucid and this makes the book interesting reading. Quite a number of books have been published in this line in recent years but most of these are merely descriptive and have neglected to demonstrate the underlying principles, that is, how the fundamentals of physics, chemistry, physical chemistry, rheology and engineering science have been applied in the development of the manufacturing processes in question. This book is, however, not 'just another' of such types.

In an introduction to the subject, the author gives a historical account and thereafter deals with the present status, advantages and limitations of adhesive bonding as a fastening method, cost factors and certain technical aspects, viz. mechanical design problems, statistical problems, chemical and rheological problems, process engineering problems, etc. A full chapter has been devoted to the mechanics of adhesive joints while laminating and bonding resins and adhesive formulae have been the subject of another chapter. The rheology of adhesives which is a study of flow and deformation of matter has been treated with essential mathematical deductions rather exhaustively. Incorporation of chapters dealing with general properties and mechanical testing of adhesives with due linking to A.S.T.M. Standards under two chapters confirms the manifold utility of the book which may serve as a text-book for the students in a polytechnic. How the properties of adherent materials play an important role in determining the properties and behaviour of adhesive joints, has been thoroughly dealt with. Adhesive bonding process factors and equipment cover two chapters. The book has not stopped short at describing the technical details but includes two chapters—one on statistics and another on quality control. The former is to impart the background required to implement the techniques employed in the latter. Finally, the engineering aspect has been treated in the last chapter and pertains to design of adhesive joints, selection of joint shape and dimensions, selection of adhesives and bonding processes, design

calculations and safety factors. A large number of plates, diagrams, figures, graphs and tables based on actual experimental data have been incorporated to make the book quite comprehensive. A glossary at the end of the book will be of much help to the reader. References at the end of each chapter include not only monographs but also selected recent reviews and papers. Inclusion of a descriptive chapter on different types of bonded and laminated products would have made the book more useful.

S. R. SEN GUPTA

MODERN FISHING GEAR OF THE WORLD, edited by Hilmar Kristjónson [Fishing News (Books) Ltd, London], 1959. Pp. xxxi + 607. Price £ 5 5d.

Though fishing as an occupation is probably as old as the human race itself, the extent of development of fishing gear and techniques of fishing differs greatly between countries. In some of the advanced countries very efficient commercial fishing gear are in use and efforts are being made to improve on them as well as to introduce new and yet more effective gear. In recent years there has been considerable interest in modernizing the fishing gear in most of the underdeveloped countries of the world where there is an immediate need for increasing fish production by improving the fishing gear and extending the fishing operations. Such countries can benefit considerably from the experience of the advanced fishing nations. The convening of the International Fishing Gear Congress by the F.A.O. at Hamburg in October 1957 was of special interest in this context and served the important purpose of pooling the experience gained in gear design and operation in various countries of the world. This book contains the papers presented at the Congress and the summary of the discussions that ensued. Over 100 papers setting out the experience gained on various aspects of fishing gear technology included in the book make this the first comprehensive reference work on the subject and a worthy successor to the book entitled *The Fishing Boats of the World*, published in 1957, containing the papers presented at the first F.A.O. sponsored International Fishing Boat Congress held in Paris and Miami.

The book is divided into 13 major sections covering net materials, net making and net preservation, rational design of fishing gear, detection, location and attraction of fish and electrical fishing. The papers on net materials and net making discuss in detail the variety of natural and synthetic fibres used in net making and the techniques of manufacture and preservation of nets. It is stated that the ideal fibre for nets has yet to be developed and there are indications that the ideal fibre of the future may be made

into knotless nets. The papers on rational design of fishing gear lay emphasis on testing and standardization of trawl nets and the use of measuring instruments and underwater observations for this purpose. Our knowledge of fish behaviour and net action is very meagre and the investigations now being conducted in some countries with television camera and other methods of underwater observation may contribute greatly to a better understanding of these problems. In recent years the efficiency of fish detection devices has improved and the papers in this section review the experience gained in different countries in the use of echo sounders, asdics and other devices. Detailed studies on the food and feeding habits of fishes as also of related factors such as currents, temperature, water colour, etc., may in the future lead to efficient methods of locating fish. The spectacular progress made by Russian workers in the use of underwater light in fishing for the Kilka (a small clupeid fish) in the Caspian is of special interest in this connection. A suction hose, with electric lights attached at the opening, is lowered down to the required depth. Fish attracted by the light to within the critical range of the hose opening are sucked and pumped to the fish hold. This method completely excludes the use of conventional nets. Electrical fishing has gained considerable importance after the last war especially because of the introduction of impulse current. The experience gained in Germany, Japan and Israel is detailed in the papers on this subject and the report on electro-fishing in Lake Huleh (Israel) may be of special interest in connection with the exploitation of the fisheries of large reservoirs in India where the operation of nets has proved to be extremely difficult.

The book is profusely illustrated with 595 illustrations and is well printed. However, being essentially a reference book, it would have been desirable to have it cloth bound.

B. S. BHIMACHAR

INSTRUMENTATION IN TESTING AIRCRAFT—Aeronautical Monographs 5, by C. N. Jaques (Chapman & Hall Ltd, London; *Distributors in India*: Asia Publishing House, Bombay), 1957. Pp. xi + 291. Price 45s. net

The book deals with the special instruments needed in the measurement and recording of physical quantities and data commonly met with during flight and ground tests on aircraft components and aero engines.

The types of measurements that may be conveniently adopted for the indication of various individual quantities met with during the tests and the special instruments available for the various applications are described. As it covers a wide range, the

book does not go into details in each case, but gives in brief the principle together with a general description of the functioning of the instruments and devices recommended. The book deals with the equipment available in U.K., and out of the whole range of instruments available selectively recommends types considered specially suitable for individual applications.

This is one of the series of aeronautical monographs published under the authority of the Royal Aeronautical Society, U.K. It is recommended as a highly useful publication for ready reference to engineers and scientists engaged in flight tests of prototype aircraft, structural tests on aircraft and recording of data on the conditions to which aircraft are subjected in military or civil operations.

S. RAMAMRITHAM

THE PROCEEDINGS OF THE THIRD SYMPOSIUM ON COSMICAL GAS DYNAMICS—I.A.U. SYMPOSIUM SERIES, SYMPOSIUM NO. 8, edited by J. M. Burgers & R. N. Thomas (Smithsonian Symposium Publication No. 1; International Union of Theoretical & Applied Mechanics & International Astronomical Union, Washington), 1957. Pp. 905-1108

The Third Symposium on Cosmical Gas Dynamics was held, from 24 to 29 June 1957, at the Smithsonian Astrophysical Observatory, Cambridge (Mass.), and the proceedings of the symposium have now been published in the *Reviews of Modern Physics* (Vol. 30, No. 3). This series of symposia had been arranged jointly by the International Union of Theoretical and Applied Mechanics and the International Astronomical Union with the purpose of bringing the sciences of aerodynamics and astronomy together to explain the various cosmical phenomena requiring the fluid-dynamical concepts like shock waves, expansion waves, turbulence, etc., for their explanation.

The *Proceedings* under review consists of the following eight parts: (1) Empirical studies of velocity fields in, and related structure of, the interstellar medium; (2) Theoretical considerations on the production and dissipation of velocity fields in the interstellar medium; (3) General summary of discussions of the problems raised in parts (1) and (2); (4) Cooling and condensation of interstellar matter; (5) Kinematic structure of gaseous envelopes; (6) Conditions at the ionization and shock fronts in collision of gas clouds; (7) Some general gas-dynamical problems; and (8) Summaries and conclusions.

Part 1 consists of eleven papers and discussions on them and deals mostly with the observational data collected during the past few years. This critical presentation of the topics like density and velocity distribution of the interstellar gas, large-scale

structure and direction of rotation of galaxies, formation of interstellar gas clouds, and microstructure of the galactic magnetic field sets the stage for the following theoretical discussions.

Five papers with discussions are included in Part 2. The first paper on Gross Dynamics of Interstellar Medium reviews the processes which have been attributed from time to time to the interstellar motions. The second and the third papers discuss the aerodynamical dissipation and the magnetohydrodynamical dissipation respectively. These papers are followed by the papers on Thermal Inelastic Collision Processes and Cross-section of Photo-ionization from Valence-electron States.

Discussions of the problems raised in Parts 1 and 2 are summarized in Part 3. A number of interesting questions have been raised and discussed from various angles. Apart from recording the opinions of the experts on these topics, this part provides immense material for future thinking on some of the outstanding problems on the velocity fields prevailing in the interstellar medium.

Problems concerning the cooling and condensation of interstellar matter such as cooling of hot HII region to a cold HI region, single and multiple star formation, magnetic field in a contracting protostar and turbulence in a protoplanetary cloud are discussed in six papers in Part 4.

Seven papers are included in Part 5 which deal with the kinematic structure of gaseous envelopes. The main problems on which the attention is focussed in this part are: (i) internal kinematics and local density variations; (ii) comparison of the contributions of the gas pressure and radiation pressure in problems of dynamics of planetary nebulae; (iii) internal motions in the Orion Nebula; and (iv) kinematics of the filaments in, and the nature of emissions of, the Crab Nebula.

Part 6 includes six papers dealing with the conditions at the ionization fronts and the shock fronts formed in collisions of gas clouds. The main problems discussed are: (i) structure, stability and propagation of ionization fronts; (ii) collision of highly

ionized clouds; (iii) gas-dynamical effects of star formation; and (iv) collisions between galaxies.

General gas dynamical problems such as mechanics of stellar outbursts, exact solution of equations of magnetohydrodynamics in the presence of self-attraction and magnetic field, mathematical structure of turbulence and distortion of toroidal fields by convection form the subject matter of six papers included in Part 7.

Part 8, which is the concluding part, takes account of the achievements of the symposium. It starts by recording the impressions and summarizing the remarks by Burgers, Liepmann, Van De Hulst and Kahn on the central problem, namely 'What do we really know about the dynamics of cosmic clouds?' discussed in the present symposium, and its two predecessors. This difficult task has been ably done by the four scientists mentioned above. This section along with the general discussions that follow it indicates the directions in which the future investigations should proceed.

To sum up, it is clear that every worker in this branch of knowledge would find these *Proceedings* immensely useful in more than one way: (i) every paper summarizes the present position of the topic discussed in it and records the reference to important papers on that topic. Consequently even a beginner would be benefited by reading these *Proceedings* and would easily get at the necessary bibliography, and (ii) the discussion following each paper provides a many-sided view of the topic discussed in it and the suggestion for further work.

The Organizing Committee, the Chairman Prof. J. M. Burgers and the Secretary Dr R. N. Thomas, in particular, who ably set out in the very beginning the lines on which the symposium should be run, deserve hearty congratulations for the brilliant success of the symposium. The editors deserve sincere thanks and admiration of all workers in the field for bringing out so quickly these *Proceedings* for the benefit of those who could not attend the symposium.

P. L. BHATNAGAR

Recent Publications

Physics

ADVANCES IN MASS SPECTROMETRY: The Proceedings of the London Conference, 1958, sponsored by the Institute of Petroleum Hydrocarbon Research Group, edited by J. D. Waldron (Pergamon Press Ltd, London), 1959. Pp. c. 500. Price 70s. or \$ 10.00

SEMICONDUCTORS, edited by Norman B. Hannay (Reinhold Publishing Corp., New York; *Distributors in India*: Asia Publishing House, Bombay), 1959

PLASMA PHYSICS — ACCELERATORS — THERMONUCLEAR RESEARCH — JOURNAL OF NUCLEAR ENERGY, Part 'C', edited by H. Hurwitz (Jr) *et al.* (Pergamon Press Ltd, London), 1959. Pp. 400. Price £ 7 or \$ 20.00 per volume for libraries, industries, government departments, etc., and £ 3 10s. or \$ 10.00 per volume for private subscribers

PROGRESS IN DIELECTRICS: Vol. 1, edited by J. B. Birks & J. H. Schulman (Heywood & Co. Ltd, London), 1959. Pp. 322. Price 70s.

GENERAL CIRCUIT THEORY by Gordon Newstead (Methuen & Co. Ltd, London), 1959. Pp. 152. Price 15s.

CONSTITUTIONAL DIAGRAMS OF URANIUM AND THORIUM ALLOYS by Frank A. Rough & Arthur A. Baner (Addison-Wesley Publishing Co. Inc., London), 1959. Pp. 160. Price \$ 5.00 or 38s.

ATOMIC RADIATION AND POLYMERS — International Series of Monographs on Radiation of Materials: Vol. I, by A. Charlesby (Pergamon Press Ltd, London), 1959. Pp. 550. Price c. £ 5 10s. or \$ 17.50

AN INTRODUCTION TO THERMONUCLEAR RESEARCH — International Series of Monographs on Nuclear Energy — Thermonuclear Division — by Albert Simon (Pergamon Press Ltd, London), 1959. Pp. 200. Price c. 35s. or \$ 5.50

VISTAS IN ASTRONAUTICS: Vol. II, edited by Morton Alperin & H. F. Gregory (Pergamon Press Ltd, London), 1959. Pp. 330. Price c. £ 5 5s. or \$ 15.00

ATLAS OF GAMMA-RAY SPECTRA FROM RADIATIVE CAPTURE OF THERMAL NEUTRONS by L. D. Groshv, V. N. Lutsenko, A. M. Demidov & V. I. Pelakhov (Pergamon Press Ltd, London), 1959. Pp. 200. Price c. £ 7 or \$ 20.00

PLASMA PHYSICS AND THERMONUCLEAR RESEARCH: PROGRESS IN NUCLEAR ENERGY — Series XI, Vol. 1, Edited Proceedings of the Second International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958, edited by C. Longmire, James L. Tuck & W. B. Thompson (Pergamon Press Ltd, London), 1959. Pp. 625. Price c. £ 5 5s. or \$ 15.00

RECENT ADVANCES IN ATMOSPHERIC ELECTRICITY — Proceedings of the Second Conference, New Hampshire, 1958, edited by L. G. Smith (Perga-

mon Press Ltd, London), 1959. Pp. c. 400. Price c. 120s. or \$ 17.50

SOLID STATE PHYSICS, U.S.S.R. (FIZIKA TVERDOGO TELA), edited by A. F. Ioffe (Pergamon Press Ltd, London), 1959. Price £ 20 or \$ 56.00 per annum

ELECTROMAGNETIC RADIATION FROM CYLINDRICAL STRUCTURES by James R. Wait (Pergamon Press Ltd, London), 1959. Pp. 200. Price c. 50s. or \$ 7.50

QUANTITATIVE MOLECULAR SPECTROSCOPY AND GAS EMISSIVITIES by S. S. Penner (Addison-Wesley Publishing Co. Inc., London), 1959. Pp. c. 570. Price \$ 15.00 or 113s.

Engineering

RHEOLOGY OF DISPERSE SYSTEMS, edited by C. C. Mill (Pergamon Press Ltd, London), 1959. Pp. 240. Price c. 70s. or \$ 10.00

INTRODUCTION TO THE THEORY OF COMPRESSIBLE FLOW by Shih-I-Pai (D. Van Nostrand Co. Ltd, London), 1959. Pp. xiv + 385. Price 73s. 6d.

CRYOGENIC ENGINEERING by Russel B. Scott (D. Van Nostrand Co. Ltd, London), 1959. Pp. xii + 368. Price 42s.

PROGRAMMING FOR DIGITAL COMPUTERS by Joachim Jeanel (McGraw-Hill Book Co. Inc., New York), 1959. Pp. 517. Price \$ 12.00 or 93s.

PRINCIPLES OF CIRCUIT SYNTHESIS by E. S. Kuh & D. O. Pederson (McGraw-Hill Book Co. Inc., New York), 1959. Pp. 244. Price \$ 8.50 or 66s.

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

DYNAMICS OF FLIGHT: STABILITY AND CONTROL by Bernard Etkin (John Wiley & Sons Inc., New York), 1959

PROCESS EQUIPMENT DESIGN: VESSEL DESIGN by Lloyd E. Brownell & Edwin H. Young (John Wiley & Sons Inc., New York), 1959

AN INTRODUCTION TO PLASTICITY by William Prager (Addison-Wesley Publishing Co. Inc., London), 1959. Pp. c. 128. Price \$ 6.50 or 49s.

Chemistry

CHEMISTRY OF CARBON COMPOUNDS: Vol. IVB — HETEROCYCLIC COMPOUNDS (*contd.*), edited by E. H. Rodd (D. Van Nostrand Co. Ltd, London), 1959. Pp. xviii + 656. Price £ 5 15s.

INDUCED OXIDATION by W. P. Jorissen (D. Van Nostrand Co. Ltd, London), 1959. Pp. viii + 208. Price 42s. 6d.

SOME PROBLEMS OF CHEMICAL KINETICS AND REACTIVITY: Vol. II, by N. N. Semenov; translated by J. E. S. Bradley (Pergamon Press Ltd, London), 1959. Pp. 176. Price c. 35s. or \$ 5.00

ANALYTICAL CHEMISTRY: Progress in Nuclear Energy, Series IX, Vol. I, Edited Proceedings of the Second International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958, edited by M. T. Kelley (Pergamon Press Ltd, London), 1959. Pp. 398. Price c. £ 5 5s. or \$ 15.00

PROCESS CHEMISTRY: Progress in Nuclear Energy—Series III, Vol. 2, edited by F. R. Bruce, J. M. Fletcher & H. H. Hyman (Pergamon Press Ltd, London), 1959. Pp. 580. Price c. £ 5 10s. or \$ 17.50

PROCEEDINGS OF THE THIRD CONFERENCE ON CARBON, edited by S. Mrozowski (Pergamon Press Ltd, London), 1959. Pp. 725. Price c. £ 7 or \$ 20.00

LIQUID-LIQUID EXTRACTION by L. Alders (D. Van Nostrand Co. Ltd, London), Second Edition, 1959. Pp. xii + 209. Price 42s. 6d.

POLYMERS AND RESINS—THEIR CHEMISTRY AND CHEMICAL ENGINEERING by Brage Golding (D. Van Nostrand Co. Ltd, London), 1959. Pp. viii + 744. Price 112s. 6d.

Technology

PHYSICAL METALLURGY by C. Ernest Birchenall (McGraw-Hill Book Co. Inc., New York), 1959. Pp. 323. Price \$ 8.50 or 66s.

SEVENTH INTERNATIONAL SYMPOSIUM ON COMBUSTION—Proceedings of the Seventh International Symposium on Combustion held at the Royal Institution and University of Oxford—Aug. 28 until Sept. 3, 1958 (Butterworths Publications Ltd, London), 1959. Pp. c. 960. Price £ 11 4s.

TABLES FOR THE DESIGN OF FACTORIAL EXPERIMENTS by Tosio Kitagawa & Michimo Mitome (Dover Publications Inc., New York), New Revised Edition, 1959. Pp. vii + 253. Price \$ 8.00

LUBRICATION SCIENCE AND TECHNOLOGY: Vol. 2, No. 1—Published semi-annually—ASLE TRANSACTIONS, edited by John Boyd (Pergamon Press Ltd, London), 1959. Pp. 160. Price c. 70s. or \$ 10.00

PROGRESS IN VACUUM SCIENCE AND TECHNOLOGY: Also published in Vols. 6, 7 and 8 of the "VACUUM", edited by A. S. D. Barret (Pergamon Press Ltd, London), 1959. Pp. 164. Price c. 70s. or \$ 10.00

CORROSION AND DEPOSITS IN COAL AND OIL FIRED BOILERS AND GAS TURBINES, prepared on behalf of the American Society of Mechanical Engineers Research Committee on Corrosion and Deposits from Combustion Gas (Pergamon Press Ltd, London), 1959. Pp. 198. Price c. 50s. or \$ 6.00

METALLURGY AND FUELS: Progress in Nuclear Energy—Series V, Vol. 2, edited by H. M. Finniston & J. P. Howe (Pergamon Press Ltd, London), 1959. Pp. 650. Price c. £ 7 7s. or \$ 21.00

METALLURGY AND FUELS: Progress in Nuclear Energy—Series V, Vol. 3, Edited Proceedings of the Second International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958, edited by H. M. Finniston & J. P. Howe (Pergamon Press Ltd, London), 1959. Pp. c. 600. Price c. £ 5 5s. or \$ 15.00

Biology

MICROBIAL VARIATIONS, edited by V. D. Timakov; translated from the Russian by Dr Beale (Pergamon Press Ltd, London), 1959. Pp. 210. Price c. £ 2 10s. or \$ 7.50

THE BIOLOGY OF THE LABORATORY MOUSE, edited by George D. Snell (Dover Publications Inc., New York), 1959. Pp. ix + 497. Price \$ 6.00

ELEMENTS OF MATHEMATICAL BIOLOGY by A. J. Lotka (Dover Publications Inc., New York), 1959. Pp. xxx + 460. Price \$ 2.45

RADIOBIOLOGY AT THE INTRA-CELLULAR LEVEL, edited by T. H. Hennessy *et al.* (Pergamon Press Ltd, London), 1959. Pp. 225. Price c. 60s. or \$ 8.50

GRASSES OF INDIA, BURMA AND CEYLON (EXCLUDING BAMBUSEAE)—International Series of Monographs in Pure and Applied Biology, Botany Division—by N. L. Bor (Pergamon Press Ltd, London), 1959. Pp. c. 550. Price c. 80s. or \$ 12.50

Biochemistry

THYROID HORMONES—International Series of Monographs on Biochemistry—by Rosalind Pitt-Rivers & J. R. Tata (Pergamon Press Ltd, London), 1959. Pp. 250. Price c. 50s. or \$ 7.50

BIOCHEMISTRY OF THE CENTRAL NERVOUS SYSTEM—The Edited Proceedings of the Fourth International Congress of Biochemistry, Vienna, Vol. III, edited by F. Brucke (Pergamon Press Ltd, London), 1959. Pp. 336. Price c. 88s. or \$ 13.50

BIOCHEMISTRY OF ANTIBIOTICS—The Edited Proceedings of the Fourth International Congress of Biochemistry, Vienna, Vol. V, edited by K. H. Spitzzy & R. Brunner (Pergamon Press Ltd, London), 1959. Pp. 256. Price c. 68s. or \$ 10.50

PHYSICAL CHEMISTRY OF HIGH POLYMERS OF BIOLOGICAL INTEREST—The Edited Proceedings of the Fourth International Congress of Biochemistry, Vienna, Vol. IX, edited by O. Kratky (Pergamon Press Ltd, London), 1959. Pp. 272. Price c. 70s. or \$ 11.00

BIOCHEMISTRY OF WOOD—The Edited Proceedings of the Fourth International Congress of Biochemistry, Vienna, Vol. II, edited by K. Kratzl & G. Billek (Pergamon Press Ltd, London), 1959. Pp. 300. Price c. 70s. or \$ 11.00

BIOCHEMISTRY OF STEROIDS—The Edited Proceedings of the Fourth International Congress of Biochemistry, Vienna, Vol. IV, edited by E. Moseetting (Pergamon Press Ltd, London), 1959. Pp. 316. Price c. 75s. or \$ 12.00

CARBOHYDRATE CHEMISTRY OF SUBSTANCES OF BIOLOGICAL INTEREST—The Edited Proceedings of the Fourth International Congress of Biochemistry, Vienna, Vol. I, edited by M. L. Wolfrom (Pergamon Press Ltd, London), 1959. Pp. 230. Price c. 70s. or \$ 10.00

ELECTROPHORESIS: THEORY, METHODS AND APPLICATIONS, edited by Milan Bier (Academic Press Inc., New York; *Distributors in India*: Asia Publishing House, Bombay), 1959. Pp. 563. Price \$ 15.00

NOTES & NEWS

International Conference on Information Processing

THE INTERNATIONAL CONFERENCE on Information Processing organized by the Unesco at Paris from 15 to 20 June 1959 was attended by about 2000 electronic computer experts, mathematicians, scientists and engineers from 37 countries. The main purpose of the conference was to bring the experts together to share their knowledge and experience, and the deliberations showed clearly that the conference was timely and that there was an urgent need for stocktaking of the developments in information processing methods. The experts in various fields of science and technology during the past ten years have invented a new terminology which is compounded of all languages, and which, with the help of the Unesco, is being systematized in an international glossary. This is a noteworthy development.

At the conference the discussions centred round machines which could control other machines, predict the weather, memorize all the knowledge in the world, compose music, translate languages, and solve, in a few seconds, problems in which mathematicians could spend a whole lifetime. The experts were of the opinion that within a few years electronic devices will be produced which can memorize all the vast knowledge in the world, and the equivalent of human memory could be embodied on a piece of glass plate, 5 x 6 in., on which electric circuits could be stencilled. Also, no difficulty will be experienced in storing information but the problem would be how to organize the stored information so that it can be easily retrieved. The view was also expressed that a computer can be so designed as to have the power to make value judgements as well as logical reasoning, and that the machine could copy any human process which is logical. Some emphasized the need for recognizing the vast social implications of the introduction of computer technology and find answers to such

questions as: Who will own the machines? Who will fill the store? Who will control the integrity of the information which will fill the store? Who will use it and who will abuse it?

As far as languages and information processing were concerned, the discussions were confined to machines which could translate Russian, Japanese, French, English, etc., and machines which will have to 'understand' languages in order to do their job. Machine translation was considered to be still in its infancy but offered great possibilities in the field of computer calculation. Automatic translation of a text in one language to another at sight or have the spoken word translated automatically is the ultimate object, but by transferring a text to a punched tape in the original language and passing it into a computer, the mechanical memory of which has been supplied with a dictionary, passable translations have been obtained. Science papers can now be translated in a form which is at least intelligible to the experts in a particular branch. In one institute in the United States, 250,000 words of foreign language texts have been processed in this way. An important outcome of the attempts made to make languages intelligible to the machines is that the experts have come to recognize that much is still imperfectly understood about language itself. It was observed that it is difficult to evolve a common language for computers as each computer, by the nature of its electrical circuits, will have its own private 'language'.

It was decided at the conference to set up an International Federation of Information Processing Societies, which will convene the next conference on information processing to be held in 1963.

Ultrasonic absorption microscope

AN INTERESTING AND USEFUL DEVICE, the ultrasonic microscope (or micrograph) described, constitutes an elegant application of the

characteristics of pulsed ultrasonic waves to the investigation of the microstructure of biological systems (cellular and sub-cellular organization of biological tissue) achieving high resolution. The instrument is expected to yield information relating to such systems which is not obtainable by either light or electron microscopy. This possibility follows from two known facts: (1) the protein constituents of tissue are largely responsible for its absorption of acoustic energy in the ultrasonic frequency range; and (2) some different types of protein molecules, at equal concentrations, absorb sound at different rates. Thus, a suitably designed acoustic device could yield information on both spatial distributions and identification of types of protein in tissue.

The principle of operation of the new device will be clear from the following: The specimen is embedded in a liquid (the 'coupling medium') which closely matches in acoustic impedance, and is irradiated with short pulses of high frequency (12 Mc/s.) sound waves. Some of the ultrasonic energy is absorbed in the specimen and the remainder leaves it and excites a small thermoelectric probe (an iron-constantan junction was used) placed immediately adjacent to the region being investigated. As the specimen, which is between the sound source and the probe, is moved in a direction normal to the direction of sound propagation, depending on the structure of that part of the specimen, a varying acoustic signal will be detected by the probe. The variation in the transmitted energy level, as a function of the position of the probe relative to the specimen, constitutes an 'image' of the ultrasonically detected structure.

The thermoelectric e.m.f. of the probe is fed, via a d.c. amplifier, to the vertical deflection plates of a cathode ray oscillograph. When the sound source is driven by a suitable pulse, the cathode ray beam is transiently deflected from its equilibrium position, the magnitude of the deflection being a measure of the relative amount of acoustic energy detected by the probe. As the specimen is moved through the pulsed acoustic field, the changing deflection of the cathode ray beam is observed and

recorded. Plot of the data so obtained gives a 'picture' of the disturbance to the sound field distribution, caused by the presence of the specimen. Measurements with nylon filaments of 0.001 in. diam. demonstrated that at a frequency of 12 Mc/s. a structure with a diameter of 25 μ could be resolved.

In view of the possibility that some materials can have widely different ultrasonic absorption coefficients with practically the same light absorption coefficient or index of refraction, the new device is expected to detect many structural components of biological materials, which are missed by the light microscope. Experience with this device showed that the instrument offers a ready method of determining the intensity of absorption coefficient per unit path length in highly absorbing viscous liquids. This can be accomplished by moving the probe along the axis of the sound beam and observing its output as a function of the probe position [*J. Acoust. Soc. Amer.*, **31** (1959), 632].

Detection of changes in dislocation density

A METHOD REPORTED FOR DETERMINING the changes in lattice heat conductivity, at low temperatures (2-5°K.), promises to offer a useful tool in detecting relative changes in dislocation density in a specimen of a cold-worked alloy after deformation. An advantage of the method is that changes in heat conduction are not affected by stacking faults. The method is claimed to have an accuracy surpassing that of all other techniques now in use. Previous methods of estimating the dislocation density such as X-ray line broadening, electron microscope, etch pits and indirect estimates from theoretical calculations have been found to have one drawback or another.

The present method is based on the fact that the lattice heat conductivity of a specimen after straining is reduced by the dislocations produced by the deformation. Dislocation density can be calculated from the decrease in conductivity at liquid helium temperatures in accordance with a theory outlined by Klemens. Single and polycrystals of α -brasses have been tested by this method. The

experimental procedure consisted of measuring the thermal conductivity, K , by creating a temperature gradient between the two ends of the specimens and the residual electrical resistance, R_0 , by immersing the specimen in a Dewar flask containing liquid hydrogen and passing a current through it and measuring the potential across the copper contact. Both the conductivities were measured initially on the annealed specimen and then again after extending the specimen by about 1 per cent. The measurements were repeated after further deformation until the specimen broke. The lattice heat conduction in the helium range in an annealed specimen is limited by the scattering of the lattice vibrations by the conduction electrons and by any dislocations present. Both these processes give a conductivity of the form $K = BT^2$. As the specimen is strained dislocations are introduced and effective value of B decreases. From the change in B the number of dislocations introduced can be calculated.

The results of these experiments are in qualitative agreement with conclusions expected from current theories of work-hardening and confirm the main hypothesis put forward to explain the three stages of the stress-strain curve. Actual counting of the dislocations from transmission electron microscope on some specimens with known constants showed that Klemens's theory overestimates the dislocation density by a factor of *c.* 6. So a scaling down of the values of dislocation density by a factor of 6 should give quite representative absolute values. Comparison of the electrical resistivity data with the lattice thermal conductivity results gave further evidence for the suggestion that the electrical resistivity is affected by stacking faults rather than by dislocations, thus rendering the method independent of stacking faults [*Phil. Mag.*, **4** (8 Ser.) (1959), 467].

Newer antibiotics and their structure

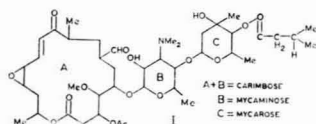
THE EXISTENCE OF A WIDE VARIETY of structures among the newer antibiotics and some of the specific structure problems that have been solved, have been reviewed in a paper [*Trans. N.Y. Acad. Sci.*, **21**

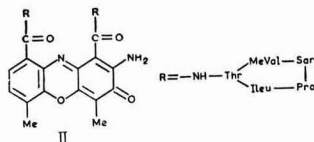
(1959), 469]. During the past few years new classes of natural products with antibiotic properties have been discovered. They are: (1) macrolide antibiotics, (2) peptide lactone antibiotics, and (3) those represented by the conjugated polyene antifungal antibiotic, pimaricin.

The common feature of the macrolide antibiotics is a highly substituted, many-membered lactone system; in addition all of them contain a glycosidically bound amino sugar. There are a dozen or more closely related members of this macrolide family. Among them pikromycin, magnamycin, erythromycin and spiramycins have been investigated in detail.

Confirmation of the lactone system in magnamycin (I) was made possible through a study (R. B. Woodward) of the behaviour of reduced derivatives of carimbose, obtained from magnamycin by hydrolytic cleavage of the neutral sugar, mycarose. An elegant series of oxidative and hydrolytic reactions demonstrated the macrocyclic nature of the lactone system in the magnamycin.

Structural studies on the macrolide antibiotics methymycin and neomethymycin are of particular interest, since in them C. Djerassi has made application of his extensive studies in optical rotatory dispersion. Rotatory dispersion is a powerful physical tool with important contributions to problems of absolute configuration location of carbonyls in polycyclic systems, analytical questions and detection of subtle conformational factors. In neomethymycin the acid degradation product anhydrocycloneomethynolide was found to have infrared maxima at 5.75 and 5.88 μ . Initially, these bands were assigned to lactonic and ketonic carbonyls. However, the anhydrocompound had plain positive rotatory dispersion, in contrast to the anomalous single Cotton effect curves observed in its precursors. Stability to lithium aluminium hydride of the 5.88 μ band in the anhydrocompound confirmed the fact that it

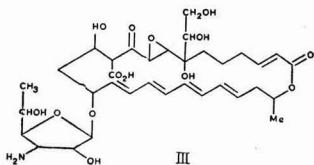




did not arise from a carbonyl group, but from enol-ether structure.

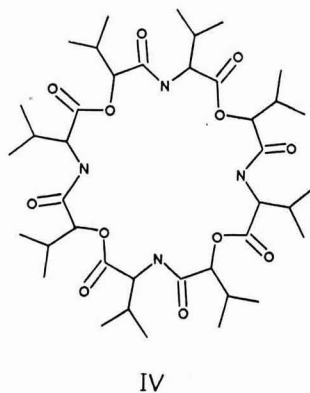
Actinomycins, which are about a dozen in number, are members of the peptide lactone class of antibiotics. These substances (II) consist of a phenoxazine-3-one nucleus that holds two 16-membered lactone rings whose elements are amino acids. It is likely that all the actinomycins are similarly constituted and that they differ in the amino acid composition of the peptide chains. A method has been developed for separating the intact peptide lactone systems before conventional amino acid sequence determination, and it has been shown that there are two identical lactone rings in each of the actinomycins so far investigated.

Actinomycin C₃ consumes two equivalents of alkali in about 4 hr and further consumption is much slower. The product actinomycinic acid C₃ is a chromatographically homogeneous dibasic acid. The weakly basic group of actinomycin, titrable with perchloric acid, is still present, but no other basic groups could be detailed. The 5 amino acids originally observed in actinomycin hydrolysates were still present in the acid. Actinomycinic acid, in contrast to actinomycin, has been found to reduce periodic acid, which indicates generation of hydroxyl groups in the saponification. Formation of a crystalline dimethoxy dimethyl ester completed characterization of this acid. The nature of the lactone ring has been further elucidated by the observation that, while threonine is present in total acid hydrolysates of actinomycin C₃, this hydroxy amino acid is the only one of the five not detected in total hydrolysates of periodate-oxidized actinomycinic acid. This suggests closure of the lactone system on the hydroxyl groups of the threonine moieties. Conventional degradation procedures revealed the sequence of amino acids in the peptide chain, defined the C-terminal amino acid, and thus



indicated the fine structure of the lactone systems.

Pimaricin, an antifungal antibiotic, has the unusual polyene macrolide structure (III). It is recognized as an α , β -unsaturated lactone from infrared and ultraviolet spectral data and from the observation that it consumes one mole of base to yield a single hydrolysis product. When allowed to react with methanolic hydrogen chloride, pimaricin gives the amino sugar mycosamine. Crotonaldehyde was isolated with chromic acid oxidation; apparently the tetraene system is destroyed. Sebacic acid was obtained by chromic acid oxidation of a partially hydrogenated derivative of pimaricin. Alkaline hydrolysis of pimaricin gives ammonia and a polyene aldehyde identified as 13-hydroxy-2, 4, 6, 8, 10-tetradecapentanal. This polyene aldehyde gives a much poorer yield of crotonaldehyde on oxidation than did pimaricin itself, indicating that the lactone system closure occurred on C-13 of the aldehyde moiety.



Amidomycin (IV) is typical of a group of antibiotics that comes close to defying any simple chemical classification. They are macrocycles in which amide and ester images alternate. Amidomycin has a 24-membered ring structure.

New synthesis of emetine

A NEW SYNTHESIS OF EMETINE HAS been successfully carried out at the University of Kansas, U.S.A. The starting material, gallic acid, on high pressure reduction using 5 per cent rhodium-on-alumina, furnishes hexahydrogallic acid in 45-50 per cent yield. Following acetylation and conversion to the corresponding diazoketone derived from 1-diazopropane, this acid is homologated by the Arndt-Eistert procedure in the presence of homoveratrylamine to the amide which on selective hydrolysis provides the free triol in 25 per cent overall yield from the acetylated acid. Cleavage of the triol with periodic acid and cyclization of the product with warm phosphoric acid gives the aldehyde lactam which on oxidation with silver oxide is converted to the lactam acid, m.p. 190-1°. Reduction of the acid by sodium in alcohol, after esterification with ethanol, leads to the known aminoester which is converted to emetine by dehydrogenation with mercuric acetate [*J. Amer. chem. Soc.*, **81** (1959), 503].

Basically substituted pyridine compounds

A NEW METHOD FOR THE DIRECT substitution of the alkylamines at the 2-position of the pyridine ring is reported. This work is of importance in the synthesis of ethylene diamine derivatives carrying a 2-pyridyl substituent and which possess antihistaminic activity. It has been found that the pyridine and the alkylamine can be converted to the required secondary amine by heating together under reflux in toluene in the presence of sodium. The amount of the powdered sodium is stoichiometrically, at least, the equivalent of pyridine used; the alkylamine employed being in slight excess. When alkylamine is heated alone with sodium, no reaction is observed, indicating the non-formation of the sodium alkylamide. The mechanism whereby this amine substitution is accomplished is not yet clear [*Chem. & Ind.*, (1959), 259].

Finger printing of peptides

THE TECHNIQUE OF 'FINGER PRINTING' of peptides is being increas-

ingly used by protein chemists to compare normal and abnormal proteins. The technique consists in subjecting the mixture of peptides obtained through any one of the several available degradation procedures, to high voltage electrophoresis on paper in a volatile buffer. After the run, the partially separated peptides are chromatographed in the second direction and the peptides are located with ninhydrin. This method has been successfully employed in the comparison of normal human and sickle cell haemoglobin.

A modified procedure for the preparation of peptide 'finger prints' has been recently developed [*Federation Proceedings, U.S.A.*, **18** (1959), 257]. One or two milligrams of a peptide mixture is first subjected to chromatography in *n*-butanol-acetic acid-water mixture of the ratio of 4:1:5, followed by electrophoresis at 2000 V. in pyridine-acetic acid buffer of pH 3.7 or 6.5. Adequate precautions are taken to ensure proper cooling. This method, which is highly reproducible, has been employed to the study of a few problems of protein structure. It has been found possible, for example, to compare beef and sheep pancreatic ribonucleases, which differ in the identity of three amino acid residues. One involves the replacement of threonine at residue 3 in the bovine protein by serine in the ovine enzyme and the second, the replacement of a lysine residue at position 37 by glutamic acid. While definite evidence points to a third difference existing between the two proteins, the exact position has not been so far assigned [*J. biol. Chem.*, **234** (1959) 1185].

Detection of phosphate esters

A SIMPLE DIP PROCEDURE FOR THE detection of phosphate esters, important intermediates in biological reactions, containing as little as 0.007 μ mole of phosphorus, has been developed.

The phosphate spots, developed on paper chromatograms with volatile buffers and solvents, are located by immersing the developed and dried paper in a solution of 0.5 per cent quinine sulphate $2H_2O$ in absolute ethanol. After drying the paper at room temperature for a few minutes, the phosphate spots

can be detected by examining the paper under ultraviolet light in a darkened room. The spots show up as light areas against an intense grey-blue fluorescent background. The best results are obtained with a low pressure mercury source filtered to exclude visible light and producing predominantly ultraviolet radiation in the 2537 Å. region.

Quinine sulphate dip, in addition to its ease of use, offers the advantage of employing an alcohol-soluble and apparently non-reacting spot-detecting compound. After marking the spots under ultraviolet light as rapidly as possible, one can wash the bulk of the quinine sulphate off the chromatogram with absolute ethanol thus leaving the phosphate ester spots unmoved and free for elution and further determinations. The spots may also be left on the paper, following the alcohol wash, for study by other spot-detection procedures such as specific ketose reactions [*Nature, Lond.*, **183** (1959), 1739].

Analysis of heat-resistant alloys

A GENERAL, CHEMICAL, THREE-STEP procedure, based on the formation of metal-fluoride complexes, having different properties, is described for the separation and analysis of titanium, zirconium, tungsten, molybdenum, niobium and tantalum in heat-resistant alloys.

Hydrofluoric acid is added to the alloy to form soluble fluoride complexes of the group of metals mentioned above. The solution is then placed on an anion-exchange column and the metals are eluted by passing appropriate media through the resin column. Boric acid and cupferron (nitrosophenylhydroxylamine) are then added to each eluate. With cupferron the metals form insoluble complexes from which the particular metallic element can be readily determined. Boric acid, on the other hand, does not react with cupferron at all, but forms a complex with the fluoride which is more stable than that formed with the metals. Photometric analytical methods are then employed to determine the amounts of the individual metals present.

With this basic procedure, not only these metals can be determined

in various high-temperature steels, but also niobium and tantalum, which are extremely difficult to separate quantitatively, can be determined in titanium-base alloys [*Tech. News Bull. U.S. Bur. Stand.*, **43** (1959), 90].

Spectrophotometric estimation of chlorine

A RAPID AND PRECISE SPECTROPHOTOMETRIC method for the estimation of low concentration of free chlorine in atmosphere, in industrial towns and factories, is described.

Chlorine is dissolved in an organic liquid, such as carbon tetrachloride, chloroform, trichloroethylene, tetrachloroethylene and acetone, and the absorption spectrum of the solution examined in the ultraviolet region. The absorption maximum of chlorine dissolved in carbon tetrachloride has a wavelength of *c.* 350 m μ and its height is proportional to the concentration of chlorine.

For the rapid determination, a standard curve is drawn with the help of Zeiss universal spectrophotometer. The concentration of the chlorine in the standard solution of the carbon tetrachloride is determined by potentiometric titration and by dilution of this sample standard solution other samples are prepared [*Nature, Lond.*, **183** (1959), 1390].

Analysis of gases in biological fluids

AN ACCURATE, QUICK AND REPRODUCIBLE method for the determination of small quantities of permanent gases contained in biological fluids has been successfully carried out with a technique combining vacuum extraction with gas chromatography. The remarkable sensitivity of the instrumentation to minute changes in oxygen content in small samples of biological fluids, its stability and accuracy offer its widespread use in biological research and clinical medicine.

The apparatus consists of a gas chromatograph, a 1-mV., 1-sec. full-scale strip chart recorder, and a Van Slyke volumetric extraction chamber, the waste arm of which is connected to the carrier-gas stream of the gas chromatograph proximal to the chromatographic

column. Helium is used as the carrier gas.

The sample of gases are removed from the biological fluid in the Van Slyke reaction chamber. The sample gases are then placed in the carrier gas stream and carried through the chromatograph column and eluted as separate components; the length of time required depends upon the characteristics of the gas and the column material. Each component is detected, and the quantity of the gas present is determined by the thermal conductivity reference and by sensing cells; the signals are amplified and recorded, in time, on the strip chart recorder.

The use of 4 ft, 5-A molecular sieve column, 0.25 in. in diameter, allows the oxygen component to be eluted first from the column; this is followed by nitrogen and carbon monoxide. All permanent gases like CO₂, with the exception of argon, which at present cannot be separated from oxygen by known column materials, can be separated and analysed by means of molecular sieve column, a silica-gel column, or a charcoal and firebrick column [*Science*, **129** (1959), 900].

Rapid analysis of chlorine in organic compounds

A QUICK, INEXPENSIVE METHOD FOR the analysis of chlorine in organic compounds has been developed at the Texas Agricultural Experiment Station, U.S.A. Samples containing about one milliequivalent of chlorine are weighed into a beaker — the only vessel used during the entire procedure. Excess ammonia and ethyl ether are then added to chill and dissolve the sample. Two or three pieces of metallic sodium (0.5 g.) are added to reduce chlorine to chloride ions. The reduction is complete in about 2 min., indicated by appearance of a blue colour. After evaporation of ammonia and ether excess sodium combines with moisture in the air to form sodium hydroxide. At this stage blue colour disappears. The solution is then neutralized with nitric acid and the chloride titrated with silver nitrate. End point is determined amperometrically or potentiometrically or visually.

If sulphur is present in the sample it is removed by oxidation

to sulphate with hydrogen peroxide and heat before neutralization step. Accuracy of the method is good, the error seldom exceeding 3 per cent [*Chem. Engng News*, **37** (14) (1959), 34].

Scientific Institutions and Scientists in Pakistan

THE UNESCO SOUTH ASIA REGIONAL Office has issued a 501-page mimeographed survey report about scientific institutions and scientists in Pakistan. The report is divided into three parts, viz. (1) scientific organizations, (2) scientific associations, societies and technical periodicals and (3) lists of scientists actively engaged in research in various scientific institutions in Pakistan. The section on scientific organizations has an introductory chapter which presents briefly the organization and functions of Governmental bodies connected with education. Details are given about different universities and the institutions under the Pakistan Council of Scientific & Industrial Research; the institutions under the latter are grouped subjectwise, the subjects being arranged in alphabetical order. The scientists are also grouped subjectwise, but the subject classification is according to the decimal system.

This is a useful publication which provides information about scientific organizations, universities and active research workers in Pakistan under one cover. The Unesco South Asia Regional Office would be rendering a valuable service if it can compile similar data for other South Asian countries.

U.S.S.R. patents and inventions

THE RUSSIAN GOVERNMENT, RECOGNIZING the value and importance to itself and other countries of the widest dissemination and exchange of scientific and technical information, and in particular the dissemination of patents and inventions to users at home and abroad, has permitted, for the first time since 1940, the export abroad of copies of its patent specifications and application, *Biulleten Izobretenii* (U.S.S.R. Patents and Inventions). The English cover-to-cover translation of this bulletin is being published by the Pergamon Press,

London, in collaboration with the Pergamon Institute. The annual subscription rate is £ 30 (\$100.00).

New ASTA Rules on Short-circuit Testing

WITH A VIEW TO REMOVE LIKELY misinterpretations of the rules set down in B.S. 88:1952, the Association of Short-circuit Testing Authorities (Inc.) (ASTA) have redefined very clearly the criteria for short-circuit testing and certification of low and medium voltage electric fuses, in a new publication, ASTA No. 20:1959, entitled *Rules Governing the Short-circuit Testing and Certification of Low and Medium Voltage Electric Fuses for Use on Alternating Current Circuits*.

Divided into eight sections the ASTA No. 20:1959 has been prepared with the purpose of setting down, for the convenience of manufacturers, the rules which will be applied by the Association if fuses or fuse-links are submitted to it for test and certification. Particular attention has been given in Section 3 to the identification of fuses and in Section 6 to the assessment of their performance, while in Section 8 the range of applicability of Certificates of Short-circuit Rating is clearly set out. For instance, it defines the conditions which must be met if it is desired to claim 'ASTA Certification' for a whole range of fuses or fuse-links as well as the method of marking of the fuse-links which have been certified and covered in this way.

These rules will fill a long-felt need in the industry and will contribute to a high standard of product besides the resulting safety to the public.

Developmental Biology

THIS NEW BIMONTHLY JOURNAL, published by the Academic Press Inc., New York and London, from the spring of 1959 (subscription £ 5 per volume of six issues), will contain articles bearing on problems of embryonic and post-embryonic development, growth, regeneration, and tissue repair of both plants and animals. The journal will be international in character publishing papers in the English, French or German language.

Experimental Neurology

THIS NEW BIMONTHLY JOURNAL, published by the Academic Press Inc., New York and London, from the spring of 1959 (subscription £ 5 14s. 6d. per volume of six issues) will include results of original research by experimental methods in neurophysiology, pharmacology and chemistry as well as experimental neuroanatomy, embryology and pathology.

Journal of Biochemical and Microbiological Technology

IN ORDER TO PROVIDE COMPREHENSIVE information on topics of interest to the engineers, technologists and scientists working in industries based on microbiological processes the Interscience Publishers Inc., New York, have started the publication of a new quarterly, *Journal of Biochemical and Microbiological Technology and Engineering*, from February 1959 (subscription, covering one volume annually, £ 5 15s. or \$15.50). The first number contains nine papers which illustrate the kind of topics which the publication covers. For example, a paper describes the separation of proteins by means of foam, a review paper reviews the principles employed in different types of presses, filters and centrifuges by which the fluids may be separated from fibrous pulps on a large scale. Besides these there are reports on equipment for the culture of algae and of other micro-organisms of diverse kinds for various purposes, on the destruction of moulds by irradiation, on the evaluation of microbiological nutrients and on means for the removal of algae from drinking water.

Instrument Construction

A COVER-TO-COVER ENGLISH translation of the Russian monthly journal *Priborostroenie* is produced, under the title *Instrument Construction*, with effect from January 1959, by the British Scientific Instrument Research Association for the Department of Scientific & Industrial Research, London. The journal, published by Taylor & Francis Ltd, Fleet Street, London E.C. 4, is priced at £ 6 (post free) and £ 3 for university and technical college libraries.

Announcements

■ Dr B. N. Mitra, Assistant Director-General, Council of Scientific & Industrial Research, New Delhi, has been appointed Director of the Regional Research Laboratory, Jorhat, Assam, with effect from 1 August 1959.

Dr Mitra, who was born on 26 January 1905, obtained his D.Sc. degree in Chemistry from the Dacca University in 1935. He proceeded to Minnesota on a Rockefeller Foundation Fellowship in 1936-37 and obtained the Ph.D. degree in Agricultural Biochemistry in 1937. He also worked for some time at the Rothamstead Experimental Station, Harpenden, England.

After returning to India, Dr Mitra joined the Forest Research Institute & Colleges, Dehra Dun, and later worked at the Imperial Serological Department and All-India Institute of Hygiene & Public Health, Calcutta. He was commissioned in the Army during the last war and rose to the rank of Colonel. He was released from the Army early in 1958 and was appointed Assistant Director-General, Council of Scientific & Industrial Research, New Delhi, from 28 January 1958. During his tenure in the Army, he held a number of key positions, such as Superintendent of Proof and Experiments, Chief Superintendent of Ammunition Development, etc. He was responsible for research, design and development of armament stores.

Dr Mitra attended, on invitation, the Third International Congress in Microbiology held in New York in 1939 and the Eleventh Session of the International Congress of Pure and Applied Chemistry held in London in 1946.

He is a Fellow of the Royal Institute of Chemistry of Great Britain and Ireland, and a Member of the Society of Sigma XI of the Minnesota Chapter of America.



DR B. N. MITRA

■ A Steering Group on Space Research, under the chairmanship of Sir Edward Bullard, has been appointed by the British Government to advise on the formulation of space research programme and to co-ordinate the arrangements for carrying it out.

■ A symposium on Iron and Manganese Ores of India, organized by the Geological, Mining and Metallurgical Society of India, will be held in November 1959. The symposium will cover the distribution and geology of ore deposits, mineralogy and paragenesis, quality and grade, industrial uses and world consumption, mining, extraction, beneficiation, output, mineral economics, internal trade, export trade, etc. Further details can be obtained from the Convener, Shri N. N. Chatterjee, Geology Department, Presidency College, Calcutta 12.

■ *Bombay Natural History Society Grants for Field Work*—The Bombay Natural History Society proposes to offer financial assistance for specific projects of field work in natural history to be carried out during the current year. Applications giving full particulars, including the following: (1) details of the nature of work proposed to be carried out, (2) total cost of project and amount required, and (3) previous experience of applicant, may be sent to the Honorary Secretary, Bombay Natural History Society, 91 Walkeshwar Road, Bombay 6.

■ *Award of Doctorate Degrees*—The following have been awarded the Ph.D. degree of the Poona University for the respective theses noted in parentheses against each of them: Shri Pundalik Pandharinath Chiddarwar (*Studies on the fungus genus Cercospora in Bombay*) and Shri Noshir Neriman Dastur (*A study of the metabolic changes occurring during the germination of seed grains, when only distilled water is supplied*); Dr Brij Nath Mattoo has been awarded the D.Sc. degree, in Chemistry, of the same University for his thesis on *Ionic equilibria in aqueous solution*.

Shrimati Sunder Mohini Luthra and Shri M. K. Machwe have been awarded the Ph.D. degree of the Delhi University for their respec-

tive theses on *Statistical mechanics and the partition theory of numbers and Differential cross-section for 3-7 Mev. neutrons elastically scattered from sulphur, iron, cobalt, nickel and zinc.*

INSTRUMENTS AND APPLIANCES

A simple micro stirrer

A SIMPLE MICRO STIRRER HAS BEEN developed for microanalyses involving quantities of fluid varying from 1 ml. down to small drops of fluids which are titrated on waxed slides. Its main advantages over previous methods of micro stirring are that it is cheap, and relatively simple to make and can be controlled to give almost instantaneous even mixing without splashing or bubbling. It is also suitable for continuous stirring while performing potentiometric or colorimetric titrations.

Even and splashless stirring is obtained by limiting the travel of the hammer arm by means of two movable stops, one on each side of the arm. The high frequency vibrations are transmitted and amplified by the whip of the stirring arm, the lateral vibrations of which should be very small to obtain the desired type of stirring. The amplitude of the vibrations is controlled by the length and stiffness of the wire, while their frequency can be altered by varying both the voltage energizing the bell and the setting up of the interrupter set screw [*Nature, Lond.*, **183** (1959), 201].

Moisture content meter

A NEW AND IMPROVED MOISTURE balance for fast and accurate determinations of moisture content in a wide variety of materials, e.g. dry milk, corn products, pharmaceuticals, leather, soap, detergents, soil, yeast, plastics, cotton, etc., has been designed by Central Scientific Co., Chicago. The instrument is suitable for testing products that do not change their chemical structure or decompose while losing water. The principal feature of the new balance is its built-in autotransformer which regulates voltage automatically and provides more convenient temperature control. The balance is sim-

ple to operate and reduces the time required for accurately determining the moisture content from $\frac{1}{2}$ hr or more to only a few minutes. The balance performs both drying and weighing operations simultaneously and eliminates the cumbersome procedures of weighing, drying and reweighing.

The balance is operated as follows: A 5 g. sample (exact weight need not be known) is placed in the balance pan and the indicator crank is set for 100 per cent moisture. The hood is then lowered, the infrared lamp is turned on; heat quickly penetrates the sample. When moisture is driven off, the percentage moisture lost is read directly on a calibrated scale. The instrument works on 115 V., 60 c/s. power supply [*J. Franklin Inst.*, **267** (1959), 261].

In-circuit transistor tester

THE FIRST TRANSISTOR TESTER capable of checking the performance of transistors while they are connected within their circuits, has been developed by Philco Corporation, and a commercial model will be available in the near future. The tester saves fault location and servicing time without turning on power in the equipment. Other commercially available transistor testers cannot perform in-circuit transistor measurements since they are unable to differentiate between normal input and output signals generated by the transistor and spurious signals appearing at either the input or output terminals, and arising from the sneak paths propagated by the circuitry surrounding the transistor under test. Low impedance methods are employed in both the input and output circuits to nullify the effects of the external circuitry [*J. Franklin Inst.*, **267** (1959), 260].

Ultrascope

A NEW ELECTRON TUBE, CALLED the 'Ultrascope', which is expected to help medical and industrial research, has been demonstrated recently by the Radio Corporation of America.

The tube, cylindrical in shape, $2\frac{1}{4}$ in. long and $1\frac{3}{8}$ in. in diameter, is the 'eye' of a new simple attachment for a microscope, which for the first time allows direct visual

focussing of an image under ultraviolet light. It converts invisible ultraviolet images of specimens into visible pictures that can be interpreted quickly by medical research workers in such fields as cancer, arteriosclerosis and viral infections. It should also find application in many areas of industrial research for ultraviolet examination of organic materials, including latex, nylon, tobacco, paint and foods.

The ultrascope is expected to be a valuable asset in hospitals, medical schools and biochemical manufacturing. A commercial model of the unit, equipped for direct viewing and photography, will be made available in the near future by the Bausch & Lomb Optical Co. of Rochester, N.Y. [*J. Franklin Inst.*, **267** (1959), 316].

Nitrometer

A GAMMA RAY SPECTROMETER which analyses nitrogen in solids in a few minutes is described. The unit consists of an instrument panel of various electronic components and a detection unit comprising test chamber, neutron source, scintillation counters and neutron monitor.

For carrying out the analysis the solid sample of about half a cubic foot is put into the test chamber. Fast neutrons from the source bombard the sample and are slowed down to thermal energy neutrons by the hydrogen in the sample and by shielding. These thermal neutrons are then captured by N^{14} present in the sample whereby it is converted to N^{15} . This form of nitrogen immediately decays to a lower energy state by emitting a gamma ray of 10.8 Mev. Scintillation counters detect the gamma rays, and the pulses from these counters are amplified, analysed and stored on a register.

The strength of the neutron source is monitored by another counter and pulses amplified and analysed on another register. Nitrogen content is then computed by dividing the counts from gamma register by the number of counts on the neutron register multiplied by the sample weight. The quotient is directly proportional to nitrogen in weight per

cent, the latter being determined from a calibration curve.

For nitrogen contents 3 to 6 per cent of the sample, accuracy is within 1.25 per cent of the nitrogen concentration [*Chem. Engng News*, 37 (16) (1959), 82].

New artificial larynx

A NEW ARTIFICIAL LARYNX FOR persons who have lost their voices through surgical removal (laryngectomy) or paralysis of their vocal cords is described. With a minimum of difficulty and training, laryngectomees can use the new electronic larynx to speak conversationally. It is especially effective when conversing over the telephone. By means of a finger-operated combination push-to-talk switch and inflection control, the user can easily control the pitch of his artificial voice, thus giving his speech a natural sounding quality previously unobtainable.

The underlying principle of the new artificial larynx is a vibrating driver (transducer) held against the throat. It measures only $1\frac{3}{4}$ in. in diameter by $3\frac{1}{2}$ in. long, and is completely self-contained and cylindrically shaped thus acceding to plaints of laryngectomized people for an unobtrusive device. The unit consists of a modified telephone receiver serving as the throat vibrator, a highly efficient transistorized pulse generator with pitch control, and a battery power supply. By employing printed-circuit techniques it is anticipated that an even more compact unit can be built.

The vibrator of the unit is pressed against the throat and on switching the pulse generator with the finger, the vibrations so produced are transmitted into throat cavities and transformed into speech sound by normal use of the articulatory mechanisms, i.e. throat cavity or pharynx, tongue, mouth, teeth, and lips in the vocal tract.

Output speech volume obtained with the artificial larynx is equal to that of a person speaking at a normal conversational level, though the sound is a bit buzzy and mechanical. Nevertheless, the frequency spectra of vowel sounds show that the frequency range transmitted into the person's throat is sufficient for satisfactory production of such sounds. The intelligibility tests give results lower than those of normal speech, still they are superior to those of any other artificial larynx. The new artificial larynx can give a sentence intelligibility of 97 per cent or more, depending on the experience of the users [*News from the Bell Telephone Laboratories*].

Recording microwave hygrometer

A HYGROMETER WHICH CAN ACCURATELY measure the relative humidity between $+40^{\circ}$ and -40° C. and shows promise of becoming a suitable secondary standard has been evolved by the staff of the U.S. National Bureau of Standards, Washington. The instrument is in effect a microwave refractometer which measures the change in refractive index of gas due to the change in the vapour content, and is designed to measure and record the water vapour pressure in a moving air stream, particularly at very low vapour pressures. In this instrument, employing microwave techniques (depending on the difference between the resonance frequency of two microwave cavities), the difference in refractive index between dry and humid air is determined and then converted to vapour pressure by an empirical formula.

The instrument can be readily calibrated by the use of pure gases whose dielectric constants are precisely known. Because of the automatic null-balancing technique used, the instrument has

good calibration stability. With the instrument, vapour pressures can be measured in the ranges of 0.0-15 mm. and 0-15 mm. Hg. A sensitivity of 0.004 mm. Hg with a four-decade range extending to 71.3 mm. Hg vapour pressure is obtainable. The instrument can be used to measure the refractive index of unknown gases and, therefore, lends itself for use as a gas analysis device. It is adaptable, in particular, as a quality control device, where the standard gas is sealed in the reference cavity and the position detector output is used to maintain automatically the refractive index of the test gas at a preset value [*Rev. sci. Instrum.*, 30 (1959), 348].

Auto-optic recording pyrometer

AN OPTICAL RECORDING PYROMETER that can measure extremely high surface temperatures with a response time of milliseconds has been developed. It is automatic and, even under adverse conditions such as an electric arc experiment, it gives reliable measurements of sample brightness temperatures within $\pm 20^{\circ}$ C. It accurately measures surface changes in temperature over an area of $\frac{3}{8}$ in. in diameter in the range of 1400° to 3000° C.

The radiation-sensitive element is a high vacuum phototube. Monochromatic light of wavelength 0.65 micron is focussed upon an opaque plate having a small opening which admits the radiant energy to the phototube. The phototube output is amplified by a highly stable amplifier mounted in the pyrometer housing. A recorder may be plugged into the pyrometer to provide a complete record of temperature versus time for the entire operation.

The instrument is calibrated by comparing the output with the known brightness temperature of a standard tungsten lamp [*J. Franklin Inst.*, 267 (1959), 464].

Progress Reports

NATIONAL RESEARCH COUNCIL, CANADA

THE REPORT OF THE NATIONAL RESEARCH COUNCIL, Canada, for the year ending 31 December 1957 records many outstanding contributions and the research output of the Council is indicated by the large number (over 800) of research papers published during the year in its research journals.

A method developed for the production of citric acid in 50 per cent yield by submerged fermentation of blackstrap molasses has stimulated commercial interest.

Slip cast magnesia crucibles have been fabricated which resist penetration by molten alloys and slags, e.g. ferrous oxide, fluorapatite, calcium phosphate, etc., at 1500°C. This development enables the study of the kinetics and equilibria of reactions at high temperatures without serious interference from the container.

As a result of the work carried out in the Council's Applied Physics Division, the wavelength of the orange line of krypton-86 has been adopted as the basis of International Metre. Also, the International Temperature Scale has been re-created. The new scale is superior to those established in any of the other major standards laboratories. The development of a revolutionary photogrammetric instrument, the 'Analytical Plotter', based on an entirely novel principle and which offers many advantages like simpler construction, smaller size and better stability over previous types, is also one of the many achievements of the Applied Physics Division. This instrument utilizes a mathematical projection system instead of the conventional physical one.

An interesting and highly utilitarian device developed by the Mechanical Engineering Division is the automatic crash position indicator for searching of crashed aircraft and survivors. In case of a crash, the gadget weighing c. 12 lb. disengages at the instant of impact by means of a simple mechanical system and broadcasts a distress signal continuously for a week.

A simple instrument which permits quick interconnections, without requiring much human dexterity, of the ends of the severed blood vessels has been developed and is of much importance in accident cases. The finished connections are free from internal protuberances and the method produces perfect sutures, even in very small vessels. The new technique simplifies the implanting of grafts to replace diseased sections of arteries and has been found to be quite successful in the anastomosis on the aorta of live animals.

In the following sections some of the other important research activities of the different divisions are summarized.

Applied biology—Investigations on the mechanism of carbohydrate degradation by *Aspergillus niger* have demonstrated the presence of two enzymes of the hexose monophosphate pathway in preparations of cell-free extracts from mycelia grown in

(a) a fermentation type medium (molasses) and (b) a rich growth medium. The two enzymes are (1) TPN-specific glucose-6-phosphate dehydrogenase and (2) TPN-linked 6-phosphogluconate dehydrogenase. Studies on cyanide inhibition of photosynthesis in $C^{14}O_2$ have provided new evidence for an alternate pathway of carbon assimilation that does not involve phosphoglyceric acid.

Atlantic Regional Laboratory—Methods for the analysis of galactose, anhydrogalactose and standardization of agar from various red seaweeds have been developed, which depend upon the use of the anthrone reagent and a modified Seliwanoff reagent.

Two entirely new species of *Phialophora* have been isolated along with a number of other known species of fungi which form slime at various locations in pulp and paper mills.

Prairie Regional Laboratory—A new genus and species of the fungus *Volucrispora aurintiaca* has been described and its relationships with the new species *Tricellula curvatis* and *T. inaequalis* have been clarified.

Commercially important alkaloids by pure culture of *Claviceps purpurea* have been increased by strain selection. Yields of 75 mg. of alkaloids per litre of culture mixture, of which a substantial portion is ergometrine-ergometrinine pair, have been obtained by pure culture of *Claviceps purpurea*.

Studies with C^{14} -labelled wheat starches have given new evidence of a close interrelationship between the biosynthetic routes to amylose and amylopectin. The results support the view that amylopectin is derived from amylose. Amylopectin sub-fractions isolated from the starches are found to have widely different C^{14} contents which provides radiochemical evidence for heterogeneity in wheat starch.

A mechanical foam breaker to assess the effects on large-scale fermentations of chemical antifoams, utilizing the pressure of the air fed to the fermenter as the breaking force, has been developed.

Applied chemistry—The products of the photolysis of nitrogen dioxide, a process playing a fundamental role in 'smog' formation in some cities of Canada have been identified. The long wavelength threshold of light which inhibits this process has been identified. A method has been devised for taking samples from a pressurized glass reactor without reducing the pressure. Employing this method the effects of pressure on the acid-catalysed hydrolysis of ethylene, propylene and isobutylene oxides, up to 3 kb., have been measured; this study has shown that the slow step is bimolecular, contrary to the usually accepted view.

A polymer fractionation apparatus has been fabricated and distribution of different molecular weight species in poly- α -methylstyrenes produced under various experimental conditions has been measured. Another apparatus set up to measure small amounts of monomer, evolved on thermal decomposition of polymer, using a gas chromatographic technique,

enables a more detailed study of thermal decomposition reaction of polymers.

Researches on the utilization of lignin as a substitute for carbon black in the reinforcement of rubber has led to the development of satisfactory tyres which gave better performance in road tests. The tyres showed 15 per cent better abrasion resistance than the carbon black controls.

Pure chemistry — The synthesis of a unique collection of monosubstituted steroids has been completed. Quantitative measurements on the infrared spectra of these compounds have shown that the absorption in the 1350-650 cm^{-1} region can be analysed in terms of bands associated with the functional group, side chain and the steroid ring system; in selected cases it has been possible to predict the spectra of new steroids with good approximation. Study of the crystal absorption and fluorescence spectra of anthracene has shown significant variations in individual crystals depending on their method of preparation and past history. This suggests that the energy transfer process in such crystals as well as that of charge carrier formation is influenced by the nature and number of crystal imperfections.

Applied physics — During non-destructive testing of plywood, it has been observed that the excitation of plywood surface by means of a brush resulted in noise that is quite sensitive, in the high frequency region, to the presence of blisters on plywood.

An improved method for calibrating short end gauges in terms of standard wavelengths has been developed for the measurement of optical phase change at the surface of the block, a factor which, till now, has been the greatest single source of uncertainty in such procedures. A fully engineered instrument based on the new method is being built.

Pure physics — Investigations on the influence of thermal fluctuations on the plastic flow of metals have led to a new theory of the mechanism of strain-hardening. The hardening is envisaged to arise principally from the short-range interactions between individual dislocations.

High resolution electronic spectra of the chemically unstable NCO molecule have been obtained for the first time. A new band system of P_2 near 3000 Å. has been observed whose lower state is the ground state of the molecule and whose upper state is a previously unknown excited state.

On the basis of a new principle of observation which embodies the elements of the special theory of relativity, quantum mechanics and the quantum

theory of fields and which gives a consistent theory of observation and of the transformation relations of information from one observer to another, it has been found possible to give a new simple formulation of gravitation theory which gives the same result as the general theory of relativity except for the subatomic and cosmical dynamics. In the former, the new theory is free from the divergence difficulty of the usual field theory; in the latter, the difficulty of the time scale in the usual cosmological theory based on the general theory of relativity has been eliminated.

Mechanical engineering — Work on two special machines is in progress. One of the machines incorporates several features which make it useful for the production of models of ships' hulls and other objects characterized by surfaces of double curvature, e.g. propeller blades. It can accommodate models up to 25 ft long, 5 ft wide and 2.5 ft deep and can cut light metals besides wax or wood. The other automatic control system follows a contour line on a drawing and reproduces the contour accurately on a model.

A new and highly sensitive (accurate to 1 part in 10,000) method useful for the quantitative determination of ethylene glycol, an injurious trace impurity in engine lubricants, has been developed. It is based on the cleavage of the carbon-to-carbon bond in the glycol molecule with periodic acid and estimation of the formaldehyde formed.

Radio and electrical engineering — Methods for obtaining and measuring pressures as low as 10^{-4} mm. Hg have been developed and employed to investigate the absorption behaviour and the ionic pumping of gases. A method of measuring the voltage gradient across each unit of a high-voltage suspension insulator-string by which proper design of grading rings for optimum stress distribution will be facilitated has been devised. An electric detector of flaws in paper which can sort automatically several tons of paper has been designed and fabricated and it showed satisfactory performance under actual operating conditions. To achieve greater flexibility and facility in making maps from aerial photographs, a new instrument incorporating a computer and using electronically controlled positioning of the photographs under the optical viewer, instead of the usual mechanical linkages, has been developed. A control system which automatically varies the pumping speed to maintain a predetermined blood pressure and a transistorized blood pressure monitor have been developed and used clinically with success.



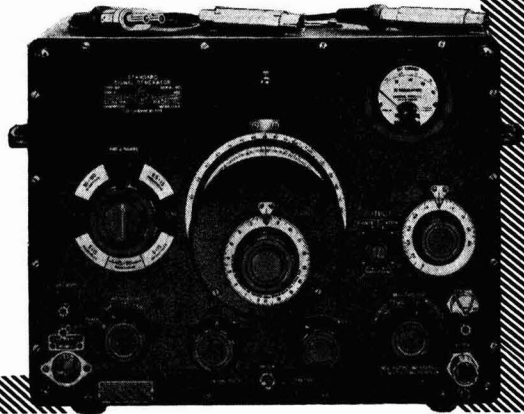
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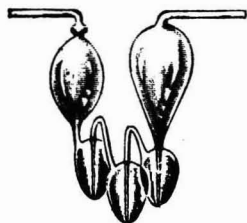
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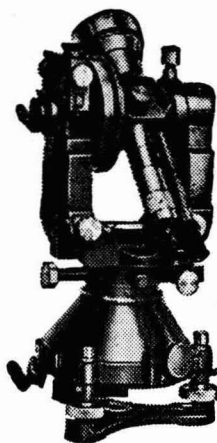
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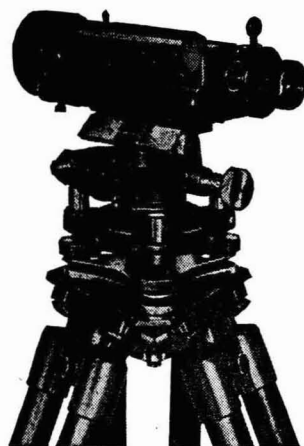
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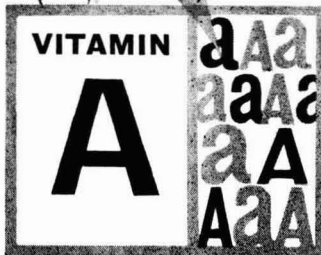
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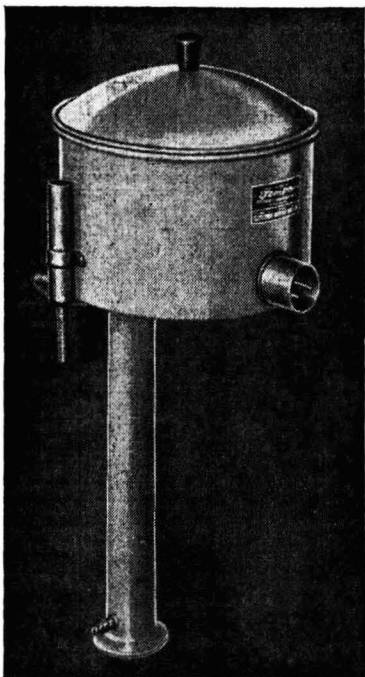
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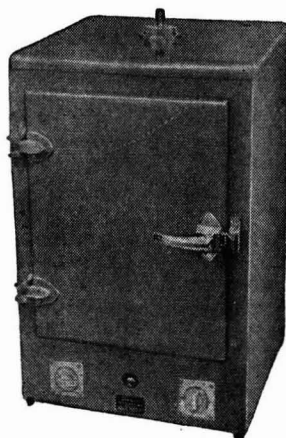
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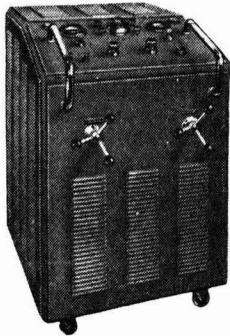
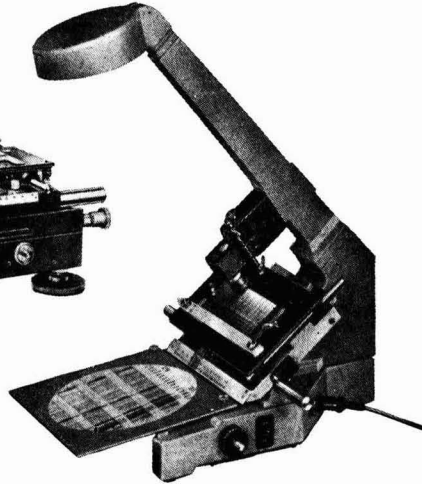
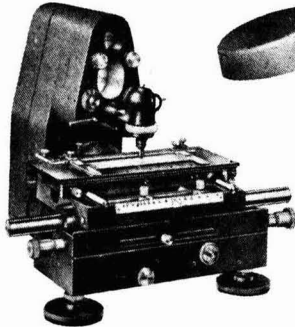
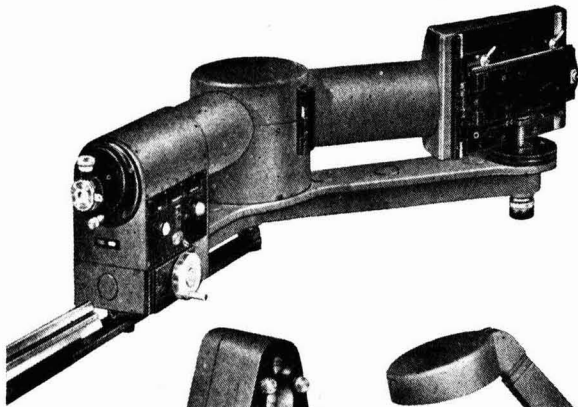
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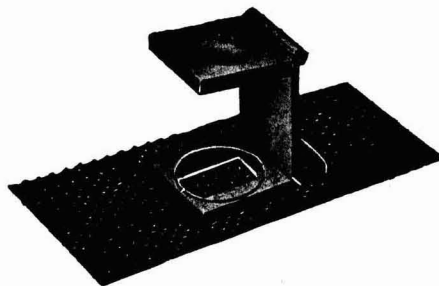
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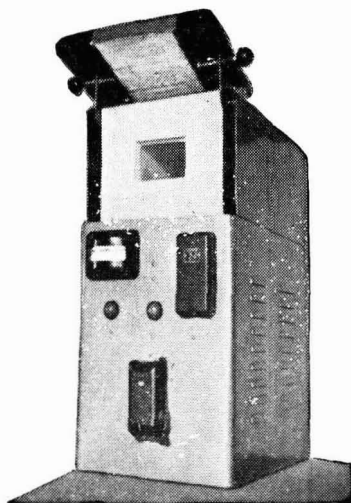
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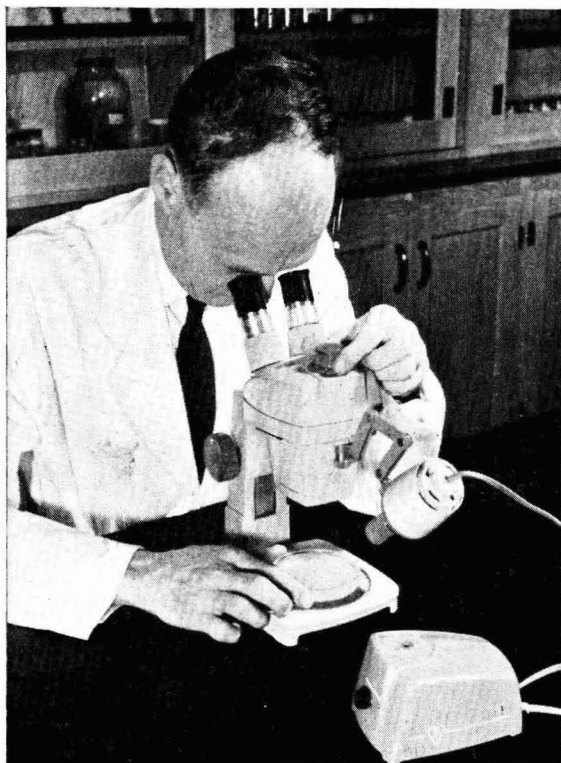
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