Journal of Scientific & Industrial Research

IN THIS ISSUE

A: GENERAL

Lathe type of disc recorder

Fractionation of shellac: shellac-urea complexes

Magnesium chloride in cotton warp sizing

B: PHYSICAL SCIENCES

Magnetic storage system for a double fourier series synthesizer

New band systems of FeBr in the visible region

Separation and identification of hydroxy acids in shellac

C: BIOLOGICAL SCIENCES

Utilization of fructose, galactose and glucose in diabetic rhesus monkeys

Two new Anoplocephalid cestodes

■ ■ ■ ■

A—GENERAL

J. sci. industr. Res.
Vol. 18A, No. 5, Pp. 201-248

MAY 1959

THE COUNCIL OF SCIENTIFIC &
INDUSTRIAL RESEARCH, NEW DELHI

nuclear-chicago

d/M-GAUGE

The Nuclear-Chicago d/M-Gauge

is a new, modern superior measuring instrument for commercial or scientific applications that require moisture and density determinations

Representative fields of application for the d/M-Gauge include:

- Studies of sub-soil moisture and density conditions prior to highway, railway, building and dam construction
- Immediate cross-section studies of moisture content and density variations which occur in the manufacture of raw materials, chemicals, consumer products, fertilizers, etc.
- The determination of asphaltic content in flexible concrete mixes and measurement of moisture content of aggregates for asphaltic mixes
- Controlled experiments on the relation of moisture to plant growth (field capacity and wilting point measurements)
- Studies of ground water movements for agricultural purposes and for drainage and irrigation control projects
- The determination of density and moisture content in heavy snows
- The maintenance of proper sand moisture in foundry castings and related processes
- The measurement and control of the moisture content of sintered ores in production of pig iron
- The quantitative inventory of large stockpiles of coal, grain or other similar masses by means of density determinations, etc.

In addition to its ready applicability to industrial processes requiring moisture or density determinations, the d/M-Gauge is an equally valuable tool for scientific research and development projects

For further particulars please write to:
Sole Distributors

THE SCIENTIFIC INSTRUMENT Co. Ltd.

ALLAHABAD, BOMBAY, CALCUTTA, MADRAS, NEW DELHI

Journal of
Scientific & Industrial Research

Vol. 18A, No. 5, MAY 1959

EDITORIAL BOARD

CONTENTS

Current Topics

For Contents of Sections B & C, *see* page A4
For Index to Advertisers, *see* page A25

The JOURNAL OF SCIENTIFIC & INDUSTRIAL RESEARCH *is issued monthly.*

The Editorial Board in its work of examining papers received for publication is assisted, in an honorary capacity, by a large number of distinguished scientists working in various parts of India.

Communications regarding contributions for publication in the JOURNAL, *books for review, subscriptions and advertisements should be addressed to the* EDITOR, JOURNAL OF SCIENTIFIC & INDUSTRIAL RESEARCH, OLD MILL ROAD, NEW DELHI 1.

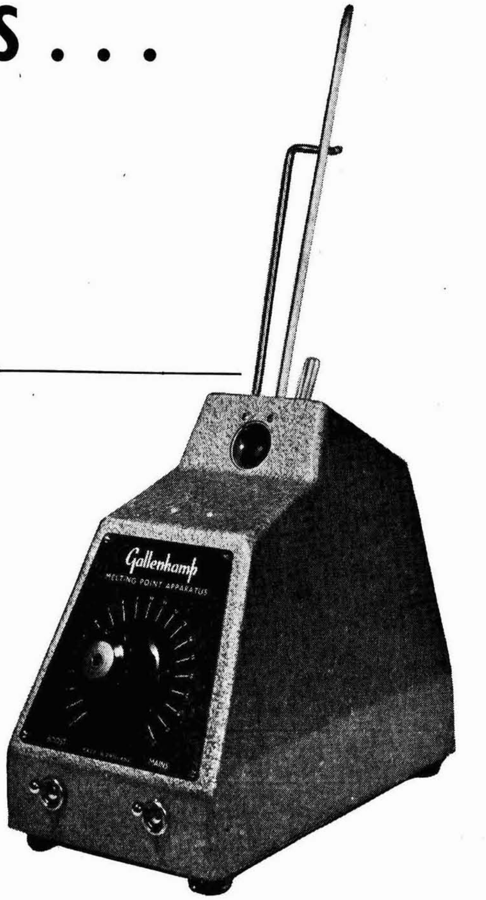
Annual Subscription: Rs 20 (inland), £ 2 or $ 6.00 (foreign). Single Copy: Rs 2 (inland), 4 sh. or $ 0.60 (foreign)

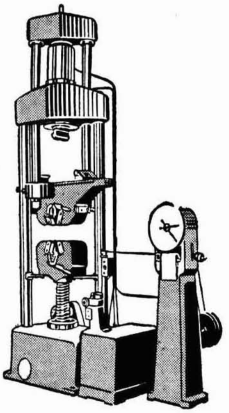
CONTENTS

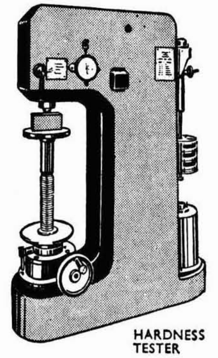
SECTION B

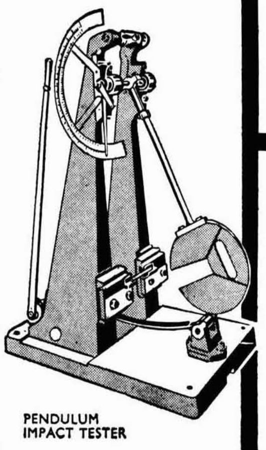
Letters to the Editor

SECTION C

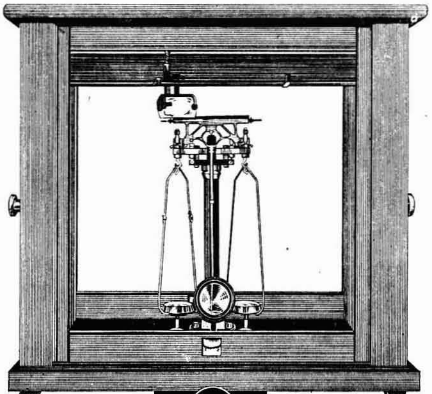

Gallenkamp
MELTING POINT APPARATUS
MAINS



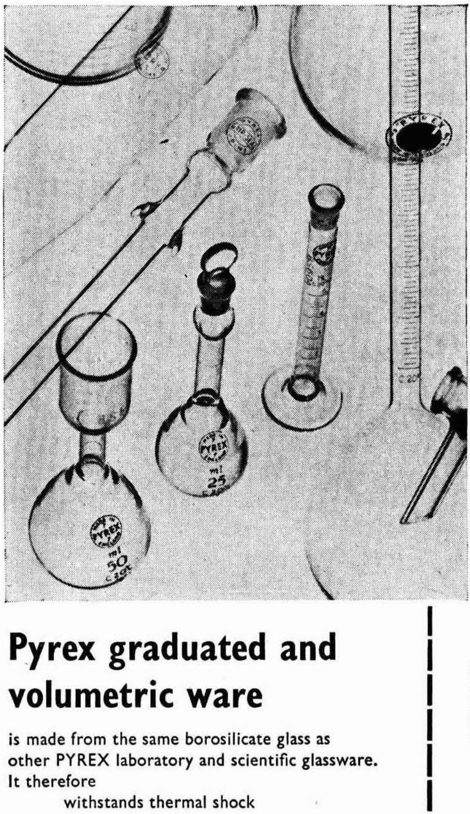





ATORY BDH REAG
Sodium Carbonate
ANHYDROUS
BRITISH DRUG HOUSES LTD
LABORATORY CHEMICALS GROUP



A good measure of Pyrex



—and measuring is more than a question of millimetres and millilitres, when you actually have the flask in your hand or the measuring cylinder before you on the bench. Will it, for instance, wash? Will it wobble or joggle? If it fell over, what are its chances? Will it *sterilize?* When it's PYREX, you needn't waste time asking these questions; for you know everything has been thought of, planned for, carefully checked. That is true of everything in the PYREX range.
Small wonder that so many people with scientific work to do demand PYREX

Pyrex graduated and volumetric ware

is made from the same borosilicate glass as other PYREX laboratory and scientific glassware. It therefore

- withstands thermal shock
- resists chemical attack
- has exceptional mechanical strength

Accurate Three grades are supplied all within the tolerances laid down by BSS for normal laboratory use, for precision work and for reference standard work: the last is independently certified by NPL

Dependable Graduation is carried out by the most modern methods

Easily readable Graduations are fired-in, permanently sharp and clear

Safely sterilized because PYREX glass withstands sterilizing temperatures easily—and that means lower replacement costs

Practical Cylinders have electrically welded hexagonal feet for extra stability; stoppers on cylinders and flasks are ground to the standard BSS joint sizes and are easily replaceable

PYREX

Regd. Trade Mark BRAND

MADE IN ENGLAND
JP
PYREX
JP

Laboratory and scientific glass

- **Obtainable from all main dealers**

INDUSTRIAL SALES EXPORT DIVISION JAMES A JOBLING & CO LTD
WEAR GLASS WORKS SUNDERLAND ENGLAND

PYREX

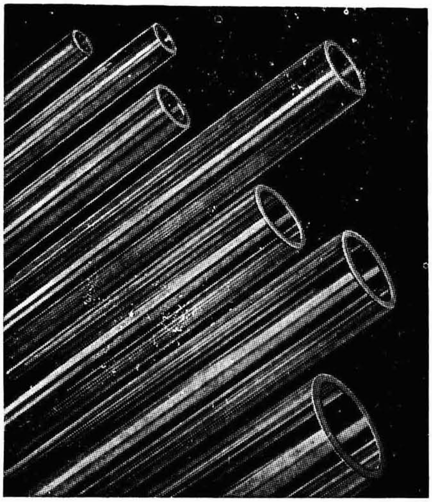
REGD. TRADE MARK BRAND

Laboratory and Scientific Glassware

A boro-silicate glass of low alkali content, 'PYREX' Brand Glassware resists attack from all ordinary reagents. Its low coefficient of expansion enables 'PYREX' Brand apparatus to be made with thicker, stronger walls, thus reducing risk of breakage while retaining a very high resistance to the effects of sudden temperature changes.

A simple but very effective system ensures accurate calibration of 'PYREX' Brand Graduated Glassware to NPL, Class A or Class B, Standard required.

The foregoing properties offer very sound reasons for using 'PYREX' Laboratory and Scientific Glassware, on grounds both of efficiency and economy.



'PYREX BRAND'
PRECISION BORE
GLASS TUBING

Made by a continuous stretching process which ensures highly accurate inside dimensions, 'PYREX' Precision Bore Glass Tubing is exceptionally suitable for hypodermic syringe barrels, pump cylinders, etc. Normally supplied with a bore tolerance of plus or minus 0.05 mm., but for special needs can be supplied to plus or minus 0.02 mm.

JAMES A. JOBLING & CO. LTD.
WEAR GLASS WORKS, SUNDERLAND, ENGLAND

Sole Agents in India

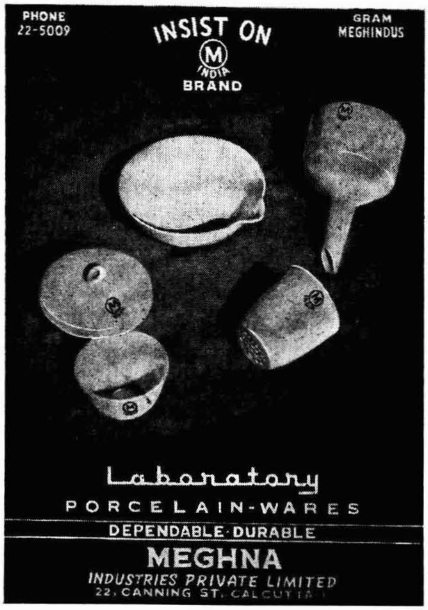
GORDHANDAS DESAI PRIVATE LIMITED
PHEROZSHAH MEHTA ROAD, BOMBAY I

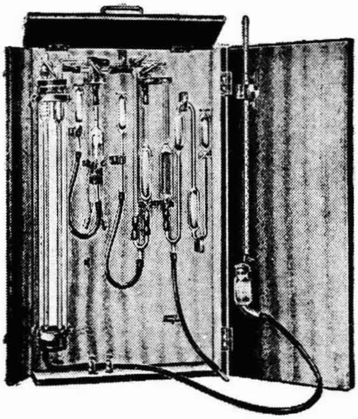
Branches :

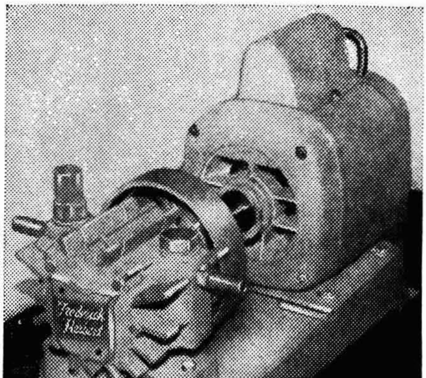
P-7 MISSION ROW EXTENSION
CALCUTTA I

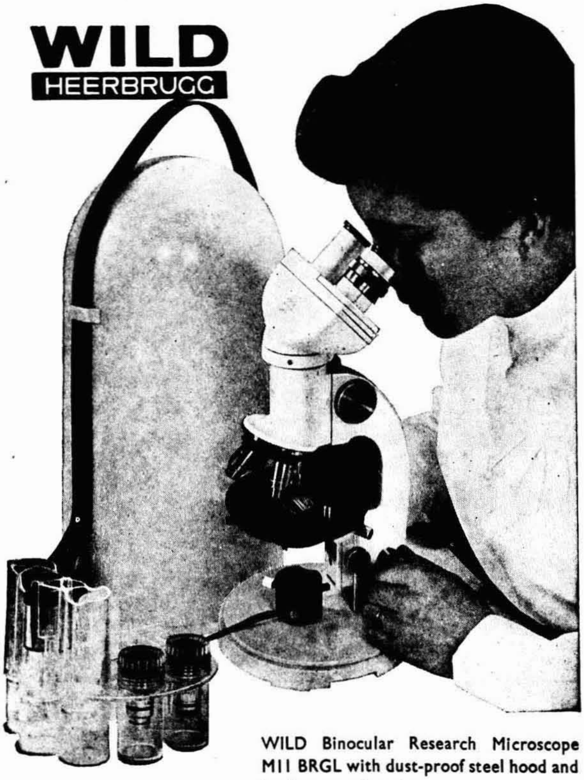
4/2B ASAF ALI ROAD
NEW DELHI

22 LINGHI CHETTY STREET
MADRAS I

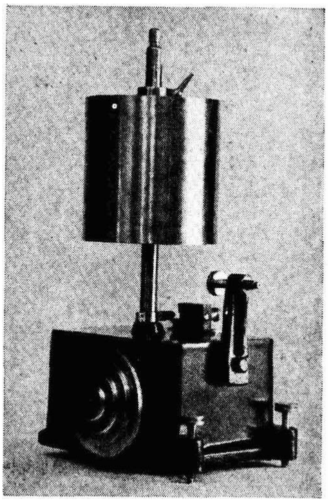


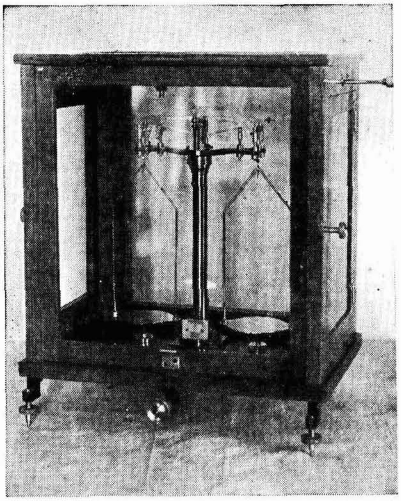






WILD
HEERBRUGG





ROUTINE CHEMICAL BALANCE

This balance has been designed to meet the normal weighings of chemicals with speed and accuracy. Its use has been wide in dyes laboratory where proportional weights have to be determined.

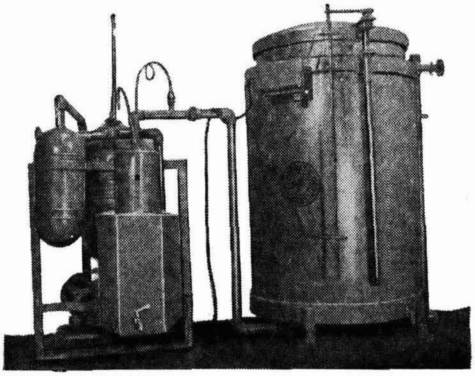
It is made from properly selected materials.

Beam & Stand — Gunmetal
Edges & Planes — Agate
Case — Teak wood and glass

As usual it carries our guarantee with it for our good workmanship and service after sale.

For further particulars please write to:

Saple's SCALES MANUFACTURING CO. (PRIVATE) LTD.
PROSPECT HOUSE, 29 RAGHUNATH DADAJI STREET, BOMBAY 1



'PINCO' GAS PLANT
for Educational, Research and Industrial Laboratories, Hospital and also for cooking purpose

We manufacture

* 'PINCO' Gas Plant, Burners, Taps
* Incubators: Hatching & Bacteriological
* Thermostatic Baths, Ovens & Hot Plates
* Vacuum Pumps, Ovens & Stills
* Laboratory Shakers & Stirrers
* Autoclaves & Sterilizers
* Automatic Distilled Water Stills
* Glass Density Apparatus
* Physical, Chemical & Biological Apparatus, Models & Charts

etc. etc. etc.

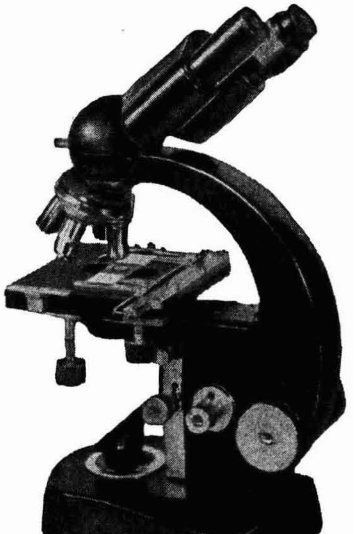
We repair

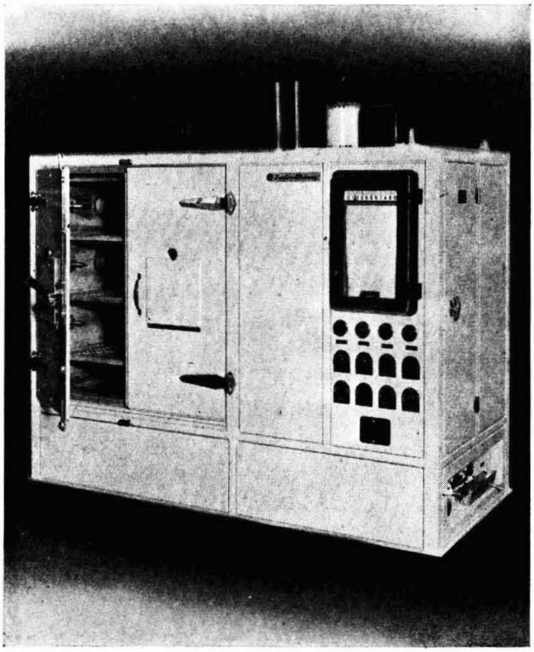
* All types of Optical, Mechanical, Electrical, Electronic & Survey Instruments

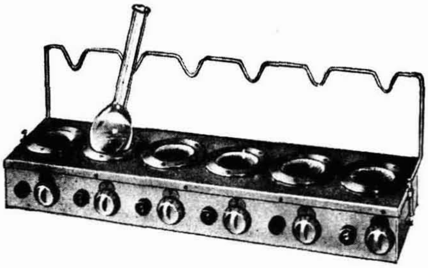
PRECISION INSTRUMENT CORPORATION (INDIA) PRIVATE LTD.
46 DHARAMTALA STREET, POST BOX No. 8905, CALCUTTA 13

Telegram :
PINCO, CALCUTTA

Telephone :
24-3271







An important announcement regarding

Comprehensive
Analytical Chemistry

Edited by **CECIL WILSON,** Ph.D., D.Sc., F.R.I.C., F.I.C.I., Queen's University, Belfast.
and **DAVID WILSON,** M.Sc., F.R.I.C., Sir John Cass College, London.

and a distinguished International Advisory Board:

R. BELCHER, B.Sc., Ph.D., F.I.F.
F. FEIGL, Eng., D.Sc.
L. GORDON, Ph.D.
L. T. HALLETT, Ph.D.
J. HASLAM, D.Sc., F.R.I.C.
E. B. SANDELL, Ph.D.
A. A. SMALES.
H. M. N. H. IRVING, M.A., D.Phil., F.R.I.C.
P. W. WEST.

¶ **Professor Cecil Wilson** of the newly created Chair of Analytical Chemistry will be assisted in this great task by his brother, David W. Wilson of Sir John Cass College, in order that Volume One, originally planned as one book, may be published in its three separate parts between **May and December of this year.** This accession of strength will be understood and welcomed by scientists since publication of the entire work may now proceed more swiftly. When completed, it is expected to run to five volumes, as detailed in the new brochure.

¶ **A work of international scholarship,** awaited with keen interest by analysts and scientists working in related fields as a reference to the widest range of analytical topics, detailing all types of determinations: classical, instrumental, and physical.

VOLUME ONE, CLASSICAL ANALYSIS

¶ **Vol. IA, General Methods of Analysis** (with separate index). Approx. 600 pages.
Pre-publication*, 90s. Post Publication*, 105s.

Vol. IB, General Methods of Analysis, contin. (with separate index). Approx. 800 pages.
Pre-publication*, approx. 120s., post*, approx. 144s.

Vol. IC, Gravimetric and Titrimetric Determinations (with index). Approx. 700 pages.
Pre-publication*, approx. 105s., post*, approx. 136s.

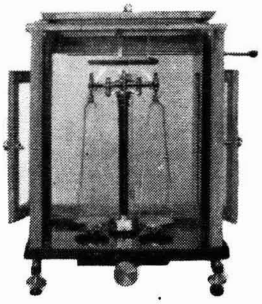
**Refers to publication of Vol. One, complete in its three parts.*

¶ **for new brochure, full details, special prices, write now to**

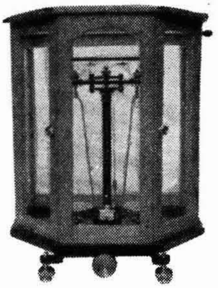
Van Nostrand

PUBLISHERS SINCE 1848 · DISTRIBUTORS FOR ELSEVIER

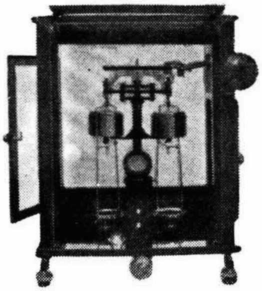
358 KENSINGTON HIGH STREET · LONDON W14 · WES 0223



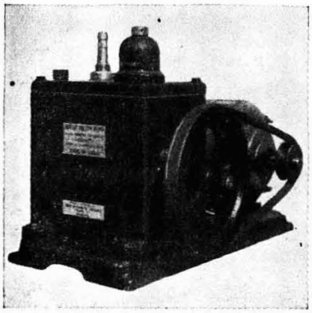
No. 5x



No. 6



No. 2



INDEX TO ADVERTISERS


D.C. RANGES
A.C. & Ω RANGES

Current Topics

SCIENTIFIC INSTRUMENTS INDUSTRY

THE SCIENTIFIC INSTRUMENTS COMMITTEE SET UP BY the Planning Commission in April 1957 under the Chairmanship of Prof. M. S. Thacker, Director-General, Scientific & Industrial Research, to assess the demand for various categories of scientific instruments and to make specific proposals for the planned development of scientific instruments industry in the country, has recently submitted its first report. In view of the increasing demand for scientific instruments, consequent on expansion programmes in scientific and technological education, increased tempo of scientific and technological research, and rapid industrialization, the publication of the report is timely. The report is to be welcomed for other reasons too: it has drawn attention to the needs of a vital industry, and it has put forward concrete and practical measures for its development on sound lines. In accordance with the terms of reference, the Committee has assessed the requirements of scientific instruments for teaching and research, and for use of the essential services and industry; the information gathered has been published in a series of appendices to the report. The Committee has surveyed the present position of the industry and has collected valuable data regarding indigenous capacity and production, imports, training facilities for technicians and specialized personnel, and establishment of standards.

The scientific instruments industry in the country is still in its infancy and there are only a few firms, both in the public and private sectors, actually manufacturing scientific instruments, while others are engaged mainly in assembling instruments from imported components. The present demand for instruments is largely from educational and research institutions and the variety of instruments needed by these institutions, essential services and industry is large, and in some cases the items number over 450. The country's needs are largely met by imports: in 1957 scientific instruments valued at Rs 589·92 lakhs were imported whereas indigenous production was worth only Rs 80 lakhs; this does not take into consideration electrical and electronic instruments imported. Many simple instruments which could be easily manufactured in the country are also imported. As regards the future requirements of the country, the All India Instrument Manufacturers and Dealers Association (IMDA) have estimated, keeping in view the increasing emphasis on scientific and technological education, and the increasing tempo of scientific and industrial research and industrialization, that the demand for scientific instruments would be of the order of Rs 15 crores per year.

It appears from the memorandum submitted by the IMDA that the industry suffers from many handicaps such as non-availability of the right types of components and raw materials; non-availability of data concerning the requirements of scientific instruments by different categories of users; lack of standards; and paucity of trained personnel. The Association has emphasized the need for undertaking a survey to assess the potential requirements of scientific instruments for use in different fields. This is being looked into by the Committee which will not only assess the future requirements of scientific instruments but will also draw up a scheme indicating the various types of instruments required and the centres where their manufacture could be undertaken. It may be relevant to add in this context that in addition to this survey, it would be worth while to carry out a survey of the basic raw materials needed for the industry as this information is important for the organized development of the industry.

In the light of the available data, the Committee has made a number of useful recommendations, of which the most important relates to the establishment of a central agency for the promotion and development of indigenous manufacture of scientific instruments on the pattern of an organization suggested by the Council of Scientific & Industrial Research. This agency will survey and assess the present and future requirements of various types of scientific instruments; draw up a phased programme of development of the industry during the next ten years; create new development and design units and centres of instrument production; establish national standards for instruments; train technicians and specialized personnel; and stimulate scientific instruments manufacture on an industrial scale. The compilation and publication of a directory of scientific instruments and components manufactured in the country; creation of a separate division in the Indian Standards Institution for standardization and testing work; and establishment of design and development units, on a co-operative basis, at a number of production centres already in existence, are some of the other recommendations of the Committee.

The report of the Committee and the recommendations embodied in it provide the basis for the planned development of scientific instrument industry in the country and the implementation of the recommendations would not only help in achieving a certain measure of self-sufficiency with regard to scientific instruments in the course of next ten years but also help the growth of an important industry.

OPERATIONAL RESEARCH

OPERATIONAL RESEARCH — THE APPLICATION OF scientific methods, techniques and tools to problems involving the operation of systems so as to provide those in control of the operations with optimum solutions to the problems — has come to be recognized as an important tool in the sphere of planning. Though for the present, operational research has found intense application in defence research and services, its value in promoting industrial objectives can hardly be over-emphasized. Recognizing this, various organizations in western countries are fostering the use of this new research tool in diverse fields of activity. In India, except in defence research and development, operational research is yet to make a deep impression. Statistical organizations in the country are adopting this technique with a certain measure of success.

The Fourth Operational Research Conference was organized by the Defence Research and Development Organization of the Union Ministry of Defence during 19-21 March 1959 with a view to bring together workers engaged in this field of research from military and civil establishments and provide opportunities for mutual exchange of ideas and experiences. The Conference also provided valuable ideas for scientists and administrators as to how operational research methods could be applied with advantage in their respective fields.

Broadly grouped under three divisions, namely (i) Techniques and Methodology, (ii) Operational Research in Defence and (iii) Applications of Operational Research, 17 papers were presented and discussed. Eight papers presented to the first session discussed the use of linear programming in the solution of certain types of military problems; a priority problem in queuing theory; a methodology for devising optimum search pattern of enemy submarine; analysis of the simultaneous inventory control with limited capital; fluctuations in population as functions of time and other parameters; the limitations of the weapon system of an aircraft carrier and its escorting vessels; load stress and efficiency; and the optimum economic reserves of stores in services. During the second session, interesting data on wastage of army recruits; efficient stock piling of shells; life of service stores under field conditions; and the role of operational research in the designing of electronic equipment and in economy of packaging, were presented. The results of studies on the effect of distracting noises on visual efficiency and rinder pest control by the operational research technique and the significant role of libraries and information services in operational research were discussed during the third session.

Nature of Coal—A Symposium

A THREE-DAY symposium on the 'Nature of Coal' was organized by the Central Fuel Research Institute (CFRI) at Jealgora from 7 to 9 February 1959 to review the work so far carried out on this subject not only in India, particularly the C.F.R.I., but also in several institutions in several countries abroad. The symposium, which was inaugurated by Prof. B. C. Guha, Head of the Department of Applied Chemistry, University of Calcutta, was presided over by Prof. M. S. Thacker, Director-General, Scientific & Industrial Research. Forty papers contributed by scientists and technologists from India and abroad [U.S.S.R. (8), Japan (3), Australia (2), West Germany (2), Canada (2), Belgium (1), U.K. (1), New Zealand (1) and Czechoslovakia (1)] were presented and discussed in six technical sessions on different aspects of coal structure including origin and systematics of coal, petrographic and X-ray studies on coal, physical and chemical methods of studying coal constitution and physico-chemical properties of coal.

Seven papers were presented in the first technical session which was devoted to the origin and metamorphism of coal. Dr A. Lahiri, Director, Central Fuel Research Institute, reviewed the present status of our knowledge on the metamorphism of coal and gave a résumé of the work being carried out in C.F.R.I. in the field. There are two petrologically discrete constituents in coal, namely vitrain and fusain. Chemically parallel to these are the 'disordered' or 'ordered' carbons in coal. The disordered fraction consists of alicyclic carbon and methyl groups (apart from functional groups), and the ordered part, made up of polycondensed aromatic nucleus, remains little affected during geothermal and geo-tectonic changes till the coal attains 90 per cent carbon content. The evolution of coal from peat to anthracite apparently takes place in several discrete steps of dehydration, decarboxylation, dehydroxylation and demethylation followed by dehydrogenation to complete the aromatization. These steps, however, concern the 'disordered' carbon, or vitrain. The alicyclic bodies are confined to vitrain and almost absent in fusain.

Prof. A. Gillet, University of Liége, Belgium, presented the results of his investigations on the action of alkali on cellulose in a closed bomb in the temperature range 150-350°. The concepts of 'simple' and 'composite' evolution were introduced and the effects of these and of external oxidizing action on the metamorphism of fuels were discussed. The five papers presented by Russian workers dealt with fossil fuels and brought out the fact that during the initial stages of coal formation, biochemical synthesis plays a chief role. The studies carried out by this group relate to the genesis of fossil fuels such as peat and lignite, and the nature of caustobioliths and origin of sulphur in coal. Prof. Kassatochkin, Institute of Fossil Fuels, Moscow, on the basis of thermodynamic concepts, arrived at the conclusion that the coalification process comprises two steps: formation of condensed aromatic layers and their subsequent growth. Condensation to aromatic ring takes place at the peat stage involving high activation energy and a corresponding low rate of reaction. Subsequent growth process of the aromatic layers requires low activation energy and hence takes place easily.

Four papers dealing with petrography and X-ray studies on coal were considered in the second session. K. C. Lahiri and R. N. Bhattacharya (CFRI) drew attention to the wide divergence in the physical and chemical properties of the petrographic components in coal from the same source and between coals from different sources, and pointed out that rank classification of banded coals based only on chemical analyses of the overall coal is unreliable. Modified washability characteristic curves have been constructed by them, which in addition to providing information on the ash content and yield of the coal fractions, also give data regarding the petrographic composition of the coal for different specific gravity cuts. This will enable the selection, for specific use, of a coal fraction with suitable petrographic composition. X-ray studies on coal, carried out by S. Z. Ali (CFRI), have shown that substitution in the coal nucleus is relatively small (often < 4), the number of rings increases from 2·1 to 5 for coals with 80 to 93 per cent carbon and the number of C—OH, C=O, C—O—C and C—C linkages, the ratio H_{ali}/C_{ali} and methyl groups decrease with the rise in the rank of coal.

In the session on ultra-fine structure of coal, in which 4 papers were presented, I. G. C. Dryden, U.K., evaluated the possible influence of functional groups on the surface area of coal and drew attention to the fact that it is possible that a given level of carbon content does not indicate similarity between coals in different regions. He concluded that bituminous coals have specific internal surface in the range of 30-100 sq. m./g. The greater part (70-90 per cent) of the oxygen in bituminous coals occurs as hydroxyl and quinone groups, the former probably exceeding the latter except in coking and higher rank coals. Investigations at C.F.R.I. by K. A. Kini *et al.* have shown that the surface area of a coal has a value which is intermediate between that measured by the Argon adsorption method at −183°C. and that obtained by the heat of wetting or adsorption method using methanol. P. L. Agrawal, Hindusthan Steel Ltd, has determined the apparent density of powdered samples by mercury displacement method and has noted a close relationship between the density and surface area as measured by gas absorption. A minimum value of 1·29 g./ml. for the real density of coal has been obtained for a sample with 86-87 per cent carbon. The relationship between specific volume and per cent nitrogen is similar to the linear relation between specific volume and hydrogen. From observations on the sudden rise in density of coal during carbonization at 450-500°C., it has been inferred that important structural changes take place in the coal at that range.

The application of physical methods for investigating the constitution of coal and the results of such studies were dealt with in seven papers during the fourth session. T. N. Basu and D. Bagchi (CFRI) have observed a progressive linear relationship between rank of vitrain and its reflectance with breaks at points dividing the vitrains into groups, viz. high rank with $C > 85$ per cent and the other low rank with $C < 85$ per cent. In the semi-anthracite and anthracite region with above 90 per cent carbon, a sharp and abrupt increase in reflectance is observed with rank. D. S. Montgomery and his co-workers, Department of Mines and Technical Surveys, Ottawa, Canada, presented relationships between the refractive index, density and hydrogen/carbon ratio of the quinoline-soluble portion (binder) of the pitch with the help of which it is possible to predict the hydrogen to carbon ratio and density of the binder hydrocarbons in the whole pitch without the removal of free carbon. R. A. Durie and S. Sternhell, C.S.I.R.O., Australia, have found that the spectrum of lignin treated with hydroiodic acid is very similar to that of brown coal. A. Mukherjee and co-workers, Institute of Nuclear Physics, Calcutta, described their work on the paramagnetic resonance of coal samples from different depths and D. C. Bhardwaj, Birbal Sahni Institute of Palaeobotany, Lucknow, discussed the importance of micropalynological investigations in the correlation of coal seams.

Of the 14 papers presented in the fifth session on the application of chemical methods in the elucidation of the constitution of coal, nine were from C.F.R.I. T. A. Kukharenko, Institute of Fossil Fuels, Academy of Sciences, U.S.S.R., described the results of investigations on the composition and structure of humic acids. The main structural links of the macromolecules of humic acid comprise an aromatic system of a low degree of condensation with aliphatic side chains. Methoxyl, carboxyl and carbonyl groups have different spatial distributions. Nitrogen, oxygen and sulphur exist partly in closed rings and partly in the side chains. With increase in the rank of coal, the humic acids tend to have a more condensed aromatic structure containing fewer side chains and hydrolysable bonds. The ether bond increases with the increase in the rank of coal, and this is also reflected in the optical density measurements on the alkaline solution of humic acids. Based on their studies on oxidation of coal and chemical structure of humic acids, C. Yokokawa and co-workers, Kyoto University, proposed a structural model of coal with a number of polymerized structural units each of which on oxidation becomes humic acids. They also suggested that in the case of lower rank coal, the structural differences between unit structure and bonding part are not quite distinct, because of the presence of many phenolic groups and the degree of condensation of aromatic rings is low. With progress in coalification, aromatic condensation proceeds with the growth of unit structure and the reduction of bonding part. P. M. Mukherjee and A. Lahiri (CFRI) presented evidence to show that the structural units of coal and humic acids are practically identical and they derived a structural model for humic acid. Studies on aerial oxidation of Assam coals have led M. S. Iyengar (CFRI) to differentiate three types of sulphur: (i) sulphur eliminated during the initial stages of oxidation (unidentified so far), (ii) sulphur oxidized to sulphonic acids identified as thiophenol and found to be constant (*c.* 2·3 per cent) for the coals studied, and (iii) sulphur resistant to oxidation identified as thiophene. Thiophene in coals containing over 3 per cent organic sulphur increases with increase in sulphur content, the variation in thiophene content being from 0·22 to 2·14 per cent; thiophene is absent in coals containing less than 3 per cent organic sulphur. K. A. Kini and co-workers (CFRI) suggested that the improvement effected in the coking property of coal by partial hydrogenation may be bound up with the removal of the more stable oxygen linkages.

Dehydrogenation studies with coal have led B. K. Mazumdar and his collaborators, at C.F.R.I., to bring out the significance of alicyclicity in coal structure on the behaviour of coals. The alicyclic carbon is the coking constituent of coal and by manipulating it, it seems possible to achieve fundamental changes in the property of coal. A. Lahiri contended on the basis of this finding that by mixing chemicals containing alicyclic structures such as quinine, pitch, etc., a non-coking coal may be converted into a coking variety. Another observation made from this study is that irrespective of the ranks of coal, on prior dehydrogenation, the retention of carbon in coal on low temperature carbonization is of the order of 90-91 per cent while normally 70-80 per cent of carbon only is retained. The extra carbon is a measure of the alicyclic carbon and hence also the alicyclic hydrogen in coal. The results of studies on sulphonation, wet chlorination and the aliphatic groups of coal were presented. H. S. Rao *et al.* (CFRI) postulated a free radical mechanism for the coalification process based on their investigations on $C-CH_3$ group in coals. Demethanation in coal metamorphism is considered as a result of demethylation and dehydrogenation of the alicyclic groups by free radical reaction mechanism. From theoretical consideration, these workers calculate that the evolution of methane per ton of coal is 28 cu. m. during its evolution from 79 per cent carbon to 93 per cent carbon.

Low temperature coke or char is considered totally aromatic in character and pyrolysis of coal up to 600°C. does not liberate any of the aromatic carbon in it. B. K. Mazumdar and others (CFRI) presented additional data to establish that the primary bodies in tar result mainly from the hydro-aromatic part and the hydrocarbon gases arise from the aliphatic part of coal. K. A. Kini *et al.* stated that ring condensation occurs at about 500°C. and that a good correlation exists between the active groups content and the gaseous products of pyrolysis of coal.

Some of the physico-chemical properties of coal were discussed in five papers during the sixth session. C. Kroger and N. Dobmayer, Institute for Brennstoffchemie, West Germany, postulated, on the basis of specific conductivity studies, that fusinites and semi-fusinites are formed by thermal process. It was, however, brought out during the discussion that there are some fusains which are not of thermal origin. N. N. Dasgupta and his colleagues at C.F.R.I. reported excellent agreement between the reaction velocity of coking and rank of coal, and between reaction velocity and the physical strength of coke. They also noted that the quality of metaplast is of greater importance than its quantity in determining the final strength of the coke. From a study of the weight loss-temperature curves in relation to the nature and kinetics of the pyrolytic process, N. Berkowitz, Research Council of Alberta, Canada, suggested that the weight loss-temperature curves are governed by rate-determining diffusion process and that the decomposition reactions occurring in coal at any temperature are relatively fast.

Conclusion

The symposium not only served the purpose for which it was organized, but also revealed the active interest that is being shown by different coal-producing countries on research into the constitution of coal. Summarizing the proceedings of the symposium, both Dr A. Lahiri and Dr J. W. Whitaker brought out the highlights of the findings by the different schools of workers and drew a broad parallelism between the metamorphism of coal and the evolution of life itself. The need for greater and sustained interest in the study of rheology of coal was also emphasized.

A Lathe Type of Disc Recorder

I. RAMAKRISHNA RAO & G. S. S. SARMA
Faculty of Instrument Technology, Madras Institute of Technology, Madras

Manuscript received 5 *June* 1958

The construction and performance characteristics of a 12 in., 78·26 r.p.m., lathe type disc recorder, complete with magnetic cutter, record-replay amplifier and power supplies, are described. The unit incorporates new features like (i) simplified and stable vibration-free mounting of the driving motor, (ii) simplified friction-drive gear with micrometer control for speed adjustment, (iii) adjustable spindle bearing to compensate for wear and (iv) precision cutter mount.

The recorder, most of the individual components of which have been fabricated using indigenous construction materials, is specially designed for use in the tropical climatic conditions obtaining in India.

OF the different types of records in use for recording sound, the flat-disc type is the most common due to its small mass which facilitates storage and ease of handling both when recording and replaying. Recorders with lathe mechanisms are principally used for professional work and those with swinging arm mechanisms for home use. In both cases the main feature is a turn-table of a slightly bigger size than that of the record. The latter is more commonly used due to the inherent ease of operation. The turn-table is coupled to a lead screw which varies the position of the cutterhead continuously, while the cut is taking place. The path of the cutterhead with respect to the table is a radius in the case of lathe mechanisms and an arc in the case of swinging arm mechanisms. The cutting needle, fixed inside the cutter-head, cuts a uniformly smooth spiral or helical groove, due to the motion imparted to the cutter-head itself. The path of the cutting point, when modulated, is no longer uniform but becomes zig-zag depending on the frequency and amplitude of the signal. Cutterheads are principally of two types: electrodynamic and piezoelectric. In the former type, fluctuating currents through a coil, due to the input signal, actuate the oscillations of the cutting needle, while in the latter, voltages actuate the motion.

Although magnetic tape recording is a serious competitor, it can never replace disc recording entirely, particularly where a number of copies are required at reasonable cost. The manufacture of disc recorders has not received much attention in India so far, although equipment made abroad, by reputed manufacturers like Presto (U.S.A.), Audio-Devices (U.S.A.), and E.M.I. (U.K.) are widely used in the country. The cost of imported equipment is prohibitively high, besides difficulties in procurement. The present investigation was undertaken with a view to studying (a) vibration-free mountings of motors, (b) speed stabilization of rotary systems, (c) electrodynamic transducers with flat response characteristic, and (d) high fidelity audio amplifiers, monitoring and equalizer systems. These have been solved satisfactorily employing indigenous materials. Consideration of the availability of materials and methods involved modifications of design to suit Indian conditions. The performance of the recorder, tested according to accepted standards of professional recordings, has been found to be satisfactory.

General description of the recorder

New features — The recorder incorporates certain new features like (i) simplified and stable vibration-free mounting of the motor, (ii) simplified friction-drive gear with micrometer control for speed adjustment, (iii) adjustable spindle bearing to compensate for wear, and (iv) precision cutter mount.

Motor and its mounting — The recording table is driven by a fractional horsepower motor, mounted with its spindle vertical, on spring supports, inside a U-shaped bracket. The size and rating of springs are determined by trial (owing to the fact that suitable materials are not available as per design) such that the natural frequency of vibration of the springs under the load and that of the motor are far removed from the range of frequencies generally used in recording, and the amplitude of transmitted vibration to the mount was negligible. The transmitted amplitude of vibration of the motor to the turn-table was approximately $1{\cdot}6 \times 10^{-5}$ in., which is 45 db. below the maximum signal amplitude, which, in the present case, was approximately 9×10^{-3} in. The amplitude of mechanical vibrations of the table was found to increase slightly to 40 db. when the turntable was geared to the motor and was in rotation. This is supposed to be due to imperfections in the friction-drive transmission system used. By the provision of steel helical springs, replacing the rubber grommets in conventional designs, the defects due to age, which are normally present in parts mounted with rubber, were eliminated. The design of the entire spring mounting system is simple if requisite materials of the correct specifications are available. Good stability and elimination of interfering resonances can be ensured by electromechanical analogies. The provision of viscous damping has not been attempted since, even with the above set-up, satisfactory results have been obtained, there being a mechanical rumble level of approximately 40 db. under operating conditions. This figure compares favourably with the specifications of equipment made by reputed manufacturers. The springs support the motor in the bracket through flange bushings provided at each end of the springs. Thus, the bushing at one end of the spring was suitably tapped to go on the motor tie-rods, while those on the other end were provided with suitable holes so that the free ends of the springs could be fixed, by means of bolts and nuts, to the framework consisting of the bracket and the top-plank.

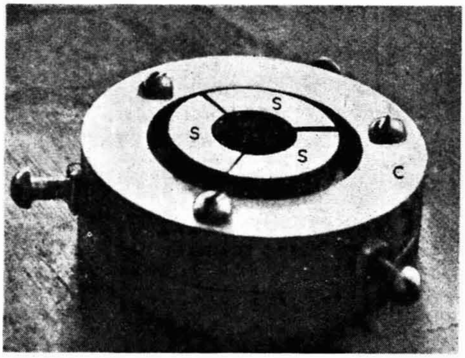


FIG. 2 — PROVISION FOR COMPENSATION OF SPINDLE BEARING WEAR [S, S, S, brass sectors; and C, cover]

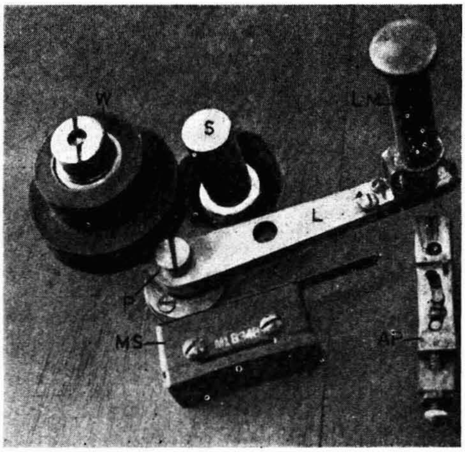


FIG. 3 — FRICTION DRIVE AND THE LOCKING SYSTEM ENABLING VARIATION OF TURN-TABLE SPEED [AP, plate assembly; L, crank lever; LM, locking mechanism; MS, microswitch; P, lever pivot; S, motor spindle extension; and W, hard rubber wheel]

Turn-table — The turn-table (Fig. 1), 12 in. in diameter, was made of cast iron of ¼ in. wall thickness throughout, fitted on a spindle over its flange. At the bottom end of the spindle a cavity was made in order to locate a steel ball on which the spindle was supported. A corresponding cavity was made in the top of the bearing for the spindle to locate the steel ball. This, together with the recessing on the spindle about the centre, reduced frictional resistance considerably, compared with conventional type of foot-step bearings. Compensation for wear was provided by a special set-up at the top of the bearing as shown in Fig. 2. The set-up consists of three sectors S, S, S, made of brass, housed inside a cover C (Fig. 2) such that they can be made to close on the shaft and fixed in any given position by means of bolts and checknuts. Thus any shaking due to wear can be compensated and the spindle runs true and smooth. The friction drive to rotate the turntable was provided by means of a hard rubber wheel W (Fig. 3), which has a bronze bush at the centre. This was pivoted on the short end of the crank lever L, which in turn was pivoted at P on the table. At the other end of the lever, a self-acting locking

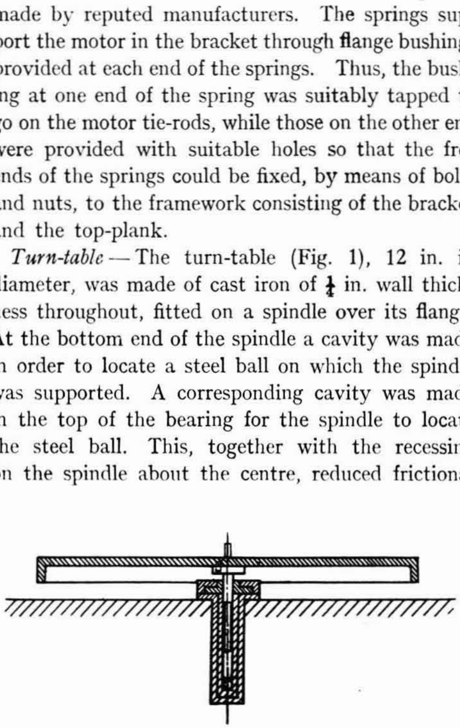


FIG. 1 — CONSTRUCTIONAL DETAILS OF TURN-TABLE

mechanism LM was provided to lock the lever in position, when the rubber idler is in contact with the table and the motor spindle extension S and the table is in rotation. Locking was achieved by means of a pin which registers itself in a hole provided in an adjustable plate assembly AP. Thus, the rubber wheel can be moved away from the turn-table and the motor shaft when it is desired to stop the turn-table, or it can be brought into engagement with both by suitably shifting the crank lever. This provision preserves the shape of the idler, since it is contacted only with parts in rotation. The top plate assembly AP can be altered to any position and fixed in the requisite position to vary the contact pressure between rubber wheel, motor shaft and turn-table. Thus the torque transmitted to the table and hence the speed of the turn-table can be varied and maintained at any value. Also, this torque determines the variation of the speed when the cut is actually taking place, since the resistance to motion offered by the cutting point in shearing hair-like material from the surface of the recording blank, causes varying resisting moments from near the centre to the edge of the record. The shifting of the crank lever to the locking position simultaneously starts the motor (drive) through a microswitch MS provided on the table. Thus, the turn-table is started just by shifting the lever to its self-locking position, and stopping is effected by displacing the lever from its locked position. The maximum recording time per side of the 12 in. disc is 5 min. The initial and the end diameters are respectively 3·75 and 11·5 in.

A lamp holder with shade is provided on the table to illuminate the table for work at night and also for obtaining sufficient contrast during the day.

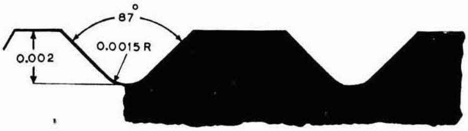


FIG. 4 — SHAPE OF THE GROOVE MADE ON THE RECORD

A low-power microscope (with a magnification of 200) is also provided to check the 'land' to groove ratio, and to set it to the proper value for optimum results. When properly illuminated the regions of 'land' appear as white and the grooves black.

The usual practice of equal land to groove width ratio was adopted by making suitable adjustment on the lathe mechanism, and on each occasion the surface of the record was observed under the microscope, before the recording was started. This setting is important in order to obtain proper depth of cut and good modulation. If the groove is too shallow, tracking on replay will be difficult; if the groove is too deep, then the width of land is narrowed down resulting in cross-cutting into adjacent grooves during high modulation levels. The shape of the groove made with the standard 87° short shank straight cutting stylus and the depth of cut, which give satisfactory results, are shown in Fig. 4.

Lathe mechanism — A lathe mechanism (Fig. 5) is provided to space the position of the cutter continuously as the disc rotates, the path taken by the cutting point being a spiral. A pitch of $\frac{1}{112}$ in. was chosen, this being the standard value. The lead-screw having 24 threads/in. is driven through a six start worm meshing with a wheel W. The wheel W, having 28 teeth, is fixed to one end of the leadscrew, and the worm is fixed on the top of a flange.

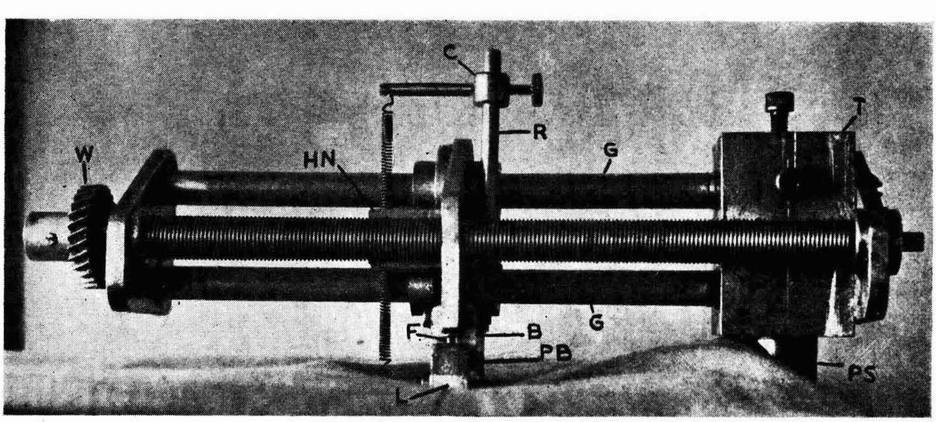


FIG. 5 — LATHE MECHANISM TO SPACE THE POSITION OF THE CUTTER CONTINUOUSLY AS THE CUTTER ROTATES [B, bracket carrying the cutterhead; C, collar; F, set screw; G, G, guide rods; HN, half-nut; L, lever; PB, pin block; PS, pivot shaft; R, guide rod; T, terminal block; and W, worm wheel]

The flange which registers itself on the central pin of the table can be clamped to the table by a cheese head screw. Thus it rotates with the table. The lathe mechanism is provided with a terminal block T at the bottom of which a stout pivot shaft PS (Fig. 5) is provided. The shaft rests on a vertical flange bearing and can be clamped in any desired position by means of a wing nut. Thus the end of the lathe mechanism which carries the wheel rotates about its pivot and the wheel can be brought into mesh with the worm, and the lathe mechanism locked in position, so that the leadscrew remains geared to the turn-table through the worm. This method was found to have the advantage that any rumble of the table has little effect on the cutter modulation.

The cutter carriage slides on two horizontal guide rods G, G. On one side of the carriage a half-nut HN (Fig. 5) is provided with a tail-pin and a knob; the pin passes through a bearing fixed on the carriage and a compression spring is provided to thrust the half-nut on the leadscrew, displacing the cutter carriage when the leadscrew rotates and when the cut takes place. However, the half-nut can be disengaged from the leadscrew and held in that position by means of the knob. This facilitates quick displacement of the cutter carriage when necessary.

A bracket B (Fig. 5) carrying the cutterhead is fixed at the bottom of the cutter carriage. A lever L is pivoted to the bracket through adjustable screws resting on steel balls ($\frac{1}{32}$ in. diam.), housed inside the bracket in suitable cavities. Thus the balls make ring contact with both the bracket and the lever. The screws can be adjusted and locked in position by means of checknuts, such that perfect vertical compliance without any side play is obtained for the lever. Side play of the lever is not permissible since this causes non-uniformity of pitch and depth of cut besides cross-modulation. At the front end of the lever a pin block PB is fixed; the horizontal rod at the back of the cutterhead passes through the hole in the pin block and is fixed by a set screw F at the top of the block. Thus the position of the cutter can be varied in azimuth and vertical planes and fixed in the desired position so that proper cutting angle is obtained for the cutting needle, placed inside the cutterhead and the chip (hair-like material removed from the blank while cutting) is thrown towards the centre. The mode of cut is inside out; this is essential for smooth and uniform cutting.

Provision is made for adjusting the depth of cut by sliding one end of the tension spring attached to a pin on a collar C which can be slid along a vertical guide rod R fixed on the carriage. The other end of the spring is connected to the lever carrying the cutter. Thus the reaction between the cutting tip and the disc can be varied by trial for proper depth of cut.

The normal practice for obtaining proper tracking and good modulation (5 to 10 db. below commercial pressings) is to make the land and groove width equal when unmodulated.

Cutterhead (Fig. 6) — This is constructed out of available materials such as a horse-shoe pickup magnet and pole pieces. The armature which carries the cutting point is made of forged soft iron and is of the shape of a cross, the cross-section of the limbs of the cross being circular throughout except at the end point lying between the top pole pieces where damping pads are provided (where it is finned). The horizontal arms are hollow and one side of the arm is tapped to take a light weight fixing screw, to fix the cutter needle which is inserted from the bottom short limb of the cross. The distance between the two halves of the pole pieces can be adjusted and fixed in any desired position so that compliance of the bearing can be controlled for good frequency response. The top wings of the pole pieces have slots in which rubber damping pads are inserted. The compliance of these pads can be

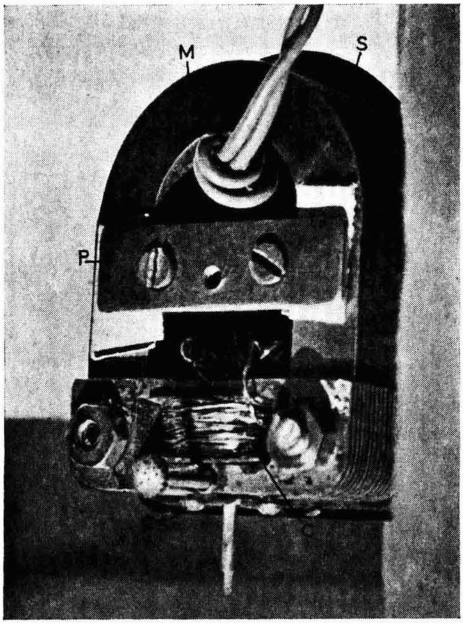


FIG. 6 — CONSTRUCTIONAL DETAILS OF THE CUTTERHEAD [C, coil; CS, clamping screws; M, magnet; P, bridge plate; and S, ebonite sheet]

adjusted by adjustable screw ends butting these against the tail fin on the armature. The magnet M is placed over the pole pieces, which are themselves fixed over an ebonite sheet S, and is fixed to this sheet by means of a bridge plate P and set screws. This is essential to prevent relative motion between the pole pieces and the magnet, when the system is in vibration. A coil C made of 33 s.w.g. super enamelled copper wire is made on an ebonite former with an impedance of 15 ohms at 400 c/s., the d.c. resistance being 4 ohms. The former is made such that the armature, which passes through the central hole in it, vibrates freely. At the same time, the clearance is not larger than what is essential. Also, the wall thickness of the former is kept minimum to provide maximum winding space. The placement of the coil in the pole piece assembly can be seen from Fig. 6; the position of the coil with respect to the poles is fixed by means of clamping screws CS. The plate carries a horizontal pin at the back through which it is fixed on the lever of the cutter carriage as indicated earlier.

Replay unit — The replay unit used was a Garrard type TOM/2 pickup head with permanent sapphire needle and a matching Garrard tone arm. The general arrangement of the unit is shown in Fig. 7.

Recording amplifier — The recording amplifier constructed for this purpose was of the conventional type. A 35-watt high fidelity feedback amplifier circuit was chosen to secure the specified flat response characteristics and low distortion. The specified noise and hum levels are appreciably low, even when the gain of the amplifier is large enough, for all recording purposes. Also, bass and treble controls are provided for use when the amplifier is utilized for purposes of reproduction. The amplifier was constructed with ordinary radio components, but with a good quality output transformer, and gave satisfactory performance as a combined record and replay amplifier.

The frequency response of the amplifier and the effect of tone controls are shown in Fig. 8 in which the frequency (abscissa) in c/s. is plotted against the output ratio (ordinate) relative to the level at 1 kc/s. It is observed that the amplifier response characteristics for recording are practically flat and within 1·5 db. in the frequency range 50 c/s. to 10 kc/s.

Low frequency attenuation, required for satisfactory recording of the higher frequencies, was achieved by introducing a 10-ohm resistor in series with the cutter coil. The effect of this resistor is prominent only in the low frequency region, where the impedance of the coil is comparable to the resistance, with the result that the effective load at low frequencies is due to impedance of the coil and the series resistor together. In the present case, the changeover frequency occurs at about 500 c/s.

The hum level of the recording amplifier constructed for the above was found to be −60 db. maximum output. A local station tuner, monitoring system, and level indicator are also provided and all the units are rack mounted. There is provision, on this, for a second power supply, play-back unit for optical/magnetic sound reproduction, and a 4-channel mixer pre-amplifier with adjustable equalizer. To the volume unit meter used for this work, a suitable series resistance is added to suit the requirements of the recording head.

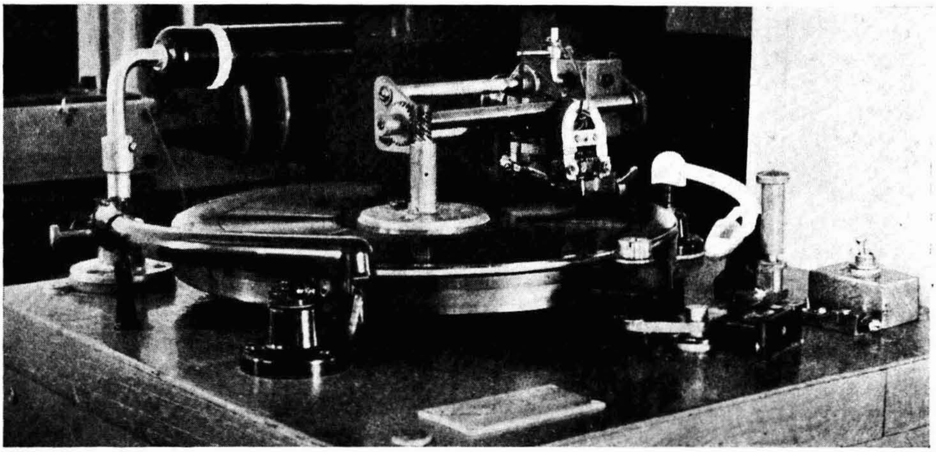


FIG. 7 — GENERAL VIEW OF THE REPLAY UNIT

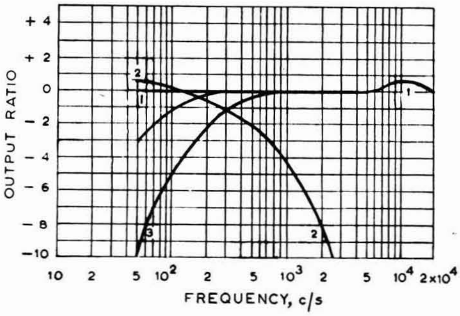


FIG. 8 — FREQUENCY RESPONSE OF THE AMPLIFIER [Curve 1, recording characteristics; curve 2, treble control characteristics; and curve 3, bass control characteristics]

Electrical analogue of the mechanical systems

For a better understanding of the mechanical systems in vibration, they can be represented in terms of an equivalent electrical circuit.

The springs of the anti-vibration mounting not only have compliance (restoring qualities) but also resistance to motion which is a function of the spring rating. The amplitude of vibration transmitted to the mounting is approximately a function of $(k/m\omega)$, where k is the damping factor, m the mass of the system (disturbed) and ω the frequency of the disturbance. The ratio of the amplitudes of disturbing and transmitted vibrations is nearly equal to $(\omega_o/\omega)^2$ where $\omega_o =$ natural frequency. Thus, by making the resonant frequency of the system sufficiently low (one-quarter of that of the disturbing frequency) the amplitude of the transmitted vibration is effectively reduced, at the same time ensuring a stable mounting which is not easily disturbed under the operating conditions.

Since the lowest recorded frequency was limited to 50 c/s. the low frequency modulation (24 c/s.) at low amplitude is ineffective to realize a good signal to noise ratio. As specified earlier, this is 40 db. below maximum signal level.

From the equivalent circuit diagram (Fig. 9), it can be seen that the mass of the armature behaves like an inductor in the system, with its compliance shunting the current path. From this it is clear that the mass and stiffness of the armature are related and, therefore, provide an optimum value for the maximum frequency response. Thus, the best results are obtained when the mass of the armature is small and its stiffness high, both of which are opposing conditions. A compromise is made by designing a tubular armature which has smaller mass but good rigidity (low compliance) with the result that the response at higher frequencies is improved. Similar conditions govern the performance of the cutting needle, whose mass and compliance are related similarly.

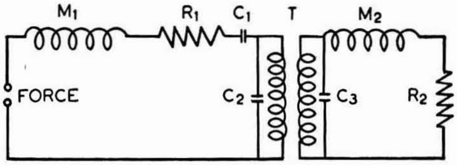


FIG. 9 — APPROXIMATE EQUIVALENT CIRCUIT DIAGRAM OF THE MAGNETIC CUTTERHEAD [M_1, armature mass; M_2, mass of cutting stylus; R_1, damping resistance; R_2, resistance presented by record; C_1, compliance of rubber; C_2, armature compliance; C_3, compliance of needles; and T, leverage of armature needle assembly]

Besides, the provision of the damping pads, which act as series capacitances in the primary equivalent circuit, increases the total impedance. It is, however, necessary to have high compliance for obtaining low impedance at the higher frequencies. But this necessarily increases the resistance part of it. Therefore, the optimum value of the damping factor is adjusted and maintained by varying the length of the damping rubber pads by micrometer screws. The resistance of the record to the cutter forms the main load in the circuit. This is accompanied by transformer losses in the armature equivalent circuit of the device. The overall efficiency of the system is dependent on the field strength of the magnet and the shape of the poles. Also, the h.f. response is dependent on the self-capacitance of the coil. By choosing the proper impedance for the coil, the h.f. response is improved.

Performance characteristics

Speed stability of turn-table — This is measured under three conditions: (1) no load, (2) while recording, and (3) while replaying. The equipment used for the measurement of speed of rotation consists of a stroboscopic cardboard disc of diameter 3 in. having 78 radial lines and placed on the turn-table and illuminated by a neon lamp. Under no load and under replay conditions, the radial lines appear absolutely stationary. Under recording conditions, the drift in speed was found to be approximately 0·05 per cent as measured stroboscopically.

Frequency response — Flat response from about 500 c/s. to 9 kc/s. is obtained. Beyond 9 kc/s. there was observed a slight attenuation (at 10 kc/s.). Below 500 c/s. the characteristic has been modified to give almost constant amplitude by the introduction of a 10-ohm resistor in series with the coil. By this, an attenuation of approximately 15 db. is obtained as observed from frequency test record at 50 c/s. with respect to the value at 1 kc/s.

Distortion — Reliable measurements on harmonic and intermodulation distortions could not be made for want of proper equipment. Tests with an oscilloscope with recorded sinusoidal vibrations indicated low distortion.

Conclusion

The recorder constructed using locally available materials gave performance characteristics comparable to those of imported equipment. The only imported components used are the fractional horsepower motor, magnet and soft iron pieces.

Acknowledgement

The authors' thanks are due to the Director, Madras Institute of Technology, for his keen interest in the project and to Shri P. V. V. S. Sastry, Assistant Professor, Electronics Faculty, for his helpful discussions and suggestions in the electronic part of the project. They also wish to thank the Gramophone Co. Ltd, Calcutta, for their kind permission to dub some of their recordings, and to Shri B. J. Gulati, Station Engineer, All India Radio, Madras, for his helpful criticism.

Plane-glass Mirror Solar Energy Concentrators for Concentrating Sugarcane & Palm Juices

MOHAN LAL KHANNA, A. L. GARDNER*, T. N. DAVEY & S. P. SURI
National Physical Laboratory, New Delhi

Manuscript received 28 *August* 1958

The design, construction and working details of a plane-glass mirror (9 in. square) solar energy concentrator are described. The results of experiments on the evaporation of water and cane juice, using reflectors with overall dimensions of 3 × 3 ft and 6 × 3 ft, are presented. The advantages of this type of collector over the conventional concentrators, such as low cost, simplicity of construction, ease of handling and portability have been pointed out and the probable economy in the sugarcane and palm *gur* manufacturing industries, by the use of this type of reflector, has been assessed.

CONCENTRATION of solar energy and its transformation into a useful form are generally carried out by the use of (1) lenses, (2) glass mirrors and (3) metallic reflectors. Of these devices, lenses are rarely used on account of their high cost and a large lens area is needed for collection of solar energy. Though small metallic reflectors are not expensive, their manufacture becomes expensive with increase in their size. Glass mirrors are by far the cheapest reflecting material available for the purpose. The major consideration, therefore, in the development of new types of solar energy concentrators is to keep down their cost of manufacture by using inexpensive materials of construction and making their design simple. In this paper are described the design, construction and working details of a plane-glass mirror solar energy concentrator which satisfies the above requirements. Also, the use of this concentrator in palm *gur* industry has been indicated.

Plane-glass mirror is by far the cheapest reflecting material available for building such a concentrator. Another important factor which adds to the cost of the concentrator is the method of mounting the reflector surface. A large single mounting carrying the whole of the reflecting surface is expensive and involves the use of expensive supports and turning

---

*Present address: c/o Pansdoc, Karachi, Pakistan.

mechanism; it also suffers from the disadvantage that focussing the sun's rays is difficult. In designing the present concentrator, these points have been taken into consideration and the mirrors used in the reflector consist of square or rectangular pieces of ordinary commercial quality 16 oz. drawn glass (window glass). The sun's rays are concentrated by employing a number of such plane mirrors, each oriented in such a way that the reflected rays coincide at a common focus. The degree of concentration achieved by such a reflector is limited by the number of mirrors used as well as by the accuracy of focussing.

The fully articulated type and the semi-articulated type of cencentrators using plane-glass mirrors have been described in an earlier communication[1]. These concentrators have certain advantages and disadvantages as compared to the conventional types now in use and which have an equivalent area. The costs of the construction materials and fabrication are lower in the case of the former type of concentrators. The accuracy achieved by an average carpenter and fitter in fabricating the plant satisfies the requirement of the units, and error, if any, in the focussing of solar radiations, is not enhanced when the wooden frame and rotating bars are exposed to different atmospheric conditions. The assembling and adjusting of the mirrors on the bars in semi-articulate and articulate type of concentrators require accurate measurement of the angle of orientation of the mirrors on the bars. Maintenance of the mirrors in a clean condition (cleaning, dusting, etc.) is difficult because the mirrors are not easily accessible. The focus of the concentrators is at an inconvenient height, with the consequent risk of damage to the mirrors by spilt liquid during concentration. Also, the effective collecting area of the mirror surface of the concentrators at low solar altitudes is reduced. The disadvantages observed in these units have been eliminated in the multi-reflector type of concentrator described in this paper. The semi-articulate and the articulate types of concentrator, and the multi-reflector type differ chiefly in the way the individual mirrors in the reflectors are oriented for maintaining them in coincidence in spite of the diurnal motion of the sun. The multi-reflector unit is specially suitable for small-scale industrial use in areas where fuel is scarce or expensive but sunshine is plentiful, and should be helpful in the development of cottage and small-scale industries.

General description of the multi-reflector type concentrator

The concentrator consists of a number of individual, portable and composite 'reflectors', each reflector comprising a square or rectangular wooden frame within which are fixed a number of plane-glass mirrors. The mirrors are fixed permanently in such a way that they approximate to a curved surface, paraboloid or spherical, and concentrate solar heat at a selected distance, called 'focal length', which is several times greater than the dimensions of the reflector frame.

In actual use, the required number of reflectors are placed in a row along a curve on the ground, facing both the sun and the point at which heat is to be concentrated. At the back of each reflector is a hinged supporting leg, by which the reflectors can be adjusted by hand at any angle so as to reflect solar heat to the same focus. As the sun moves, the reflectors are adjusted by hand as often as is necessary to concentrate the heat energy where it is needed. If heat is required under a pot, a flat chromium-plated metal plate is placed just below the pot to reflect the heat upwards and is inclined backwards at an angle of 45°. The back edge of the reflecting plate is so adjusted that it is close to the bottom of the pot blackened by soot deposition.

Constructional details

The wooden frames of the reflectors were made from a good seasoned wood. Soft wood is better than hard wood because those parts of the frame in contact with mirrors, if prepared from soft wood, are less liable to damage the glass mirrors during their fixing.

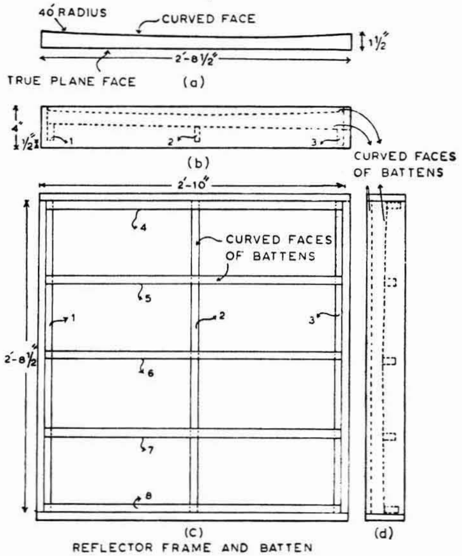


FIG. 1 — CONSTRUCTIONAL DETAILS OF REFLECTOR FRAME AND BATTEN

A 3 × 3 ft reflector has been used in the present study because of the convenience of handling.

The outer frame with inside dimensions of 2 ft 8·5 in. by 2 ft 8·5 in. was prepared from good seasoned soft wood cut accurately into four planks of the required size. Eight pieces of battens of the same wood, each 2 ft 8·5 in. long, 1·5 in. wide and 0·75 in. thick, were cut. One of the 0·75 in.-side of each batten was cut out to a true plane face and the opposite side was cut to form a concave circular curve with a radius of 40 ft (twice the ' focal length '). The crown of the curve was at mid-length of the batten. All the eight pieces used in making any one reflector were identical in shape and size. A single batten is shown diagrammatically in Fig. 1(a).

The battens were fixed in the outer frame as shown in Fig. 1(c). Three battens, numbered 1, 2 and 3, were first fixed with all their plane faces lying in a true plane about 0·5 in. from the back of the frame. The other five battens were then fixed on to the curved faces of the first three. The battens numbered 4, 5, 7 and 8 were tilted slightly inwards towards the batten numbered 6 by the curvature of those numbered 1 and 2.

Each reflector carries sixteen 8 in. square-mirrors. The mirrors were fixed to the curved faces of battens 4 to 8 by wood screws and rubber or metal washers at the corners of the mirror. About $\frac{1}{16}$ in. of glass was nipped off the four corners of each mirror to allow room for the screws to pass between the mirrors without leaving any gaps between the rows of mirrors. All the battens and mirrors were firmly held but not unduly strained to avoid spoiling the focus. The constructional details of a single reflector are shown in Fig. 2.

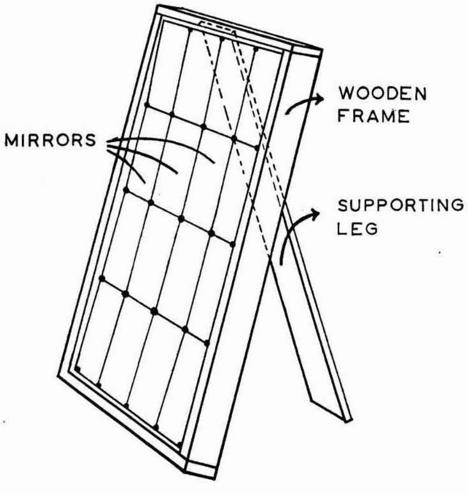


FIG. 2 — GENERAL VIEW OF A SINGLE REFLECTOR UNIT SHOWING THE ARRANGEMENT OF INDIVIDUAL MIRROR PIECES AND THE HINGED SUPPORT

The supporting leg (3 × $\frac{3}{4}$ in.) of soft wood was hinged to the top edge of the back of the frame. The lower end of the leg projecting *c.* 2 in. beyond the bottom of the frame provides a stable base when the reflector is nearly upright. In windy weather, a small hook was provided near the lower end of the leg, to which a weight could be attached when needed as a safeguard against the whole arrangement overturning. Corner braces of softwood were provided on the back of the frame to add to its stiffness.

In the present case the number of reflectors that could conveniently be placed, as close to one another as possible, was nine. If it is necessary to collect solar energy from a larger area, the size of the reflectors could be increased to 6 × 3 ft and the focal distance increased so as to accommodate the required number of reflectors for a given heat output.

The total amount of heat concentrated is directly proportional to the total area of exposed mirror surface. However, the temperature at the focus depends on the number of individual mirrors in the entire concentrator. When attainment of high temperature is the major consideration, as running a hot air engine with solar energy, higher concentration ratios are achieved by reducing the size of the individual mirror and increasing the number of mirrors for a given area. In order to get a better focussing, a different technique of mounting the reflectors in a frame was employed.

The stand for the pot can be made from any incombustible material and of any desired height. A simple stand built up by using loose dry bricks with an iron bar to support the front end of the pot was used in the present case, care being taken to see that the sides do not obstruct the reflected rays from the outer reflectors. Efficiency was increased by the use of two stands with a common side due north and south — one with its back towards the morning sun (south-east) and the other with its back to the afternoon sun (south-west) — the pot being transferred about noon. The reflectors, when not in use, were either stored in a shed or stacked in the open and covered to protect the silvering.

Effective area of the concentrator

When 16 mirrors of 8 × 8 in. fitted in a frame are used, the total mirror surface is 7$\frac{1}{9}$ sq. ft. If the portion of glass surface covered by screws and washers be taken to be $\frac{1}{9}$ sq. ft, the exposed mirror area in a frame is 7 sq. ft. The effective area in an individual reflector for axially incident parallel rays may be taken as the entire exposed mirror surface, since the reduction due to the slight curvature is negligible.

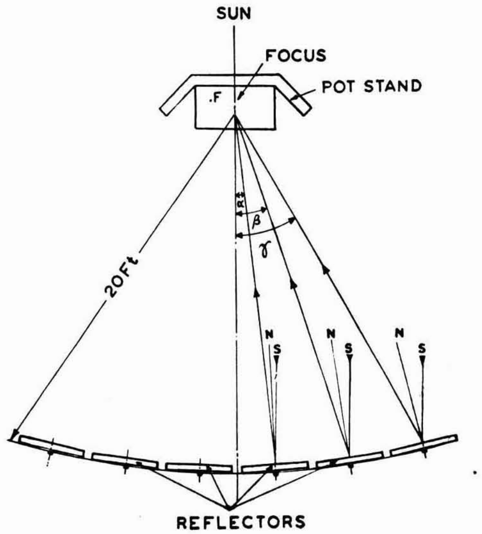


FIG. 3 — SCHEMATIC DIAGRAM ILLUSTRATING HOW THE SOLAR ENERGY IS FOCUSSED USING A NUMBER OF REFLECTOR UNITS

For calculating the effective area of the concentrator as a whole, let us suppose that an even number (*n*) of reflectors are placed along the arc of a circle with focal distance (*f*) as the radius and that *d* is the distance between centres of the adjacent reflectors, and α, β, Υ, ... are the plane angles between the direction of the sun and the directions of the focus from the centres of the reflectors. From Fig. 3 it is clear that

$$E_o=2A(\cos \tfrac{1}{2}\alpha + \cos \tfrac{1}{2}\beta + \cos \tfrac{1}{2}\Upsilon + \ldots) \quad \ldots . \; (1)$$

in which, to a sufficient degree of accuracy, we may substitute:

$$\alpha = \sin^{-1} (\tfrac{1}{2}.d/f)$$
$$\beta = \sin^{-1} (\tfrac{3}{2}.d/f)$$
$$\Upsilon = \sin^{-1} (\tfrac{5}{2}.d/f)$$

where E_o is the effective area of the concentrator for zero altitude of the sun and A, the exposed mirror surface in each reflector.

When there are an *odd number of reflectors* in a concentrator, the values of α, β and Υ will be:

$$\alpha = \sin^{-1} (d/f)$$
$$\beta = \sin^{-1} (2d/f)$$
$$\Upsilon = \sin^{-1} (3d/f)$$

and the equation (1) becomes

$$E_o = A+2A(\cos \tfrac{1}{2}\alpha+\cos \tfrac{1}{2}\beta+\cos \tfrac{1}{2}\Upsilon+\ldots) \quad \ldots \; (2)$$

By substituting $f = 20$ ft and $d = 3$ ft in equation (1) or (2), the value of E_o can be calculated.

For solar altitude S, the effective area of the concentrator E_e, to a sufficient degree of accuracy, can be obtained from:

$$E_e = E_o \cos \tfrac{1}{2}S \quad \ldots\ldots\ldots\ldots \; (3)$$

on the assumption that the focus is at the same height as the centres of the reflectors.

Accuracy greater than that given by the approximate formulae of equations (1), (2) and (3) above is not warranted, because the errors involved in hand-positioning and adjustment of the reflectors are considerably greater than those introduced by the use of these formulae. Secondly, the degree of accuracy attainable in the analysis is also limited by that of the solar radiation measurements. The solar altitude and the intensity of direct solar radiations were determined at 15 min. intervals. It was possible to calculate the total solar energy used in the experiment. From the quantity of heat required to evaporate away a given weight of water (calculated from the weights of juice at the beginning and the *gur* or syrup obtained at the end) the percentage efficiency of the process could be calculated.

Trials

Preliminary trials with the concentrator for the evaporation of water were carried out in a shallow mild steel tray (1·5 × 1·5 × 0·25 ft). The bottom of the tray was blackened by soot. The tray was heated from below with solar heat concentrated with reflectors of 3 × 3 ft overall dimensions; the size of the ' focus ' was nearly 9 × 9 in.

The temperature of the surrounding air recorded with the help of a pyrometer placed just above the reflecting metal plate and in the ' focus ' was more than 400°C. Stainless steel plate used for reflecting solar heat upwards was stained at the end of the experiments due to overheating. Brass plate electroplated with chromium may be used preferably. To start with, 4-5 lb. of water were taken in the tray. Depending on the rate of evaporation, further additions of water were made from time to time.

Results and discussion

The results of the trials conducted on five different days are summarized in Table 1.

The difference in efficiency may be due to the fact that the position of the reflectors requires frequent hand adjustments due to change of the position of the sun. The data given in Table 1 have not been corrected for the major source of heat loss due to the prevailing wind velocity.

The same set-up and technique were utilized for concentrating sugarcane juice to *gur*. The results are given in Table 2.

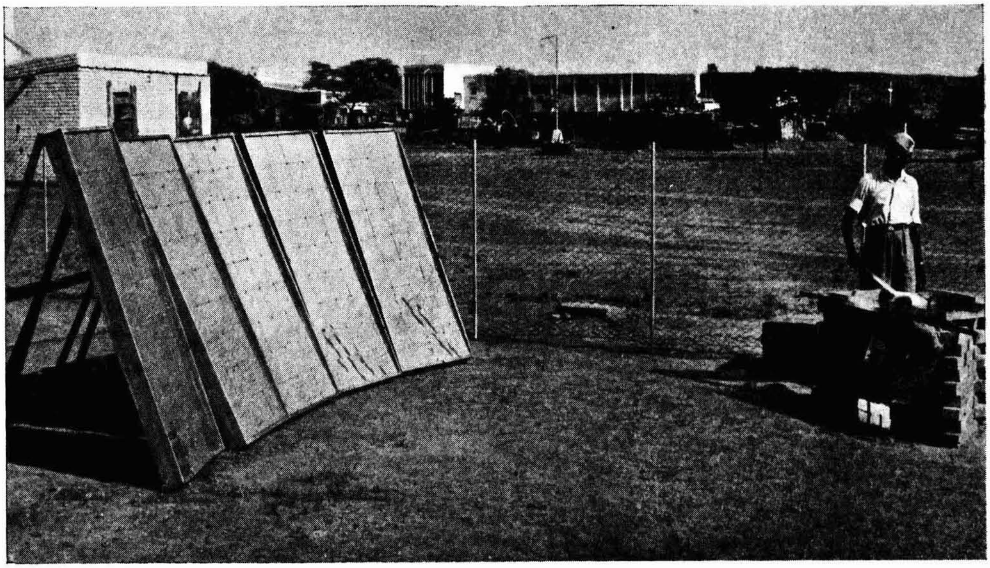


FIG. 4 — SOLAR CONCENTRATOR UNIT WITH FIVE REFLECTORS USED FOR CONCENTRATING SUGARCANE JUICE

TABLE 1 — EVAPORATION OF WATER FROM A SHALLOW PAN

(*Ambient temp., min.* 60° *and max.* 74°*F.*; *reflector*: 6 *frames of* 7 *sq. ft each*)

DATE	LOSS IN WT *lb.*	INITIAL TEMP. OF WATER °*F.*	DURATION OF TRIAL *hr*	TOTAL SOLAR ENERGY *B.t.u.* (*corrected*)	AV. EFFICIENCY %
Dec. 1954					
21	16·84	62·6	5·0	42890	44
22	28·40	55·4	7·0	58480	55
23	25·88	57·2	6·5	56390	52
24	15·40	57·2	6·5	38160	41
27	20·76	59·0	6·5	47120	49

TABLE 2 — CONCENTRATION OF SUGARCANE JUICE*

(*Ambient temp., min.* 60° *and max.* 74°*F.*; *reflector*: 6 *frames of* 7 *sq. ft each*)

DATE	LOSS IN WT *lb.*	INITIAL TEMP. OF WATER °*F.*	DURATION OF TRIAL *hr*	TOTAL SOLAR ENERGY *B.t.u.* (*corrected*)	AV. EFFICIENCY %
Dec. 1954					
28	21·83	63·5	5·75	44930	54
29	20·03	57·2	5·75	55510	41
30	19·39	55·4	6·50	55400	39

*Cane juice was reduced to a semi-solid mass, which on cooling set to solid jaggery.

A concentrator with six reflectors (overall dimensions of each 6 × 3 ft and focal distance 25 ft) were used for concentrating sugarcane juice. In Fig. 4 is shown a unit with five reflectors. The actual reflecting surface of each reflector was 15·9 sq. ft. The results of a single trial carried out on 25 February 1957 (ambient temperature, 72°F.) with cane juice are given below:

LOSS IN WT OF JUICE	INITIAL TEMP. OF JUICE	DURATION OF HEATING	TOTAL SOLAR ENERGY COLLECTED	AV. EFFICIENCY
29·75 lb.	68°F.	3½ hr	71890 B.t.u. (corrected)	46%

The trial was conducted during the period of maximum intensity of direct solar radiations. The average efficiency of solar energy utilization of 46 per cent compares favourably with the results of trials carried out with the smaller size reflectors (Table 2). When the area of solar energy collection was increased to slightly more than twice, the time required for concentrating one and a half times the quantity of the cane juice was half that required with the smaller area.

With properly constructed furnace and provision for shielding the boiling pans from direct wind, it should be possible to improve the overall efficiency of juice concentration to *c.* 50 per cent.

When the focal distance of the reflector is increased from 20 to 25 ft, eleven reflectors can be conveniently grouped for use without affecting the efficiency of the end reflectors. There is also sufficient space for the addition of an extra reflector or two in case of unfavourable weather conditions. A simple calculation shows that a solar concentrator consisting of 11 reflectors when worked for 8 hr per day will be able to evaporate 125 lb. of water from 15-16 gal. of juice. It forms a convenient working unit.

Generally, bagasse obtained from the crushing of sugarcane is at present used as fuel for the production of *gur* on a commercial scale and no additional fuel is required for heating. On the average an acre of land yields 14·25 tons of cane from which 8·55 tons of juice and 5·7 tons of bagasse are obtained[2]. In the Jullunder type of furnace, when 8·55 tons of cane juice are processed into 1·4 tons of *gur*, 4·6 tons of bagasse are required. This would thus leave a surplus of 1·1 tons of bagasse[2]. On the other hand, when a single concentrator unit, consisting of 11 reflectors, as described above, is used to process 8·55 tons of cane juice, it will take 125 days or 4 months. Taking into consideration the short period of sugarcane harvesting season, this job could be conveniently handled by four such furnaces working for one month. This results in the saving of all the bagasse. Thus the use of solar heat in place of bagasse in *gur* manufacture will create the problem of disposal of bagasse. Many suggestions have been put forward for the industrial utilization of bagasse such as in paper and cardboard manufacture, production of newsprint and in the manufacture of alcohol[3]. These avenues have to be explored further. Bagasse could also be made use of for domestic heating either alone or in admixture with cow dung, thus releasing a part of the dung for use as a manure. The successful use of a solar concentrator in making *gur* will thus largely depend on finding ways for the economic utilization of bagasse.

A reflector with an exposed surface of 15·9 sq. ft (overall dimensions 6 × 3 ft) will cost approximately Rs 16. Hence, each concentrator unit will cost Rs 176 with a reserve of Rs 40 for two extra reflectors and spare mirrors. Taking the price of coal at Rs 36 per ton, the saving in fuel will amount to Rs 206, which is approximately the cost of a single concentrator unit. Its capital cost can, thus, be recovered in four sugarcane seasons.

In the palm juice industry the fuel available is insufficient and is in short supply. The use of a concentrator unit for processing clarified palm juice either to a thick syrup of over 65°Brix or directly into palm *gur* has been discussed elsewhere[4]. It is estimated that by working for three successive tapping seasons of three months each and by processing 25-30 gal. of clarified juice, the capital cost of a concentrator unit can easily be recovered. In coconut areas the tapping season lasts about six months; the period for which the concentrator is to be used for recovery of its capital cost would be reduced to nearly half.

The advantages of the plane-glass mirror solar energy concentrators are:

(1) They are simple to manufacture and can be made from low-cost materials; (2) their operation is simple; (3) they can provide heat at any required height irrespective of the size of the concentrator (only the focal distance is fixed); (4) the focal point is well clear of the reflectors giving full accessibility and there is no risk of damage to the mirrors from spilled liquids; (5) maintenance is simple; the mirrors are fully accessible for periodical cleaning and can, if necessary, be easily dusted while in use; (6) the reflectors are portable and can be easily rigged up; (7) there are no moving parts or mechanisms; and (8) broken or faded mirrors can be replaced cheaply and easily.

Conclusion

From the above discussion it follows that the utilization of solar energy as a supplementary source of fuel in the palm juice industry appears promising, and in the production of *gur* from cane juice it hinges on the economic disposal of bagasse. The multi-reflector type of concentrator can be used as a fuel-saving device for many purposes where a medium-size fire is needed, e.g. in community cooking, heating, boiling or distilling water, concentrating liquids, roasting or boiling grains, preparation of common salt from sea water, etc.

Acknowledgement

The authors are grateful to Shri K. L. Khanna, Indian Central Sugarcane Committee, New Delhi, for helpful discussions on the utilization of bagasse and to the Director, National Physical Laboratory, New Delhi, for permission to publish this paper.

References

1. Gardner, A. L., *Proceedings of the Symposium on Wind and Solar Energy, New Delhi* (Unesco, Paris), 1956, 209.
2. Roy, S. C., *Gur Monograph* (Indian Central Sugarcane Committee, New Delhi), 1951, 195.
3. *Report of the Seminar on the Production and Use of Power Alcohol in Asia and Far East held at Lucknow in* 1952 (United Nations, New York), 1954, 64-67.
4. Mathur, K. N. & Khanna, M. L., *J. sol. Energ. Sci. & Engng*, **1** (1957), 34.

Electrodialysis: Part I—Desalting of Aqueous Salt Solutions

N. KRISHNASWAMY

National Chemical Laboratory, Poona

Manuscript received 22 *November* 1958

The construction and performance characteristics of a five-compartment electrodialysis cell using cation and anion 'Permaplex' membranes are described. It has been shown, in the case of feed solutions containing sodium or a mixture of sodium chloride and calcium chloride, that the feed rate, under a constant applied potential, governs the extent of desalting, and that by recycling the salt content of the effluent could be reduced to any desired extent.

REDUCTION of salt content in brackish waters for use in agriculture, domestic and other purposes can be accomplished by different techniques. The advent of synthetic ion-exchange membranes and the electrodialysis technique have paved the way for large-scale adaptation of this new process for reducing the salt content of saline waters. The theoretical aspects of the process have been exhaustively studied and reported[1].

This paper describes results obtained with an electrodialysis cell made up of cation and anion-exchange 'Permaplex' membranes obtained from the Permutit Co., London. Details of the characteristics of the membranes are provided by the manufacturers[2] and compared with other commercially available membranes[3]. Sodium chloride solutions of different concentrations and solutions containing a mixture of sodium and calcium chloride were employed in these studies. The influence of the rate of flow of the solutions on the extent of salt reduction and the effect of initial salt content on current utilization and salt reduction have also been investigated.

Experimental procedure

The experimental set-up is diagrammatically represented in Fig. 1A. The material of construction of the cells was machined from hard cloth laminate blocks and a section of the cell support is shown in Fig. 1B. The two end electrode chambers were constructed by scooping out the laminate and fixing palladium-rhodium gauze. The terminals were projecting brass rods soldered to the electrode material. Between the two electrode chambers four laminate structures were placed. Adjoining the cathode a negatively charged membrane (cation-exchange membrane) was inserted and this was followed by an anion-exchange membrane. In the apparatus two cation and two anion-exchange membranes were packed alternate to each other as illustrated in Fig. 1. Thus, the cell is divided into five chambers. Solution inlet and outlet were arranged with the help of attachments as shown in Fig. 1A. Through three small openings in the ridges of the laminates the feed and treated solutions could be led into and removed from the assembly. The solution to be treated and the rinse solution were fed from aspirators kept at a higher level than the unit. The potential applied between the terminals was from a rectifier and the voltage applied could be controlled. With suitable pinch-occk arrangements the rates of flow of the feed solution and the rinse solutions could be adjusted. The inlet to the chambers was from below. Chamber 1 bounded by the cathode on the extreme edge and a

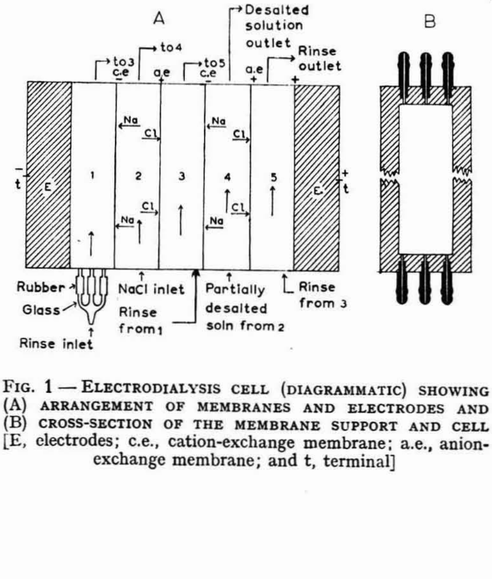


FIG. 1 — ELECTRODIALYSIS CELL (DIAGRAMMATIC) SHOWING (A) ARRANGEMENT OF MEMBRANES AND ELECTRODES AND (B) CROSS-SECTION OF THE MEMBRANE SUPPORT AND CELL [E, electrodes; c.e., cation-exchange membrane; a.e., anion-exchange membrane; and t, terminal]

cation-exchange membrane was fed by the rinse solution at a predetermined rate. As the solution filled the chamber and emerged out at the top it was led into chamber 3 by means of rubber tubing and allowed to fill up that chamber. This was again connected to chamber 5 and the resulting solution was led out as the final rinse solution. This solution would be enriched by the cations and anions transferred from the feed solution by the membranes. The feed solution to be desalted was led into chamber 2 bound on each side by a cation and an anion-exchange membrane and the solution emerging on top was led into chamber 4 by a similar arrangement as used for the rinse. The effluent from chamber 4 was collected and analysed for its salt content. The volume of each chamber is governed by the thickness of the cell support and the thickness of the membrane. After placing the membranes in position the assembly was tightly gripped into position by means of suitable clamps and the assembly was thus made leak-proof. The membranes to be used for a particular experiment were equilibrated with the solution to be studied so that they are converted to the same form and no ion exchange initially takes place after the solution is led into the chambers. Among the variations possible in this set-up are (1) changing the direction of flow of rinse with respect to that of feed solution and (2) employing separate rinse sources for the end electrode chambers and the two alternating rinse compartments.

In the experimental set-up described above, chambers 1, 3 and 5 help to rinse out of the system the cations and anions which have been transferred from chambers 2 and 4 by the two pairs of cation and anion-exchange membranes. The salt solution as it enters chamber 2 loses its salt on account of the two permselective membranes acting as the two boundaries. The cation-exchange membrane will allow only cations to pass through it while the anion-exchange membrane will allow only anions to pass through it. These ions transport the current across the cell and the partly desalted solution enters chamber 4 for further salt removal. The solution which emerges from chamber 4 may be collected and repassed through the system and the process repeated till the desired degree of salt removal is obtained. In a continuous system the progress of salt removal as a function of rate of flow can be determined without recycling the once treated solution.

Results

In the first series of experiments $N/10$ sodium chloride solution was recycled at a controlled rate through the cell, each time for different periods, and the specific conductivity of the effluents at the end of each cycle was determined. The results are given in Table 1.

TABLE 1 — SPECIFIC CONDUCTIVITY OF FEED ON RECYCLING

CYCLE No.	DURATION FOR WHICH FEED WAS PASSED THROUGH THE CELLS IN EACH CYCLE *min.*	SP. CONDUCTIVITY OF EFFLUENT AT THE END OF EACH CYCLE *mhos* $\times 10^{-3}$
—	At start	7·238
1	200	6·929
2	429	6·102
3	431	5·310
4	340	4·543

TABLE 2 — PROGRESS OF DESALTING DURING RECYCLING

CYCLE No.	DURATION FOR WHICH THE SOLN WAS RECYCLED *hr*	CELL CURRENT *ma.*	TOTAL HARDNESS (*p.p.m.* $CaCO_3$)		TOTAL SOLIDS (*p.p.m.*)	
			Initial	Final	Initial	Final
1	8	585	595	315	2265	1135
2	8	330	315	179	1135	735
3	8	195	179	95	735	290
4	3	100	95	74	290	190
5	3	75	74	53	190	125

TABLE 3 — PROGRESS OF DESALTING IN CONTINUOUS FEEDING EXPERIMENTS

VOL. OF SOLN TREATED *ml.*	RATE OF FEED *ml./min.*	TOTAL HARDNESS (*p.p.m.* $CaCO_3$)		TOTAL SOLIDS (*p.p.m.*)	
		Initial	Final	Initial	Final
435	4·8	546	326	2265	1435
565	4·7	546	315	2265	1375
490	4·1	546	294	2265	1375

In a second series of experiments $N/100$ sodium chloride solution was recycled through the cell for 6 hr per day on four consecutive days. The specific conductivities of the salt solution before and after recycling were 10·09 and 2·524 mhos $\times 10^{-4}$ respectively. The initial and final cell currents were 240 and 140 ma.

In a third series of experiments a solution containing known amounts of sodium and calcium chlorides was recycled through the cell and the effluent analysed at different intervals. The results of analysis of the effluent after each recycling are given in Table 2.

The reduction in the total hardness and total solids by passing a solution containing sodium and calcium chlorides through the cell at different rates in one pass was determined. The results are given in Table 3. The average cell current in these experiments was 680 ma. The effect of varying the rate of flow of feed solutions containing (1) different concentrations of sodium chloride and (2) sodium chloride and calcium chloride in different proportions was investigated. The results are recorded in Tables 4 and 5 respectively.

TABLE 4 — EFFECT OF FEED RATE EMPLOYING NaCl SOLUTION

COMPOSITION OF FEED SOLN	FEED RATE ml./min.	CELL CURRENT ma.	REDUCTION IN TOTAL SOLIDS %
0·025*N* NaCl	0·96	250	98·6
	1·74	390	81·9
	3·90	490	57·8
	5·72	530	35·1
	15·20	590	28·4
0·050*N* NaCl	1·11	600	97·1
	3·57	990	62·0
	31·40	1700	4·2

TABLE 5 — EFFECT OF FEED RATE EMPLOYING MIXTURE OF NaCl AND $CaCl_2$ SOLUTIONS

COMPOSITION OF SOLN	FEED RATE ml./min.	CELL CURRENT ma.	REDUCTION IN TOTAL HARDNESS %	REDUCTION IN TOTAL SOLIDS %
125 ml. of 1*N* $CaCl_2$ + 250 ml. of 1*N* NaCl in 10 litres	2·30	520	67·3	60·0
	2·90	580	59·6	55·0
	3·30	600	55·7	46·0
	4·80	680	40·4	36·6
	20·20	850	11·5	2·0
250 ml. of 1*N* $CaCl_2$ + 250 ml. of 1*N* NaCl in 10 litres	2·00	600	75·5	75·0
	2·85	720	63·7	65·0
	3·32	770	59·0	57·8
	8·30	1000	32·3	30·0

TABLE 6 — EXPERIMENTS WITH A THREE-COMPARTMENT CELL

(*Feed:* 0·10*N sodium chloride soln; electrode chambers rinsed independently; initial solids content of feed,* 5280 *p.p.m.*)

FEED RATE ml./min.	CELL CURRENT ma.	TOTAL SOLIDS IN THE EFFLUENT p.p.m.
0·052	800	3430
0·130	800	4210
0·281	400	4860

In Table 6 are presented the results of experiments carried out with a three-compartment cell to determine the reduction in total solids of solutions fed through the cell at different rates and cell currents.

Discussion

The results presented in Tables 1-6 show that with the present electrodialysis cell, it is possible to obtain different degrees of desalting. Also, higher rates of flow are not favourable for achieving a high degree of reduction in the salt content of the feed solution. This is to be expected as the volume and area of the membrane surface available for transferring the ions is relatively small and hence lower rates of flow have to be employed.

Theoretically, the greater the number of cells the lower will be the electrode reaction losses and the efficiency of the cell would increase. In the experiments reported here the aim was to study the degree of desalting that could be obtained with a limited number of cells under a constant applied voltage.

It is well known that for the adoption of electrodialysis technique employing ion-exchange membranes on a commercial scale the solution to be treated should have at least 500-1000 p.p.m. of dissolved salt content. In very dilute solutions, due to increased electrical resistance of the solution, the efficiency is greatly reduced. This has been experimentally verified using the laboratory tap water containing about 200 p.p.m. total dissolved solids. Also with highly concentrated solutions the efficiency of separation decreases as a result of Donnan diffusion of the ion of the opposite sign diffusing through the membrane and the transport number for the membrane decreases[4]. Unlike in a continuous system, recycling of the treated solution helps to decrease the salt content to any desired level. But as the salt content decreases the current efficiency decreases and the method becomes uneconomical.

Further work on cells with only one type of ion-exchange membrane and other related problems are under study and will be reported later.

Conclusion

1. The construction and operation of an electrodialysis cell using synthetic ion-exchange membranes are described.

2. It has been shown that the rate of flow of the salt solution through the membrane chambers governs the extent of desalting under a constant applied potential.

3. By recycling the treated solution the salt content could be reduced to any desired degree.

Acknowledgement

The author wishes to thank Dr Kressman of the Permutit Co., U.K., for the supply of the Permaplex membranes. The cell assembly resembles that employed at the T.N.O. Central Laboratorium, Delft, Holland, and the author gratefully acknowledges the help received from Dr A. J. Staverman, Director, and his colleagues.

References

1. Nachod, F. C. & Schubert, J., *Ion Exchange Technology* (Academic Press Inc., New York), 1956, 118.
2. *Permutit Ion Exchange Resin Membranes — Technical Data* (Permutit Co. Ltd, London).
3. Nachod, F. C. & Schubert, J., *Ion Exchange Technology* (Academic Press Inc., New York), 1956, 144.
4. Krishnaswamy, N., *J. sci. industr. Res.*, **15B** (1956), 530.

Fractionation of Shellac: Part I—Shellac-urea Complexes

S. C. SEN GUPTA

Indian Lac Research Institute, Namkum, Ranchi

Manuscript received 23 *September* 1958

A simple process for the fractionation of shellac by progressive complex formation and precipitation by refluxing a mixture of shellac and urea in acetone is described. Shellac has been fractionated into six fractions by this procedure. Of these, five are solid fractions which are presumably derived from the pure resin portion. The sixth fraction, a honey-like mass, is derived from the soft resin portion. The solid fractions are soluble in alcohol and alkali but insoluble in diethyl ether, and show marked differences in their physical and chemical properties.

A reaction mechanism between urea and shellac is suggested in which urea reacts not only with the free aldehyde group but also with other groups in shellac.

THE chemical constitution of shellac has not yet been fully elucidated. Tschirch and Farner[1], and Farner[2] were the first to fractionate shellac into two fractions by means of diethyl ether. Harries and Nagel[3], employing the same solvent, obtained an insoluble portion, 'pure resin', and a soluble portion, 'soft resin'; the latter had a honey-like consistency. Verman and Bhattacharya[4] specially recommended the use of toluene and trichlorethylene which were less hazardous than diethyl ether; they called the insoluble portion 'hard resin'. Mild alkalies[5,6], salts of weak acids[7,8] and various other organic solvents[9,10] have also been recommended for the fractionation of shellac.

Bhattacharya and Heath[5], from their work on the fractionation of shellac with mild alkalies, concluded that shellac is a mixture of several components with molecular weights varying from 300 to 3000, and that the components, which are more or less similar in chemical nature, are present in the form of an isogel. Their assumption was corroborated by the work of Schaeffer, Weinberger and Gardner[9] who fractionated shellac by means of different solvents into six fractions having different chemical and physical properties. Two of these were ether-soluble and presumably constituted the soft resin while the rest constituted the pure resin. These results indicate that neither pure resin nor soft resin is a single component but a mixture of several components.

The present work was undertaken with a view to studying the fractionation of shellac in greater detail so that the chemical nature of shellac, in particular, of the pure resin component on which the excellent qualities of shellac largely depend, may be better understood.

The method employed by Schaeffer *et al.*[9] for the fractionation of shellac, though preferable to that of Bhattacharya and Heath[5], is laborious and time-consuming. Also, the final removal of solvents from the individual fractions is not easy and their long contact with the solvents may also lead to some transformation[3,11-14]. Actually two fractions of pure resin as obtained by Schaeffer *et al.*[9] were insoluble both in alcohol and alkali, suggesting that some transformation had taken place.

Kamath *et al.*[15] have described a new method of fractionation of shellac in which an ethanol solution of shellac is extracted with butyl alcohol-hexane mixture. They obtained fractions which differed in acidity and fluidity. They claimed their process to be more advantageous than that of Schaeffer[9]. But Kamath's process is apparently not entirely free from objection as it involves the use of a liquid-liquid system for fractionation, which, because of the partition coefficient coming into play, cannot be expected to yield pure individual fractions.

Venugopalan and Sen[16] have observed that the pure resin is rendered insoluble in acetone by treating it with urea. This observation has been made use of in developing a method for the preparation of the pure resin. The method, though simple, requires four days for rendering the pure resin completely insoluble. The present author has observed that by refluxing on a water bath a mixture of any variety of shellac or even seedlac and urea, the urea complex of pure resin separates completely as a voluminous mass in about 2·5 hr. This finding has been utilized for the fractionation of the pure resin of shellac by progressive precipitation of the urea complex from acetone solution.

However, since urea is known to form complexes with straight-chain hydrocarbons, acids, alcohols and esters, dewaxed decolourized shellac has been used in the present work to guard against the possibility of urea combining with the wax-alcohols and esters of shellac. The optimum quantity of urea to be used in the reaction has been found to be 7-8 per cent on the weight of shellac[16,17]. In the present study 8 per cent of urea on the weight of shellac has been employed.

Experimental procedure

Dewaxed and decolourized shellac (200 g.) was dissolved in acetone (1 litre) (A.R., B.D.H.; moisture content, 1 per cent) by warming. A solution of urea (16 g.) (B.D.H.) in acetone (500 ml.) containing a few drops of water was prepared by warming the mixture. These two solutions were mixed together and refluxed on the water bath. After about 15 min. a solid separated (first fraction) which was immediately filtered off through cotton wool. The filtrate gave a second solid product (second fraction) on slight cooling and a third product (third fraction) on cooling to room temperature. The mother liquor was again refluxed for a further period of 2 hr and on cooling overnight, it gave a solid fraction (fourth fraction). These solid fractions were finely powdered, placed inside separate packets and extracted together with acetone to remove the adhering soluble resin; on cooling the extract to room temperature a precipitate separated (fifth fraction). The acetone solutions (the one left after separation of the fourth fraction, and the other left after separation of the fifth fraction) were mixed and, on removal of acetone, yielded a honey-like thick syrup (sixth fraction). To remove the combined urea, the first and the second fractions were heated with boiling water under pressure, while the remaining fractions were repeatedly washed with boiling water.

Results

The percentage yield, and the physical and chemical properties of the urea-free fractions are given in Table 1. Nitrogen was absent in all the fractions.

Discussion

Fractions I-V (Table 1) are pale coloured brittle products which could be powdered easily and are completely soluble in alcohol and alkali but insoluble in diethyl ether. Obviously, these fractions constitute the pure resin portion of shellac. The softening points of the fractions lie between 91° and 97°C. and the melting points between 96° and 111°C., which are much higher than those of the original shellac. The acid values of the fractions gradually decrease from 74·8 for original shellac to 60·9 in the case of fraction III, to rise again to 82·2 in the case of fraction V. The saponification values of these fractions did not vary much except in the case of fraction II. The hydroxyl values, in the fractions, however, show considerable variation. The observation that the solid complexes, from which fractions I and II were obtained, did not sufficiently soften in boiling water during removal of urea while the others did, suggests that urea forms insoluble complexes much more easily with fractions I and II, which have high molecular weights than with other fractions. Thus the properties of the individual fractions suggest that these are all different components of the pure resin.

Fraction VI was a soft, honey-like, pale yellow mass soluble in alcohol, alkali and diethyl ether. Presumably, this is the soft resin portion of shellac mentioned earlier. The properties of this fraction were also found to be almost identical with those recorded for soft resin.

This method of fractionation of shellac, through the formation of urea complexes, is quicker than the method of Venugopalan and Sen[16], and may be used for obtaining pure and soft resins of shellac in their

TABLE 1 — PROPERTIES OF INDIVIDUAL FRACTIONS OF SHELLAC

FRACTION	YIELD %	SOFTENING POINT °C.	M.P. °C.	ACID VAL.	SAP. VAL.	ESTER VAL.	HYDROXYL VAL.
Original shellac	—	78-80	85-6	74·8	220·4	145·6	243·4
I	11·0	93-4	105-6	74·0	232·6	158·6	236·4
II	17·0	95-6	110-1	70·2	252·5	182·3	238·5
III	22·4	96-7	103-4	60·9	224·2	163·3	266·3
IV	5·9	91-2	96-7	64·4	224·5	160·1	270·4
V	17·8	95-6	106-7	82·2	223·6	141·4	184·5
VI	24·4	—	—	100·8	187·3	86·5	104·7

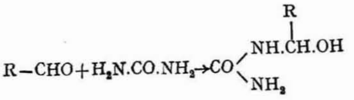
purest forms, since the pure resin is rendered completely insoluble in acetone by means of urea. Besides acetone, methyl ethyl ketone, mixture of butyl acetate (85 per cent) and butyl alcohol, and mixture of ethyl acetate and ethyl alcohol could be used for effecting fractionation.

Boiling with water under high pressure or mere washing with boiling water releases urea from the complex. This shows that urea is rather loosely bound to the shellac fractions. Complex formation between urea and shellac takes place because shellac contains carboxyl, hydroxyl, ester and aldehyde groups as well as a straight chain of at least 7 carbon atoms. Bhattacharya[17] has found that the amount of urea (7·3 per cent) in the complex is in close agreement with the calculated value (7·5 per cent) necessary for salt formation with the free acid groups of shellac (acid val., 70). He, therefore, favoured salt formation with the carboxyl group as the main reaction. Sankaranarayanan and Sen[18], from their study of the action of melamine on shellac, concluded that a loose salt formation occurs as in the case of urea. Bhattacharya[19] also came to the conclusion that the reaction is due to addition of urea to the carboxyl group with the formation of a shellac salt. Sreenivasaya and Sarma[20] studied the reaction of bleached lac with urea in butyl alcohol and found that the complex, which was soluble in the solvent, contained about 2·8 per cent urea. This amount is much lower than what (7·3 per cent) had been found by previous workers; they attributed this difference to a difference in the combining capacity of the bleached lac employed. On the basis of this finding, Gidvani[21] suggested that 2 molecules of lac combine with 1 of urea to form an additive salt (theoretical, 2·91 per cent of urea if the molecular weight of lac is 1000). According to him, the lac-urea salt on boiling with water is decomposed into urea and lac which is soluble in alcohol.

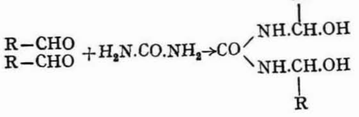
The idea of salt formation involving the combination of urea with the free carboxyl groups of shellac appears to be untenable for a number of reasons. Sreenivasaya and Sarma[20] obtained acid values of 57·94 and 63·81 respectively for the complex and the original bleached lac, which shows that a few, if at all, of the carboxyl groups participate in the reaction. The present author also finds that the acid values of the original shellac and the complex differ very little, and further that dimethylolurea behaves in a similar manner to urea in complex formation. These findings suggest a type of reaction which is altogether different from salt formation. The combination of urea with the hydroxyl and the ester groups of shellac also seems to be improbable since the resulting compounds would then be stable and, moreover, a higher temperature would be necessary for these types of combination.

There is, however, another possibility, namely that of urea combining with straight-chain fatty acids, having at least 7 carbon atoms in the chain, to produce a distinct type of complex. Shellac contains butolic acid, which has a straight chain of 9 carbon atoms, and hence might form such complexes. But actually such complex formation does not appear to have taken place, since the urea complex from shellac, unlike urea complexes with other straight-chain fatty acids, does not decompose in the presence of water at room temperature.

Another possibility in the formation of urea complex is one which involves the aldehyde group in shellac. The presence of one aldehyde group per molecule of shellac (average molecular weight, 1000), partly in the free state and partly in the combined state, has been established by Kamath and Mainkar[22] (the carbonyl value of shellac was 29-33 which increased to 52 during alkaline hydrolysis). It is well known that urea easily reacts with aldehydes. Further, dimethylolurea, the product of combination between urea and formaldehyde, is easily decomposed by boiling water[23]. This, coupled with the facts that the carbonyl value of shellac-urea complexes has been found to be nil, and that the complexes could be decomposed by boiling water, suggests that urea reacts with the aldehyde group of shellac or its fractions to form compounds of the following types of complexes:



$$R{-}CHO + H_2N.CO.NH_2 \rightarrow CO\begin{array}{l}\diagup NH.\overset{R}{\overset{|}{C}}H.OH\\ \diagdown NH_2\end{array} \qquad \ldots\ldots\ldots (1)$$



$$\begin{array}{l}R{-}CHO\\R{-}CHO\end{array} + H_2N.CO.NH_2 \rightarrow CO\begin{array}{l}\diagup NH.\overset{R}{\overset{|}{C}}H.OH\\ \diagdown NH.\underset{R}{\underset{|}{C}}H.OH\end{array} \qquad \ldots\ldots\ldots (2)$$

where R—CHO = an average molecule of shellac or a component of shellac.

On the basis that the average molecular weight of shellac is 1000 and that nearly half of an aldehyde group in it is free, the amount of urea necessary for reactions (1) and (2) will be of the order of 3·0 and 1·5 per cent respectively. This amount will be doubled if during reaction the combined aldehyde group, after liberation, also reacts with urea. Since it has been found that the carbonyl values of the original and the regenerated shellac are practically the same, it may be concluded that the combined aldehyde group does not take part in the reaction.

Though the theoretical amount of urea necessary for the first reaction agrees with Sreenivasaya's finding[20], the amounts are very much smaller than those actually found by other investigators[16,17]. Hence to account for the higher percentage of urea found in the complex, urea may be assumed to react with other groups in addition to the free aldehyde group of shellac. Further work is in progress on these aspects, the results of which will be reported elsewhere.

Acknowledgement

The author is grateful to Dr P. K. Bose (ex-Director) and to Dr S. V. Puntambekar, Director, for their encouragement during the course of this work.

References

1. TSCHIRCH, A. & FARNER, A., *Arch. Pharm.*, **23** (1899), 35.
2. FARNER, A., *Ph.D. Dissertation, University of Bern*, 1898.
3. HARRIES, C. D. & NAGEL, W., *Ber. dtsch. chem. Ges.*, **50** (1922), 3833.
4. VERMAN, L. C. & BHATTACHARYA, R., *London Shellac Res. Bur. Tech. Paper No.* 5, 1935.
5. BHATTACHARYA, R. & HEATH, G. D., *London Shellac Res. Bur. Tech. Paper No.* 16, 1938
6. THAKUR, A. K., *Indian Lac Res. Inst., Ann. Rep.* 1938-39, 5; *Uses of Shellac* (Indian Lac Research Institute, Ranchi), 1939, 63.
7. BHATTACHARYA, R. & GIDVANI, B. S., *London Shellac Res. Bur. Tech. Paper No.* 13, 1938.
8. Suter, A. F. & Co., *Brit. Pat.* 496,124 (1939).
9. SCHAEFFER, B. B., WEINBERGER, H. & GARDNER, W. H., *Industr. Engng Chem.*, **30** (1838), 451.
10. PALIT, S. R., *J. Indian chem. Soc., Industr. & News Ed.*, **5** (1942), 25.
11. JOHN, *Chem. Schriften*, **5** (1806), 1.
12. UNVERDORBEN, O., *Pogg. Ann.*, **14** (1928), 116.
13. v. ESENBECK, N. & MARQUART, CL., *Ann. Pharm.*, **3** (1835), 286.
14. TSCHIRCH, A. & LÜDY, F., *Helv. chim. Acta*, **6** (1923), 994.
15. KAMATH, N. R., KULKARNI, (Mrs) L. G. & NAGARSANKAR, V. N., *Paintindia*, **4** (1954), 27.
16. VENUGOPALAN, M. & SEN, H. K., *Chem. & Ind.*, **57** (1938), 371.
17. BHATTACHARYA, G. N., *Indian Lac Res. Inst. Bull. No.*42, 1940.
18. SANKARANARAYANAN, Y. & SEN, H. K., *Indian Lac Res. Inst. Bull. No.* 57, 1944.
19. BHATTACHARYA, R., *Chem. & Ind*, **59** (1940), 325.
20. SREENIVASAYA, M. & SARMA, P. S., *J. sci. industr. Res.*, **2** (1944), 227.
21. GIDVANI, B. S., cited in *Synthetic Resins and Alli Plastics*, edited by R. S. Morrell & M. H. Langt (Oxford University Press, London), 1951, 480.
22. KAMATH, N. R. & MAINKAR, V. B., *J. sci. industr. Re* **14B** (1955), 560.
23. FLECK, H. R., *Plastics, Scientific & Technological* (Templ Press Ltd, London), 1945, 63.

Exploitation of Sambhar Pan Crust

K. SESHADRI & (Late) S. D. BUCH

Central Salt Research Institute, Bhavnagar

Manuscript received 16 *March* 1959

Three methods based on solubility data have been worked out for the recovery of sodium sulphate from the Sambhar Lake pan crust. Ninety per cent of sodium sulphate present in the crust is recovered as technical grade quality sodium sulphate by the chilling process, 65-73 per cent by adding solid sodium chloride at 50°C. to the solution prepared from the crust and 75-80 per cent from the upgraded crust obtained by digesting it with water.

A PORTION of the salt manufactured at Sambhar is from the sub-soil (or well) brine. A crust is found deposited in the bottom of the crystallizing pans which is scraped off at the end of each season. This is known as pan crust and is comparatively rich in sodium sulphate and free from algae. It is estimated that about 1000 tons of this material are available per annum. Analyses of the two samples received from Sambhar and dried at 110°C. are given in Table 1; sample No. 1 is considered to be more representative. The recovery of sodium sulphate from the crust samples has been investigated

TABLE 1 — COMPOSITION OF SAMBHAR LAKE PAN CRUST

PARTICULARS	SAMPLE No. 1	SAMPLE No. 2
NaCl, %	41·4	31·7
Na_2SO_4, %	45·4	62·1
Na_2CO_3, %	2·4	0·6
Insolubles, %	10·6	5·4

in this Institute and the results are presented in this paper.

Experimental procedure

Three procedures based on the solubility relationships in the system NaCl-Na_2SO_4-H_2O have been examined; as sodium carbonate is present in small amounts in the crust samples, it has not been taken into consideration.

Method No. 1 — The crust is digested with a calculated quantity of water to give a solution saturated with respect to sodium sulphate and the solution chilled to 0°C. to yield sodium sulphate decahydrate.

Method No. 2 — Anhydrous sodium sulphate is precipitated from the saturated solution of sodium sulphate by the addition of solid sodium chloride.

Method No. 3 — The crust is digested with a calculated quantity of water to obtain a saturated solution of sodium chloride, leaving behind a residue rich in sodium sulphate. The residue is dissolved in water to obtain a saturated solution of sodium sulphate from which sodium sulphate is separated by crystallization.

The Sambhar Lake crust is found in the form of hard lumps and has to be powdered before digesting it with water. Solubility data of the ternary system[1] NaCl-Na_2SO_4-H_2O at 30°C. (Table 2) have been employed for the preparation of saturated solutions in the three methods employed.

TABLE 2 — SOLUBILITY DATA FOR THE SYSTEM NaCl-Na_2SO_4-H_2O AT 30°C.

(*Values expressed in g./100 g. water*)

SP. GR. OF SOLN	NaCl	Na_2SO_4	TOTAL SOLIDS	NaCl/ Na_2SO_4
1·281	0·00	39·70	39·70	—
1·282	2·45	38·25	40·70	0·06
1·284	5·61	36·50	42·11	0·15
1·290	7·91	35·96	43·87	0·22
1·275	10·61	31·64	42·25	0·33
1·270	12·36	29·87	42·23	0·41
1·258	15·65	25·02	40·67	0·62
1·249	18·44	21·30	39·74	0·86
1·244	20·66	19·06	39·72	1·08
1·236	32·43	9·06	41·49	3·58
1·200	36·03	0·00	36·03	—

Results and discussion

Method No. 1 (*chilling method*) — To prepare a saturated solution of sodium sulphate from the crust samples, the ratio of water to the crust has to be adjusted such that all the sodium chloride and sodium sulphate present in the crust are extracted with water, leaving a small amount of solid sodium sulphate in contact with the solution. For this purpose, the compositions of the solutions prepared from the crust sample Nos. 1 and 2 must be identical with the composition for specific gravities of 1·244 and 1·258 of the solutions (Table 2) respectively where the relative ratios of sodium chloride to sodium sulphate at these specific gravities are identical with the crust composition and lie with the sodium sulphate solid phase. The quantity of water required for dissolving the crusts is calculated as follows. The solution with a specific gravity of 1·244 contains 39·72 g. of solid per 100 g. of water, and sodium chloride plus sodium sulphate present in crust No. 1 is 86·8 g. out of 100 g. of solid. Therefore, one part of crust with 2·16 parts of water is the best ratio for obtaining a saturated solution of sodium sulphate containing a minimum amount of sodium chloride. Similarly, for crust sample No. 2, one part of the crust with 2·2 parts of water corresponding to specific gravity of 1·258 of the solution is the best ratio. Use of less quantity of water increases sodium chloride content in the solution which lowers the solubility of sodium sulphate.

The compositions of the saturated solutions obtained by dissolving one part of the crust with two parts of water (expressed in g./100 g. of water) are NaCl, 20·06 and Na_2SO_4, 19·27 for sample No. 1, and NaCl, 14·89 and Na_2SO_4, 24·96 for crust sample No. 2. The values are in agreement with values obtained for solutions with specific gravities 1·244 and 1·258 respectively (Table 2).

The crust was ground to a 50-60 mesh powder and water was added. The slurry was stirred for 2 hr and allowed to settle for 24 hr. The suspended clay settled quickly. The clear solution was then analysed. The compositions of the three solutions prepared are given in Table 3. Solution No. 2 was prepared by using a slight excess of water to dissolve the crust, yielding a solution not quite saturated with respect to sodium sulphate. Solution Nos. 1 and 3 were prepared by adding the crust in slight excess to obtain a saturated solution. In the latter case, the excess was left as residue and was recovered in the next batch.

After settling, the clear solution was siphoned into a cooling unit and chilled to 0°C. with rapid stirring.

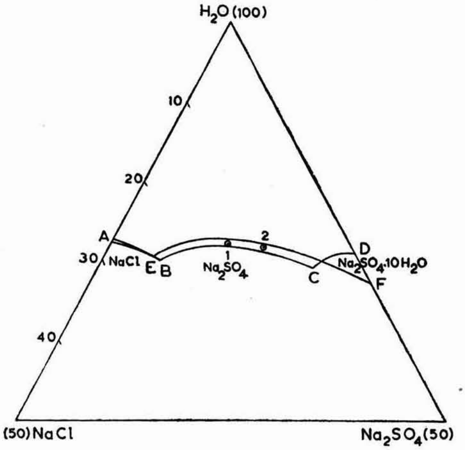


FIG. 1 — PHASE DIAGRAM FOR THE SYSTEM $NaCl$-Na_2SO_4-H_2O [ABCD represents 30°C. isotherm and AEF, 50°C. isotherm]

TABLE 3 — COMPOSITIONS OF SATURATED SOLUTION OF Na_2SO_4

PARTICULARS	SOLN No. 1	SOLN No. 2	SOLN No. 3
Crust, kg.	2·00	2·00	2·50
Water added, litre	4·00	5·00	5·00
Ratio of crust to water	1: 2	1:2·5	1: 2
Density of soln, °Bé	28·00	29·50	30·00
Composition of the soln (g./100 ml.)			
NaCl	17·86	11·40	13·40
Na_2SO_4	17·15	21·50	22·50
Final vol. of soln, litre	4·40	5·40	5·40
Residue (dried), kg.	0·42	0·17	0·55
Composition of residue (%)			
NaCl	10·20	7·60	12·70
Na_2SO_4	37·40	39·10	60·30
Na_2CO_3	1·40	1·00	2·00
Insolubles	50·70	52·40	25·00
Na_2SO_4 extracted, %	84·00	94·00	79·00

Solution No. 1 from crust sample No. 1 and solution Nos. 2 and 3 from crust sample No. 2.

TABLE 4 — RECOVERY OF Na_2SO_4 BY PRECIPITATION METHOD

PARTICULARS	EXPT No. 1	EXPT No. 2	EXPT No. 3	EXPT No. 4	EXPT No. 5
Temp., °C.	30	50	30	50	50
Vol. of soln, litre	4·4	4·4	5·4	5·4	5·4
Solid, g.	330	440	648	756	1300
Yield of Na_2SO_4, g.	360	520	750	920	1200
Purity of Na_2SO_4					
Na_2SO_4, %	96·8	96·0	95·3	96·4	95·3
NaCl, %	3·0	3·7	4·4	3·4	3·6
Recovery of Na_2SO_4, %	47·0	65·6	58·8	73·0	70·0

Expt Nos. 1 and 2 refer to crust sample No. 1 and expt Nos. 3-5 refer to crust sample No. 2.

The solution was seeded to facilitate crystallization. Sodium sulphate decahydrate formed was separated by centrifuging and the effluent contained only 1·7 g. of sodium sulphate per 100 ml.

The average composition of the product, dried at 110°C., was Na_2SO_4, 98·3 and NaCl, 1·6 per cent. The recovery of sodium sulphate from solution Nos. 1 and 3 was 91 and 94 per cent respectively.

Method No. 2 (precipitation method) — The compositions of the solutions prepared from the crust (Table 3) lie on the saturated sodium sulphate univariant line of the system[2] $NaCl$-Na_2SO_4-H_2O. The points for the two samples, expressed in g./100 g. solution, are marked by two circles corresponding to the crust samples in the graph (Fig. 1). According to the phase rule, if sodium chloride (solid) is added and dissolved by stirring, the compositions move towards the invariant points E or B where the solubility of sodium sulphate is less. Therefore, anhydrous sodium sulphate precipitates out (being situated in the anhydrous solid phase). The end point for the precipitation of sodium sulphate from solution is reached when the invariant composition is attained by the addition of sodium chloride but the sodium sulphate separating out before reaching this point will have higher purity. It is preferable to precipitate sodium sulphate at 50°C. than at 30°C., since the solubility of sodium sulphate at 50°C. at the ternary invariant point is less than that at 30°C.

Based on the above data, the calculated quantity of finely powdered solid sodium chloride was added to the solution prepared for method No. 1 and stirred for 2 hr (experiment Nos. 1-4, Table 4). The precipitated sodium sulphate (anhydrous) was recovered by filtration. The filtrate contained NaCl, 25·4 and Na_2SO_4, 9·1 per cent (w/v) at 30°C. and NaCl, 27·6 and Na_2SO_4, 5·9 per cent (w/v) at 50°C.

In experiment No. 5 (Table 4), instead of adding sodium chloride, solid bittern (1 kg.) assaying NaCl, 66·0 and Na_2SO_4, 31·2 per cent was added to 5·4 litres of solution No. 3 (Table 3) and stirred for 3 hr. Sodium chloride present in the solid bittern went into solution, leaving sodium sulphate in the solid phase. Sodium sulphate was also thrown out from the saturated solutions of sodium sulphate as sodium chloride went into solution. Sodium sulphate thus formed was separated by filtration. The effluent analysed to NaCl, 28·1 and Na_2SO_4, 8·1 per cent (w/v). The results obtained with the two crust samples by adding solid sodium chloride (99 per cent) and solid bittern (NaCl, 66 per cent) are given in Table 4. The average composition of the product was Na_2SO_4, 96·0 and NaCl, 3·6 per cent. Technical grade sodium sulphate (NaCl limit, 1·5 per cent) was obtained by washing the crystals during centrifuging or filtration.

The recovery of sodium sulphate from the mother liquor still containing appreciable quantities of sodium sulphate was done by chilling the liquor to 0°C. The overall recovery was 90-92 per cent.

Method No. 3 (*upgrading method*) — The solution for use in this method must be fully saturated with respect to sodium chloride and should approach the invariant composition. Solubility data at 30°C. (sp. gr. 1·236; Table 3) show that 32·43 g. of sodium chloride can be removed by 100 g. of water. Crust sample No. 1 contains 41·4 g. of sodium chloride per 100 g. of crust and requires approximately 127 g. of water. Similarly, for crust sample No. 2, the ratio works out as 100 g. of crust to 98 g. of water.

Powdered crust and water were stirred for 1 hr so that the density of the solution was 28·0-28·5°Bé. The slurry was then allowed to settle. The clear liquid (which was saturated with respect to NaCl and Na_2SO_4) was siphoned out and was used for recovery of sodium sulphate by artificial cooling. The compositions of the solution and solid are given in Table 5. The residue, which was upgraded to 85 per cent sodium sulphate, was dissolved in the calculated quantity of water on the basis that 100 g. of water will dissolve 30-35 g. of sodium sulphate at room temperature taking into account the presence of 5 per cent sodium chloride.

After stirring the upgraded sodium sulphate residue with water for 2-3 hr, the slurry was allowed to settle. The insoluble material (clay) allowed to settle down, the clear liquid decanted into trays and left in the open when $Na_2SO_4.10H_2O$ separated out during the night due to fall in temperature. Crystallization was stopped when the solution attained a concentration of 27 to 28 g. of sodium chloride per 100 ml. as further evaporation would contaminate the product with sodium chloride. Forced evaporation was also employed to obtain sodium sulphate. The results are given in Table 6.

TABLE 5 — PREPARATION OF SATURATED SOLUTION OF NaCl

PARTICULARS	SOLN No. 4	SOLN No. 5	SOLN No. 6	SOLN No. 7
Crust, kg.	2·00	3·20	4·00	4·00
Water added, litre	3·00	4·00	5·00	4·00
Density of soln, °Bé	28·50	28·50	28·50	29·00
Composition of soln (g./100 ml.)				
NaCl	22·50	27·21	22·40	27·80
Na_2SO_4	12·30	9·34	10·80	8·90
Final vol. of soln, litre	3·30	4·40	5·20	4·20
Residue, kg.	0·79	1·45	2·24	2·46
Composition of residue (%)				
NaCl	8·60	6·40	4·50	5·20
Na_2SO_4	64·40	72·00	85·20	86·00
Na_2CO_3	1·50	1·00	0·80	0·80
Insolubles	25·00	21·50	11·50	9·80
Na_2SO_4 recovered in the residue, %	44·70	70·00	76·90	85·00

Solution Nos. 4 and 5 were prepared from crust sample No. 1 and solution Nos. 6 and 7 from crust sample No. 2.

TABLE 6 — RECOVERY OF Na_2SO_4 BY THE UPGRADING METHOD

[*Vol. of original soln processed, 4 litres; composition of original soln (w/v): NaCl, 3·4% and Na_2SO_4, 22·4%*]

METHOD OF SEPARATION OF Na_2SO_4	YIELD OF Na_2SO_4 g.	PURITY OF Na_2SO_4 %	AV. RECOVERY OF Na_2SO_4 %
Evaporation by direct heating*	890	96·0	95
Crystallization by natural cooling† (crop collected after 4 days)	840	99·0	93

*Mother liquor (0·4 litre) left over analysed (w/v) to NaCl, 25·0% and Na_2SO_4, 9·4%.

†Mother liquor (0·5 litre) left over analysed (w/v) to NaCl, 26·5% and Na_2SO_4, 8·6%.

Anhydrous sodium sulphate was obtained by forced evaporation, whereas $Na_2SO_4.10H_2O$ was obtained by natural cooling. The decahydrate was dehydrated separately by solar heat. The purity of the product obtained by forced evaporation was about 96 per cent and that obtained by natural cooling 99·0 per cent.

Conclusion

The recovery of Na_2SO_4 from the crust is much simpler than from liquid bittern and solid bittern[3] as the crust contains relatively larger quantities of sodium sulphate and less of sodium carbonate. The quantity of sodium sulphate (technical grade) recovered was 90-94 per cent of the total amount present in the crust. The first method (chilling) will be applicable to all types of crust but will require refrigeration equipment. The second (precipitation) and the third (upgrading) methods will be applicable only to crusts, rich in sodium sulphate, and will require only a few mechanical devices such as stirrers. The overall recovery of sodium sulphate is 65-73 per cent and if higher recovery is desired, the chilling procedure is indispensable. In the precipitation method, sodium sulphate is obtained in the anhydrous state which is an advantage. Also, the solid bittern of Sambhar (Na_2SO_4, 20-30 per cent) can be employed with advantage in the precipitation method instead of sodium chloride. The yield of sodium sulphate per batch will be higher by 52 g. per litre of solution, since sodium sulphate in the solid bittern also gets precipitated. The only disadvantage is that precipitation has to be carried out at 50°C. for higher recovery. The upgrading method is simpler to operate and does not require care in the preparation of solutions and precipitation of sodium sulphate as in the precipitation method. The recovery of sodium sulphate is 75-80 per cent in the upgrading method which is slightly higher than that in the precipitation method but the product obtained is $Na_2SO_4.10H_2O$ which needs dehydration.

Acknowledgement

One of the authors (K.S.) wishes to thank Dr A. N. Kappanna for his keen interest in this investigation and for valuable suggestions.

References

1. Seidell, A., *J. Amer. chem. Soc.*, **27** (1902), 52.
2. Chretion, A., *Ann. Chim.*, **12** (1929), 155.
3. Seshadri, K. & Buch, S. D., *J. sci. industr. Res.*, **18A** (1959), 132.

Use of Magnesium Chloride in Cotton Warp Sizing

R. V. SONEJI, C. C. SHAH & P. C. MEHTA

The Ahmedabad Textile Industry's Research Association, Ahmedabad

Manuscript received 24 *July* 1958

The effects of using varying amounts of magnesium chloride in cotton warp sizing on the degradation of cloth during singeing, storage and friction-calendering have been investigated. The results of the studies show that the cloth undergoes little degradation in the presence of magnesium chloride under normal processing conditions. However, in the absence of starch, use of magnesium chloride in large concentrations produces significant degradation in the cloth even at room temperature. This cannot be explained on the assumption that magnesium chloride dissociates during various processing operations, liberating hydrochloric acid which degrades the cellulose of the cloth.

MAGNESIUM chloride is generally used for sizing of cotton warp, particularly when the warp is to be heavily sized, as in the case of cloth to be sold in the grey state. Due to its hygroscopic nature, magnesium chloride is expected to increase the moisture regain of the sized warp and facilitate weaving. Many workers[1-6] have, however, strongly criticized the use of magnesium chloride in sizing and have pointed out the danger of degradation of cloth, in subsequent processing. According to these workers tendering of cloth is likely to occur when cloth containing substantial quantities of magnesium chloride is (i) singed, (ii) friction-glazed, (iii) overdried or (iv) stored for a long period. In a recent publication Seydel[7] has observed that the harmful effects of the use of deliquescent chlorides, particularly magnesium chloride, are exaggerated, and that at temperatures that can dissociate magnesium chloride, the warp of the cloth would have undergone damage long before the dissociation of the chloride starts.

Little direct experimental evidence is available either for or against the use of magnesium chloride. The investigations reported here were undertaken to study the effect of using, in the size, varying amounts of magnesium chloride on the degradation of cloth during storage, singeing, etc.

Experimental procedure

Sizing — The yarn was sized in a laboratory slasher by drawing it from a 16-bobbin creel through a jacketed sow-box, squeezing between a pair of weighted squeeze rolls, drying by hot air during passage through a glass tube and finally winding on a wooden reel. The reel and the squeeze rolls were synchronized and were driven by the same motor, through a pulley and belt arrangement. The size used contained only maize starch and varying amounts of magnesium chloride (hexahydrate) and was prepared in the usual manner. The sized yarn was tested for total size, following the method prescribed in *I.S. Specification* 199-1957, and for total chlorides by the method of Neale[8].

Degradation due to heating — To simulate the temperature conditions encountered in drying and friction-glazing, the sized yarn samples were heated in a thermostatically controlled oven at 110° ± 1°C. for 30, 60 and 120 min. and at 125° ± 1°C. for 30 min.

Singeing — Singeing was done on a gassing machine (Arundel Coulthard & Co., Stockport) by passing the sized yarn containing the maximum amount (20 per cent on weight of starch) of magnesium chloride at a speed of 260 yards/min. Part of the yarn was singed more than once.

Storage — Samples of the sized yarn were stored for 12 months under ordinary laboratory conditions (range of temperature 10-45°C. and R.H. 20-75 per cent).

All the treated samples of yarn were desized and tested for degradation by measuring their fluidities in cuprammonium hydroxide according to *I.S. Specification* 244-1951; the fluidity values have been converted to fluidities at 20°C.

A similar set of experiments was also made in which yarn was treated with different concentrations of magnesium chloride alone. The treatment was carried out on the laboratory sizing unit, as previously described, except that the ' size ' contained only magnesium chloride and no starch. Samples of ' sized ' yarn were then treated, singed or stored and tested for degradation as described earlier.

Yarn treated in a similar manner with water and with maize starch alone were used as controls in studying the effect of heating.

Friction-calendering — A sample of bleached cloth was padded with starch paste containing 20 per cent $MgCl_2.6H_2O$ (on the weight of starch). A similar sample padded with the starch paste alone was used as control. The total amount of size on the cloth was found to be approximately 11 per cent, as determined by the difference in weight of the conditioned sized and unsized samples. The metal bowl of a 5-bowl Kleinwefer universal calender was heated for 45 min. with steam at 40-45 lb./sq. in. pressure, and the cloth samples were friction-calendered (friction ratio 1: 1·3) at 60 yards/min., giving 1, 2 and 3 nips respectively. Cuprammonium fluidities of the calendered samples were determined after desizing.

Results

In Tables 1 and 2 are given respectively the results of the effect of heating, and of singeing and storing the samples of sized yarn containing varying amounts of magnesium chloride. Similar data for yarn treated with magnesium chloride alone are given in Tables 3 and 4. The fluidities of the friction-calendered samples are recorded in Table 5.

Discussion

It is evident from the results presented in Tables 1-5 that heating at 110°C. for 60 min. produces very little degradation, the maximum increase in fluidity being 0·8 rhe for the sample containing the maximum amount of magnesium chloride. When the duration of heating is increased to 120 min., the fluidity increases, the increase being of the order of 1·5-2 rhes. It is obvious that even on very prolonged heating, such as would rarely be encountered in processing, the degradation produced is not of any serious proportions. Normal machine stoppages during sizing hardly exceed 30 min., and little degradation may be expected if the yarn is to be overheated during such stoppages. At 125°C. the extent of degradation is significantly more and even in the treatment for 30 min., the fluidity goes up to *c.* 6, showing definite signs of degradation. Temperatures encountered in friction-glazing are of the order of 125-60°C., though the total time for which

TABLE 1 — DEGRADATION OF SIZED YARN ON HEATING

MAGNESIUM CHLORIDE IN SIZE (ON THE WT OF STARCH) %	SIZE PICK UP %	CHLORIDE CONTENT OF YARN %	CUPRAMMONIUM FLUIDITY (*rhes at* 20°C.) OF DRY SIZED YARN HEATED AT				
			110°C. for				125°C. for
			0 min.	30 min.	60 min.	120 min.	30 min.
0·0	—	—	2·5	—	—	—	2·6
5·0	16·1	0·1	2·6	2·3	2·8	2·7	—
7·5	18·3	0·2	3·1	2·9	3·3	3·2	—
10·0	17·3	0·3	3·1	2·8	3·0	3·5	6·4
12·5	18·2	0·4	2·8	3·6	2·8	4·6	—
15·0	16·3	0·5	3·6	3·3	3·8	4·0	—
20·0	18·3	0·7	2·9	3·6	3·7	4·8	6·0

TABLE 2 — DEGRADATION OF SIZED YARN ON SINGEING AND STORAGE

CHLORIDE CONTENT OF SIZED YARN %	TREATMENT	CUPRAMMONIUM FLUIDITY (*rhes at* 20°C.)	
		Initial	After treatment
0·7	Singed once	2·9	3·8
0·7	Singed twice	2·9	3·3
0·1	Stored for 12 months	2·6	3·2
0·2	do	3·1	2·7
0·5	do	3·6	5·1
0·6	do	2·9	3·3

TABLE 3—DEGRADATION OF YARN 'SIZED' WITH $MgCl_2$ ALONE ON HEATING

CHLORIDE CONTENT OF YARN %	TEMP. TO WHICH YARN WAS HEATED °C.	CUPRAMMONIUM FLUIDITY (*rhes at* 20°C.) OF YARN HEATED FOR		
		30 min.	60 min.	120 min.
Water treated (control)	110	2·4	—	—
	125	2·5	—	—
0·23	110	2·7	—	—
	125	4·0	—	—
0·57	110	2·5	—	—
	125	4·2	—	—
1·85	110	6·7	10·0	14·9
	125	16·2	22·3	25·4
4·60	110	6·4	—	—
	125	16·3	—	—

TABLE 4—DEGRADATION OF YARN 'SIZED' WITH $MgCl_2$ ALONE ON SINGEING AND STORAGE

CHLORIDE CONTENT OF YARN %	TREATMENT	CUPRAMMONIUM FLUIDITY (*rhes at* 20°C.)	
		Initial	After treatment
1·85	Singed twice	1·8	2·2
1·85	Singed four times	1·8	2·3
4·60	Singed twice	2·6	2·7
4·60	Singed four times	2·6	2·8
4·60	Singed eight times	2·6	2·7
1·85	Stored for 15 days	1·8	3·6
1·85	Stored for 60 days	1·8	5·7
4·60	do	2·6	5·9

TABLE 5 — DEGRADATION OF CLOTH ON FRICTION-CALENDERING

TREATMENT OF SAMPLE	NO. OF NIPS	CUPRAMMONIUM FLUIDITY* (*rhes at* 20°C.)
No sizing	nil	7·5
Sized without magnesium chloride	1	8·2
	2	7·7
	3	7·4
Sized with magnesium chloride	1	8·5
	2	8·0
	3	7·8

*Mean of four observations.

the cloth would be exposed to this temperature would be a fraction of a minute. Cloth, which is friction-glazed without removal of warp size, is sold in the grey state without further processing. It seems unlikely, therefore, that even on friction-glazing, any degradation of cloth that may be produced would be more than what the grey cloth would undergo in the normal bleaching process. This is confirmed by the data in Table 5 which show little difference in the fluidities of the untreated bleached cloth, and of the same cloth friction-calendered after sizing with and without magnesium chloride.

Singeing does not produce significant degradation, as seen from the fluidity data. This is not unexpected because the surface temperature of cloth or yarn, moving at a speed of about 250 yards/min. over a flame, will not increase very much even though the temperature of the flame itself may be 700-800°C. The results presented in Table 1 show that even at 110°C., no degradation is observed for durations as long as 30 min. It is unlikely that the textile is subjected to more drastic conditions than these in singeing.

Storage for 12 months also does not show any degradation. The results presented (Tables 1 and 2) show that the cloth undergoes little or no degradation under all treatments excepting heating at 125°C. Even at 125°C., the extent of degradation can hardly be considered excessive. It is generally assumed that hydrogen chloride, liberated on dissociation of magnesium chloride, produces hydrolytic degradation of cellulose. Magnesium chloride, which is intimately mixed with starch in the size and applied to the yarn, would be expected, during the sizing process, to be partitioned between the cellulose and the starch phases. Conditions under which cellulose is hydrolysed would be expected as well to produce hydrolysis of starch, which is more easily hydrolysable than cellulose. It was thought that perhaps preferential hydrolysis of starch by hydrogen chloride, produced through dissociation of magnesium chloride, may account for the lack of cellulose degradation observed in most of the treatments (Tables 1 and 2).

To verify the above hypothesis, 5 per cent maize starch pastes, with and without magnesium chloride (20 per cent on weight of starch), were kept at 80° ± 0·5°C. for 118 hr and their flow time (at 80° ± 0·5°C.) and reducing value were determined at intervals. No significant differences were observed due to the presence of magnesium chloride. A similar study at 116-18°C., when magnesium chloride just begins to dissociate, presented some experimental difficulties. Use of aqueous starch pastes was not possible. On the other hand, starch films could not be used for measurement of reducing value as the films could not be redispersed in water. A somewhat rough estimate was obtained by leaching out, in hot water, the starch from samples of sized yarn containing 0, 10 and 20 per cent magnesium chloride (on weight of starch) and heated at 110° and 125°C. respectively for 30 min. Corresponding samples of the sized yarn without any heat treatment were used as controls. Here again no significant difference in reducing value was observed either due to presence of magnesium chloride or due to heating.

Considering that the first part of the study on starch pastes was carried out at a temperature much below the dissociation temperature of magnesium chloride, and that the second part of the investigation was liable to considerable uncertainty, it was thought that a study of the degradation of cellulose by magnesium chloride in the absence of starch would give a more direct and reliable answer as to whether the presence of starch affords at least a partial protection to the cellulose from the hydrolytic attack of magnesium chloride. The results of these studies (Tables 3 and 4) show that cellulose degradation is appreciably more at 125°C. for all concentrations of magnesium chloride, and particularly for the two highest concentrations, the increase in fluidity at the higher temperature is large. It is surprising that significant degradation occurs at 110°C., and even during storage at room temperature with high concentrations of magnesium chloride. These results are difficult to explain on the basis of dissociation of magnesium chloride to hydrogen chloride.

From the results of yarns containing chloride in the approximate concentration range of 0·2-0·6 per cent, on heating at 110° or 125°C. for 30 min., there does not appear to be any significant difference in the extent of degradation due to the presence or absence of starch. There is thus no conclusive evidence to show that the presence of starch protects the cellulose from degradation.

Singeing in the absence of starch in the yarn does not produce any degradation even under very drastic conditions, which goes to strengthen the arguments put forward earlier.

The results of the above studies indicate that under a variety of laboratory conditions, simulating different textile processes, the presence of magnesium chloride in warp sizing does not produce any significant degradation in the cloth. Industrial processing conditions are complex and difficult to reproduce exactly in the laboratory, and to that extent, the extension of the laboratory results to industrial conditions requires caution. It appears, however, that the dangers of employing magnesium chloride in warp sizing have been considerably exaggerated.

Conclusions

1. Cotton yarn sized with starch and magnesium chloride, and containing 0·1-0·7 per cent chloride on the weight of yarn (when heated at 110°C. for 60 min.) does not undergo any significant degradation. Extending the heating period to 120 min. produces a small but significant degradation. Heating at 125°C. for 30 min. does produce noticeable degradation; the degradation is of the same order as that undergone by the cloth in normal bleaching operation.

2. No degradation is observed with sized yarns containing 0·7 per cent chloride on singeing or on prolonged storage.

3. Friction-calendering of sized cloth containing magnesium chloride does not produce any significant degradation.

4. Magnesium chloride in large concentrations, and in the absence of starch, produces significant degradation at 110°C.; degradation is observed even at room temperature. This cannot be explained on the assumption that dissociation of magnesium chloride liberates hydrogen chloride which in turn degrades the cellulose of the cloth.

Acknowledgement

The authors express their thanks to the Ahmedabad Textile Industry's Research Association for permission to publish this paper. A part of the experimental work reported in the paper was done by Shri R. D. Mehta and Shri P. K. Chouthoy.

References

1. Cooper, *J. text. Inst.*, **17** (1926), 72.
2. Higgins, S. H. & Hodge, A., *J. text. Inst.*, **12** (1921), A268.
3. Pickstone, C., *Textile Mercury*, **70** (1924), 4.
4. Swan, E., *J. text. Inst.*, **17** (1926), T517.
5. Von Vreeswijk, A. C., *J. Soc. Dy. Col.*, **62** (1946), 120.
6. Whewell, W. H., *J. Soc. Dy. Col.*, **39** (1923), 65.
7. Seydel, P., *Textile Industries*, **120** (1956), 132.
8. Neale, S. M., *Shirley Institute Memoirs*, **5** (1926), 151.

REVIEWS

REPORTS ON THE PROGRESS OF APPLIED CHEMISTRY: Vol. XLII, 1957. Edited by H. S. Rooke (Society of Chemical Industry, London), 1957. Pp. 910

Volume XLII of Applied Chemistry Reports closely follows the previous volume, but there are a few changes. A chapter on Gas and Destructive Distillation has been added to the section on Fuel and Fuel Products. In the section on Inorganic Chemistry the chapters on Mineralogical Chemistry and Glass have been replaced by a chapter on Industrial Gases. The Metals section now includes a chapter on Electrodeposition. Explosives have been omitted from the section on Organic Chemistry. In the large and miscellaneous section on Textiles, Plastics, Adhesives and Paints a separate chapter is not devoted to Manipulation of Thermoplastic Materials. In the section on Chemical Engineering and Hazards the chapter on Industrial Hazards has been omitted, and there are two new chapters on Water Treatment and on Sewage, Trade Wastes and River Pollution. The chapter on Brewing, Malting and Allied Processes has been omitted from the last section on Agriculture and Food.

Earlier reviews of these Reports have referred to anomalies in the classification of subjects. The sections on Inorganic and Organic Chemistry deal with products and processes rather than chemistry. Like previous volumes Vol. XLII continues to be an abstract of abstracts and its main use is as a source of references to the original literature; in addition to the references which have been abstracted in the body of each chapter, there is a Supplementary Bibliography of the most recent publications. A useful feature of each chapter is the information on production and industrial progress during the period under review; for instance the chapter on Petroleum begins with data on world oil statistics, production, consumption and refinery capacity, and concludes with production figures for petrochemicals. Corrosion of metals represents one of the major problems of the chemical industry, and every volume of Applied Chemistry Reports includes a short chapter on the subject. The chapter on Intermediates and Dyestuffs consists largely of a collection of the titles of all the papers and patents which appeared or were abstracted during the year; several of the papers represent no contribution to the ' Progress of Applied Chemistry '. Critical comments on the papers and patents are not to be expected in these Reports, but some attempt might have been made to separate the grain from the chaff. It is stated that Moran and Stonehill [*J. chem. Soc.*, (1957), 765, 779] " have shown that there is no simple correlation of the fluorescence or absorption spectra with the fading and cellulose-tendering activity of certain vat dyes "; the absorption spectra determined by Moran and Stonehill are valueless since ethanol and chlorobenzene, in which most of the vat dyes are practically insoluble at room temperature, have been used as solvents, and the absorption data of these authors probably relate to the impurities present in the dyes. The chapter on Fine Chemicals and Medicinal Substances is outstanding, and it includes useful accounts of hypotensive drugs, hypoglycaemic sulphonamides (oral antidiabetic compounds), steroids, and drugs for tropical diseases. The chapter on Synthetic Fibres draws attention to the importance of the new method of spinning aqueous dispersions of polymers which avoids expensive and unpleasant solvents and offers other advantages; this chapter also includes a discussion of isotactic polypropylene as a fibre. The chapter on Plastics contains a comprehensive review of recent work on olefin polymerization with special reference to the heterogeneous organometallic catalysts of Ziegler and Natta.

K.V.

NUCLEAR CHEMICAL ENGINEERING—McGraw-Hill Series in Nuclear Engineering, by Manson Benedict & Thomas H. Pigford (McGraw-Hill Book Co. Inc., New York, Toronto & London), 1957. Pp. xiv + 594. Price $ 9.50

This volume, the first of its kind, presents a lucid account of chemical engineering aspects in the field of nuclear technology. The authors have gathered all the available declassified information in this field and have succeeded in putting it in a form of an excellent text as well as a reference book. The problems at the end of each paper are well conceived and should go a long way in understanding the various principles presented in the text.

The first chapter serves as an introduction, outlining the need for utilizing atomic energy, the principle of nuclear fission, nuclear fuels, associated reactor materials and the chemical processes associated with nuclear power industry. The second chapter deals with basic radiochemistry and reactor physics. The material is well condensed and only pertinent topics have been dealt with. The third chapter deals with fuel cycles in thermal nuclear reactors depicting various flowsheets, irradiation schemes, neutron economy in a reactor, production of fissile materials from fertile materials and their recycling.

The chemical technology associated with the production of associated reactor materials is presented in Chapters 4-6. Chapter 6 deals entirely with solvent extraction, principles and techniques which have made rapid advances during the last decade. Perhaps this chapter should have preceded Chapters 4 and 5 which describe the basic chemistry and the flowsheets for the production of uranium, thorium, zirconium and beryllium.

The properties and reprocessing of irradiated fuel for the recovery of plutonium and uranium-233 are dealt with in Chapters 7 and 8. The radioactivity and decay characteristics of fission products and production of plutonium are discussed, depicting equations for the calculation of gross activity for burn-up of natural uranium. The processes for the separation of plutonium from irradiated fuel, viz. non-aqueous and aqueous processes, have been described. The flowsheets have been schematically presented.

The final chapters include the uses of stable isotopes and methods of their separation. The principle of cascade and its application to the separation of isotopes has been described. Industrial methods of separation of isotopes, particularly the ones required for nuclear technology, are well presented.

The problem of treatment of radioactive waste arising out of reprocessing of irradiated fuel is not dealt with in this book. Perhaps this would be included in a future edition of this book.

Considerable amount of new information was presented at the Second International Conference on the Peaceful Uses of Atomic Energy, and hence inclusion, in the next edition, of pertinent information in various chapters, in particular, reprocessing of irradiated fuels and separation of isotopes, will be welcome. However, this present volume, as it is, serves an excellent purpose for training chemical engineers in the field of nuclear technology.

The book is highly recommended for the chemical engineers and chemists interested in the field of nuclear energy.

H. D. SHARMA

GLASS-MELTING TANK FURNACES by R. Gunther. Translated from the German by John Currie (Society of Glass Technology, Sheffield), 1958. Pp. xiv + 232. Figs. 110. Tables 69. Price 60*s*. or $ 9.00

The Society of Glass Technology is to be complimented for bringing out the English translation of a very commendable German book, *Glass-chmelz-Wannenofen*, by Dr Ing. Rudolf Gunther, Head of the Deutsche Glastechnische Gesellschaft. The book, first published in 1954, is the outcome of systematic work done under the auspices of D.G.G. and Huttentechnische Vereinigung der Deutschen Glasindustrie during the last 30 years, and is a sequel to the report on *Glassmelting Tank Furnaces with Regenerative Firing* which was published in 1927 by the predecessors of the H.V.G.

The paucity of good books on glass-melting furnaces in the English language has been so great that not many engaged in glass melting have felt confident to tackle even relatively simple problems relating to furnace design. Dr Gunther's book, which is intended to give a concise summary of the present state of knowledge in the sphere of tank furnaces, will contribute much towards removing this deficiency. As pointed out by Prof. Turner in the foreword, the original contributions of Dr Gunther on furnace problems, together with the mass of other experimental data available to him, have given him an authoritative position to expound the principles of furnace construction and operation. A committee of British experts have helped in enhancing the value of the book considerably by extending the list of references, given at the end of each chapter, so as to include important work done on the subject in America and Great Britain.

The book has eleven chapters: (1) Introduction, (2) Types of furnaces, (3) The essential operations of tank furnaces, (4) Constructional details, (5) Heat recovery, (6) The control of gaseous flow, (7) Control equipment, (8) Heating and cooling the furnace, (9) Furnace capacity and fuel efficiency, (10) Fundamental thermal calculations, and (11) History of the tank furnaces — a special contribution by G. Stein. Sections dealing with the design of ports, regenerators and recuperators and the distribution of temperature and the point-to-point composition of gases in the flames of a glass-melting furnace are of special interest since a good part of the information is based on original work. The chapter on fundamental thermal calculations, together with the appended tables containing data for calculations is comprehensive. A lot of useful information has been condensed in the form of tables, e.g. Table 65 for the refractory building materials; Table 18 for the furnace control instruments, etc. The book deals basically with the conventional types of tank furnaces, fired by producer gas, coke-oven gas or fuel oil, in vogue in Germany. There is no mention of some of the recent developments in other parts of the world, such as electric melting or boosting, ' unit melter ', etc. There is scope for enlarging the coverage of the subjects discussed in the book.

The book will form a very useful addition to the library of any glass technologist.

K. D. SHARMA

TABLES FOR SOLVING THE LAPLACE EQUATION INSIDE AN ELLIPSE by A. I. Vzorova, translated into English (Infosearch Ltd, London. *Sole Distributors except the U.S.A.*: Cleaver-Hume Press Ltd, London), 1958. Pp. 256. Price 50*s*.

As indicated in the preface, these tables are intended for the approximate solution of the first boundary value problem of the Laplace equation for the domain interior to an ellipse. This problem is a particular case of the general Dirichlet interior problem for an elliptic differential equation, viz. to find the solution of the equation in the interior of a simply connected region with the requirement that the solution should take on prescribed values on the boundary of the region. As is well known, it is not always possible to solve this Dirichlet problem even for the case of a simply connected three-dimensional region. In the case of two independent variables, however, it has been proved that a solution does exist provided that the function prescribed on the boundary of the two-dimensional region is continuous. But the actual analytical determination of the solution, even in this simple case where it is known to exist, offers what are at present insurmountable problems. Hence numerical methods have become quite popular in recent years, and the book is a valuable contribution in this direction, relating as it does to the Laplace equation which is of fundamental importance in many branches of science and engineering.

The actual method adopted is to assume that the continuous function $F(E)$, where E is the eccentric angle at any point of the ellipse of semi-axes a and b, is sufficiently well approximated by the nth partial sum of its Fourier series involving coefficients a_0, a_1, $a_2, \ldots a_{2n}$, and then obtain the required approximate solution U_n of the Laplace equation in the form of a series

$$U_n = m_0 + \sum_{k=1}^{u} \left(\frac{r}{a}\right)^K (m_{2K-1} \cos K\phi + m_{2K} \sin K\phi)$$

where r and ϕ are the polar co-ordinates of the point at which U is to be determined, and $m_0, m_1, m_2, \ldots m_{2n}$ are certain coefficients depending on $p = b/a$ and on the boundary values. As a preliminary to the determination of the coefficients $m_0, m_1, \ldots m_{2n}$, a sequence of 20 equidistant values of the variable E in the range 0-2π is introduced, and suitable tables set up for boundary values in E, and for sums by rows in E. Further, taking $n = 10$ formulae are set up expressing the m_i as linear combinations of the entries in the second of the above tables, multiplied by the corresponding Fourier coefficients expressed as integrals. It is mentioned that these formulae are calculated by some method of numerical integration by rectangles over the independent variable E. Some more details regarding the particular method employed would have been useful. In order to reduce the integration steps by a half and to provide a check on the accuracy obtainable from the tables, another sequence of points E' is introduced leading through the same steps, as in the case of the earlier sequence, to the determination of the set m_i' equivalent to the m_i, but permitting the derivation of a more accurate value of a coefficient by taking the arithmetic mean of m_i and m_i'.

Next are described the method of construction of the first set of tables (called Table I), and their use. The individual tables correspond roughly to equal intervals in log p, and constitute 232 in total number (pages 22-137) in the range $0{\cdot}1000 \leq p \leq 0{\cdot}9912$. Each table, for a given p, consists of two parts corresponding respectively to the sequences E and E' employed, and each part is elegantly constructed by using the tables of sums by rows in E or E', coupled with the use of four matrices (called the $\Gamma\nu$ with $\nu = 1, 2, 3, 4$) based on the quantities obtained by numerical integration suitably arranged by using recent computational methods of linear algebra. The method of computing the several m_i (or m_i') with the aid of the tables is described in detail, and is further followed by explanations about the calculation of the harmonic function U_n at any point M (r, ϕ) inside the ellipse. An assessment of the possible errors inherent in the tables has been made on the basis of the theorem of maximum values, viz. that the error in the interior of the domain is always smaller than the error at the boundary. Such an assessment has shown that Table I may give inaccurate results when, in any section of the interval not including points of the set E (or E') used, the function prescribed at the boundary changes much more rapidly than elsewhere, and, in particular, when p is small and the function prescribed at the boundary changes rapidly near $\pi/2$. For use in such cases, a second set of tables (called Table II) is set up by using another set of C_ν matrices (instead of the C_ν of Table I) having their elements expressed in terms of values of Chebyshev polynomials, and detailed explanations are given about the use of Table II in the exceptional cases mentioned above.

The value of the tables is enhanced by the illustration of their use by means of four particular examples given in paragraph 3 of the Introduction. The first two examples take general types of boundary values in order to illustrate the methods of calculation in general cases. The next two examples deal with two particular types of harmonic functions (i.e. where the analytical solutions of the Laplace equation are known), and serve as a check on the approximate solutions obtained by using the tables.

These examples show that the agreement between the approximate and exact values of U_n are quite good when Tables I and II are used.

There is no doubt that this book of tables, neatly printed on excellent paper, will be of great help to workers in many fields of engineering. It can well be considered a major contribution to numerical mathematics.

B. S. MADHAVARAO

COMPREHENSIVE INORGANIC CHEMISTRY: Vol. VII — THE ELEMENTS AND COMPOUNDS OF GROUP IVA by Harold P. Klug & Robert C. Brasted (D. Van Nostrand Co. Inc., Toronto, New York & London), 1958. Pp. ix + 302. Price 56*s*. 6*d*.

It is necessary to point out, at the outset, that Group IVA here means the main group, viz. carbon, silicon, germanium, tin and lead. The book is divided into two unequal parts. The first part, covering 245 out of 287 pages of reading matter, constitutes a broad treatment of the chemistry and technology of the five elements, including information on their occurrence, preparation, physical and chemical properties, uses and physiological action. The second part is a neatly written essay of 42 pages on borides, carbides, nitrides, silicides, hydrides and related substances such as graphitic compounds and tungsten bronzes in which the available information appears quite up to date.

In going through the book, it was a pleasant experience to notice the unremitting effort on the part of the authors to present as up-to-date information as possible with literature references, making the book a handy work of reference on the subject. Useful physical constants have often been collected and presented together in a convenient tabular form.

Though the chapter on silicon opens with the interesting statement that ' the chemistry of silicon is modern chemistry ', the respective sections, viz. simple covalent compounds, the organosilicons and the silicates have been reviewed with a wide perspective and consummate skill. As an extractive method for germanium, Tchakirian's oxalate process deserves special mention.

One mis-statement has come to the reviewer's notice. Important deposits of tin occur in Asia in its south-eastern region, not south-western, as stated on page 212.

A high standard of printing and editing has been maintained throughout the book.

J. GUPTA

4-AXES UNIVERSAL STAGE by P. R. J. Naidu (University of Madras, Madras), 1958. Pp. x + 106

The book describes the Fedorow Universal Stage and the routine operations that could be carried out with it. The book is divided into eleven chapters under the following headings: Description of the instrument and the mode of use; Optic orientation; Extinction angle; Optic axial angle; Refringence; Birefringence; Pleochroic scheme; Properties of uniaxial minerals; Determination of plagioclase felspars; Determination of potash felspars; and Plotting for petrofabric analysis.

The book is profusely illustrated with figures and diagrams. The different experimental procedures adopted with universal stage have been dealt with in some detail giving examples for each case. One does not feel happy with the fairly large number of errors that have appeared throughout the text. However, the book will serve as a useful companion to students of geology.

R.S.K.

NUCLEAR REACTOR METALLURGY by Walter D. Wilkinson & William F. Murphy (D. Van Nostrand Co. Inc., Toronto, New York & London), 1958. Pp. ix + 382. Price 42*s*.

This book is based on a course of lectures in applied reactor metallurgy delivered by the authors at the International School of Nuclear Science and Engineering of the Argonne National Laboratory. The course was sponsored by the U.S. Atomic Energy Commission and it was open to scientists and engineers with varied backgrounds. As such, the book is written in simple style to assist this type of reader. The authors, in the preface, have made it clear that they were restricted in the presentation by security considerations and it is unfortunate that material for this book was completed some months before the Second Geneva Conference on the Peaceful Uses of Atomic Energy where a great deal of further information was divulged.

Almost half the book is devoted to the metallurgy of uranium. The other chapters deal with plutonium, thorium, beryllium, zirconium, liquid metals, ceramics, control-rod materials, radiation damage of non-fissile materials, and finally non-destructive testing of nuclear reactor components. There are important omissions in the coverage such as absence of material on magnesium and pressure vessel steels which are of interest in the gas-cooled Calder Hall type reactors.

The authors have attempted to incorporate in the text basic ideas in metallurgy and have thus discussed such varied topics as electronic structure, crystal structure, Brillouin zones and electron/atom ratios but the presentation is so brief in these respects that it is doubtful whether the reader unfamiliar with the subject would be benefited to any great extent. Thus, X-ray methods for determination of preferred orientation are covered in three pages including an introduction to the concept of stereographic projections. In Chapter 3, the crystal structure of uranium is briefly discussed in order to provide a foundation for the material appearing later. In this and subsequent chapters, Miller indices are employed but it is not till much later in Chapter 6 that the authors deal with the derivation of Miller indices.

Although uranium has been dealt with in fairly great detail, the discussion on creep, which is of great importance in the design of fuel elements, is confined to a mere page and no mention is made of the important work of Cottrell and others on creep under irradiation. The chapters on materials other than uranium are well written but they suffer to some extent from brevity. Thus, in Chapter 14 on the metallurgy of beryllium, only four lines are devoted to the behaviour of this metal under irradiation.

The chapter on ceramics contains one page on graphite, one page on uranium carbide and four pages on uranium dioxide but there is no discussion of the compatibility of the ceramic fuels with canning materials.

Summing up, the book presents much valuable material in spite of a few omissions. It suffers from brevity but for a non-specialist in metallurgy, it will serve as a valuable introduction to the innumerable problems encountered in the selection and use of materials in atomic reactors.

B.P.

SOME PROBLEMS OF CHEMICAL KINETICS AND REACTIVITY: Vol. 1, by N. N. Semenov. Translated by T. E. S. Bradley (Pergamon Press Ltd, London), 1958. Pp. x + 305. Price 50s. net

Any book on reaction mechanism by Prof. Semenov would evoke worldwide interest and the present volume fulfils all our expectations. The book was written by Prof. Semenov in 1954 and in a way served as a general introduction to the All Union Conference on Chemical Kinetics and Reactivity held in 1955. This was then rewritten and now presents in about 300 pages a very comprehensive review of general mechanism of free radical reactions and mechanism of reaction chain propagation. It is not limited to discussions on isolated reactions.

Prof. Semenov writes in his introduction that the book mainly presents the viewpoint of his school at the Institute of Chemical Physics. No doubt, the emphasis is on the work carried out by the Russian school, but every section contains a brief discussion of the fundamentals, a brief historical résumé and covers work carried out at several important schools in reaction kinetics outside U.S.S.R. The style is appropriately terse, but brevity has not affected lucidity.

The book contains theoretical discussion on propagation and branching of chain reactions by uniradical and biradical reactions, chain initiation and termination, and finally kinetics of chain reaction. There is a detailed discussion on the wall effect in initiation and retardation of chemical reactions. Occasionally, laboratory techniques, such as methods of differential calorimetry, are briefly discussed.

This is a book mainly addressed to the specialists. It is a good reference book for those engaged in work on chemical kinetics and students of advanced physical chemistry. It will also provide a comprehensive review for those who seek initiation to the subject of radical reaction and chain propagation. The book is of immense value to those who have not studied the work of the Russian school. The value of the book has been enhanced by two appendices on Activated Complex and Quantum Mechanical Calculation of Activation Energy. It fulfils a long-standing hope entertained by many that Prof. Semenov will follow up his earlier book on Chemical Kinetics and Chain Reactions by a survey of recent developments in this subject.

A. K. DASGUPTA

PIONEERING IN INDUSTRIAL RESEARCH — The Story of the General Electric Research Laboratory by Kendall Birr (Public Affairs Press, Washington D.C.), 1957. Pp. vii + 204. Price $ 4.50

This book is a fascinating narrative, unravelling, in an attractive style, of the development of the Research Laboratory of the General Electric Company, U.S.A. In the course of eight chapters the author has described the genesis, growth and prosperity and the fundamental policies guiding the G.E.C. Research Laboratory at Schenectady. In Chapters 2, 3, 5 and 6 are presented the technical contributions of the G.E.C. scientists in their chosen fields of enquiry which include a broad spectrum of disciplines such as lighting, electronics, metallurgy, machines, insulation and chemistry.

The fundamental characteristics for the success of an industrial research laboratory are, in the words of the author — and there is no gainsaying to this — good support by industry, the technical excellence of the chosen personnel and their leaders, character of the research programmes, and above all the resourcefulness and the readiness of the production departments to translate speedily the laboratory results into commercial practice. The story of the growth and prosperity of the G.E.C. Research Laboratory, which amply testifies to the above thesis, is also a tribute to the wisdom of its enlightened management. In fact, few research establishments can claim among their staff such towering scientists of international repute as Whitney, Coolidge and Langmuir (the last named was a Nobel Laureate).

A valuable adjunct to the book is the *source notes* which lists a large bibliographic literature in the field of organization and growth of industrial research. The reviewer was particularly impressed by the technical excellence of the publication. Except for a minor error on page 189 while referring to Bhatnagar as Phatnagar, hardly any other blemish was noticeable. The price at $ 4.50 may be a little high for ensuring wide popularity for the book. The book will be a source of inspiration for every industrial research laboratory and of immense interest to all students of the history of technology and as such needs careful study.

S. RANGA RAJA RAO

A PRACTICAL GUIDE TO PLANT SOCIOLOGY FOR FORESTERS AND AGRICULTURISTS by F. R. Bharucha & W. C. DeLeeuw (Orient Longmans, Bombay), 1957. Pp. viii + 46

This is an interesting handy booklet, giving in a few chapters the outlines for the study of the vegetation in the field, with appropriate terminology for the description of plant communities. This is not meant to serve as a handbook for the study of flora of an area; the study and identification of plants of any given area are presupposed to the present study. Plants do not grow in a haphazard manner; they are grouped in definite ways, according to well-established laws. The aim of this booklet is to give some simple details about the manner in which such groupings can be studied and accurately described.

The authors have some strong things to say about the vagueness and inaccuracy of botanists in the past, the terms common, rare, abundant, and the like, being often much too vague, and perhaps at times even misleading. In Chapter II, the authors explain their own terms, which are precise and can be numerically estimated, but only in small areas. If we consider, for example, the National Park at Borivli, how are we to measure or count if a particular plant species covers one-twentieth to one-fourth of the National Park area? The authors use symbols, like +, to indicate that the number of individuals and the area covered by them are both very small; but then, how small is a very small area?

There is one point in this booklet which has aroused the fighting instincts of the reviewer — the terminology used for naming plant communities. It is very plainly in accordance with the classical Latin usage to call a wood of *Pinus* trees as *Pinetum*. But how is the word *Arthraxoetum* derived? *Arthraxon* is not a Latin name, but even considering it as such, the genitive of the name should be *Arthraxonis* or *Arthraxi*; in the first case the name of the association should be *Arthraxonetum* and in the latter, *Arthraxetum*, but, in no case should it be *Arthraxoetum*. The name of an alliance is given as *Lecanthion pedunculare*: the reviewer fails to see as to why the name should be in the genitive and feminine (it should be *peduncularis* for the three genders). I leave it to the experts to discuss this point.

On page 42, the authors explain for the benefit of readers not sufficiently familiar with Latin, as to how the genitive is to be formed, but examples given are rather unfortunate. *Carex* has only one form for the genitive, *Caricis*; *coerula* (should be *coerulea*, meaning sky-blue) goes into *coeruleae*; *muralis* or *murale* in the genitive has only one form for the three genders, *muralis*.

But for such questionable nomenclature, the booklet is interesting and may prove of help to those who before attempting any study of plant communities have made sure of the identification of the individual plants in any area under study.

H. SANTAPAU

PUBLICATIONS RECEIVED

INTRODUCTORY GRAPHICS by J. Norman Arnold (McGraw-Hill Book Co. Inc., New York, Toronto & London), 1958. Pp. ix + 543. Price $ 7.75

THE ATOM AND ITS ENERGY by Amalendu Das Gupta (Asia Publishing House, Bombay), 1959. Pp. vii + 140. Price Rs 9.50

RAPE & MUSTARD by Dharampal Singh (Indian Central Oilseeds Committee, Hyderabad), 1958. Pp. viii + 105. Price Rs 8.00

PHOTOMICROGRAPHY by Roy M. Allen (D. Van Nostrand Co. Inc., Toronto, New York & London), Second Edition, 1959. Pp. xiii + 441. Price 67*s*. 6*d*.

THE CHEMICAL ANALYSIS OF FOODS AND FOOD PRODUCTS by Morris B. Jacobs (D. Van Nostrand Co. Inc., Toronto, New York & London), Third Edition, 1958. Pp. xxiv + 970

CHEMICAL CONSTITUTION — AN INTRODUCTION TO THE THEORY OF THE CHEMICAL BOND by J. A. A. Ketelaar (Elsevier Publishing Co., Amsterdam, New York & London; *Sole Distributors for the Commonwealth excluding Canada*: D. Van Nostrand Co. Inc., London), Second Revised Edition, 1958. Pp. viii + 448. Price 47*s*. 6*d*.

PEACE OR ATOMIC WAR by Albert Schweitzer (Asia Publishing House, Bombay), 1958. Pp. 45. Price Rs 3.00

AN INTRODUCTION TO ORGANIC CHEMISTRY by V. N. Deshpande (Book Centre, Hubli), 1958. Pp. iii + 232. Price Rs 4.25

NOTES & NEWS

New method of measurement of velocity of light

A NEW METHOD, WHICH ENABLES the determination of velocity of light (c) in free space with greater precision than has been hitherto possible, has been proposed. The proposed method seeks to use the well-established correlation of photons in coherent light, i.e. involves the direct use of an optical standard of length in the determination of c, thus eliminating the necessity for a direct modulation of a light source; the restriction imposed on the highest practicable frequency at which a light wave can be amplitude-modulated has till now limited the attainable accuracy in the measurement of c.

The principle of the method can be understood from the following: Two wave trains of optical frequencies ν_1 and ν_2, falling on a photosensitive surface, will give a component in the photo-current at a frequency $(\nu_1-\nu_2)$. If the wave trains are divided at a half-silvered mirror and fall on two photocells P_1 and P_2, the outputs S_1 and S_2 of these cells at a frequency $(\nu_1-\nu_2)$ may be added and will interfere to give an output S_3, the amplitude of which depends on the relative phases of the signals S_1 and S_2. If P_1 is kept fixed and P_2 is moved radially away from the source, the amplitude of S_3 will have minima separated by a distance of $c/2(\nu_1-\nu_2)$, if the source can be considered to be a distant point.

At present, the method is impracticable because the signal-to-noise ratio achievable with existing light sources would be far too small. A favourable ratio would be obtained if the source emits light in two narrow bands $(\nu_1-\nu_2)$ apart and each having a frequency width much narrower than $(\nu_1-\nu_2)$. The development of the newly discovered maser principle working in the visible region should be able to provide such a source. The separation of the two components could be obtained by the Zeeman splitting of the line emitted by the maser. Though the use of such a high value of $(\nu_1-\nu_2)$ precludes the use of a conventional photomultiplier, it should be certainly feasible to design a suitable photosensitive device for use at such high frequencies.

If the maser principle could be successfully applied, c could be determined in the visible region with higher precision than has been possible hitherto and over much shorter baselines. It would also provide a light source which would allow an even more convincing demonstration of photon correlation than that of Twiss, Little and Hanbury Brown [*Nature, Lond.*, **183** (1959), 312].

Recent research in electrical gas discharges

RECENT TECHNIQUES AND THE RESULTS of researches on various aspects of gas discharge were discussed at the autumn conference of the Physical Society, London, during 17-20 September 1958. Fundamental processes; arc, transient, spark, high-frequency and glow discharges; and collision processes and energy distributions were the main subjects of discussion.

Prof. H. S. W. Massey, in his inaugural address, surveyed the recent experimental and theoretical advances in the study of atomic collisional phenomena with special reference to cross-sections for collisions of electrons on which a reliable body of theoretical knowledge now exists. Prof. Massey also dealt with the experimental verification of the existence of a negative metastable ion of helium, previously predicted on theoretical grounds by two Norwegian investigators, and other results on negative ions. One significant result is that the electron affinity of O^- has now been established as 1·45 eV.; another finding is that the cross-section for the production of I_2^- has been experimentally found to be surprisingly large (3×10^{-15} sq. cm. for low energy electrons). An experimental method for such studies, in which a modulated beam of atomic hydrogen is crossed by an electron beam and the resultant ionization is analysed by a mass spectrometer, has been developed and is being used at the University College, London.

Fundamental processes — From measurements of the temporal growth of ionization, it has been shown that with field stabilization and controlled conditions of electrode surface and purity of gas, the ' scatter ' of measurements was eliminated in the values of formative fine-lags, from which the individual secondary ionization coefficients (γ and δ/α) in hydrogen at pressures less than 10 cm. Hg were accurately deduced. The dependence of these coefficients on the work function of the cathode surface has also been determined. The recent precision measurements in hydrogen, at high pressure, of the secondary ionization coefficient showed that this coefficient is a function of the gas pressure. It follows that the fundamental secondary process (ω/α) consists mainly of the cathode photo-emission produced by molecules excited in the avalanche, but that some excited molecules are destroyed by collisions of the second kind before they are able to radiate. From measurements of the intensity of the Balmer continuum and its variation with time, values of the electron density and temperature were obtained, and using known values of the radiative recombination coefficients, the broadening effect of electrons was calculated.

Arc discharges — By considering the energy balance in the bright glow adjacent to cathode spots, the factors governing the shape and size of the glow and the electron and ion currents at the cathode surfaces have been deduced. Measurements of the gas temperature using shock-wave measuring techniques at varying times after the interruption of a low-current arc indicated thermal time constants of *c*. 500 m.sec. The forward continuous motion of an arc cathode spot in a transverse magnetic field in air at atmospheric pressures has been shown to be controlled by cathode surface condition, velocity of motion being independent of the arc current between 40 and 70 amp. A study of the jets observed in the high-current electric arc on the basis of a theory of dissociation and ionization showed that these jets account for the metal transported in the welding arc.

Transient discharges — A method, by which the distribution of current in, and the motion of, the discharge and the extent to which the plasma traps the magnetic field within itself could be obtained, has been described. Results obtained on the mechanism of initiation of parasitic arcs inside the torus and methods of controlling them have also been discussed.

It has been found that the mechanism of liberation of electrons from cold cathodes in gases under electric fields of the order 10^5 V./cm. involved emission due to the enhanced field produced by positive ions on a thin cathode film. Measurements of electron liberation at 300° and 600°K. showed that the dependence on temperature was too small to be accounted for by local thermionic emission.

Spark, high-frequency and glow discharges — Considering the effect of the various parameters, it has been shown that air circulation gives a better reproducible breakdown potential in an enclosed spark gap. Concerning the industrial applications of discharge techniques, it was shown how the leakage of air into the flue gas in electrostatic precipitators could lead to spark-over. The advantages of deuterium over hydrogen as a filler for thyratrons were pointed out.

Collision processes and energy distribution — From a study of the energy distribution and concentration of electrons and the temperature and concentration of positive and negative ions in oxygen discharges, it has been concluded that the destruction process for negative ions involves oxygen atoms. Probe measurements in striated positive columns demonstrated the existence of two well-separated groups of electrons.

Values of α for argon, helium and neon have been theoretically computed using an energy distribution function for electrons derived directly from the collision cross-section. The phenomena attributable to the excitation of hydrogen by electron swarms have been explained in terms of the experimental data for mono-energetic beams and the recent predictions of the wave-mechanical theory. Relative excitation cross-sections in helium have been computed from the intensities of lines in the spectra from high-frequency glow discharges.

Recent measurements on high-density plasmas using the microwave technique showed that the method can be greatly extended by applying solenoidal probing fields on plasmas with rotational symmetry [*Nature, Lond.*, **183** (1959), 91].

Ferroelectric polarization in barium titanate

Recent experiments on single-crystal barium titanate have demonstrated for the first time that complete ferroelectric polarization reversal can be accomplished under an applied electric field, with a single expanding domain which grows through extensive sidewise motion of the 180° domain walls. These experiments were described in a paper from the Bell Telephone Laboratories, New York, presented to the Conference on the Physics of Dielectrics held at Moscow on 26 November 1958.

The 180° domain walls are the boundaries between two adjacent areas or domains of opposite polarization. Sidewise motion involves the movement of boundaries in a direction perpendicular to the dipole moment of the domain. In the work reported above, a single crystal of barium titanate is mounted with liquid electrodes applied to either side, and is subjected to an external applied field. The electrodes used were silver or platinum rods (1·0 mm. in diam.) with a small hole drilled in one end containing an aqueous saturated solution of lithium chloride as the electrolyte.

Partially switched crystals were studied by removing them from the apparatus and etching them for a short time in weak hydrofluoric acid. The positive dipole ends etch preferentially; examination with a microscope after etching allows observation of the domains visually. With the liquid electroded crystals, the number and size of the reversed domains in the partially switched crystals are of great interest. In numerous cases, a single reversed domain comparable in size to the total electrode area was observed. Many of the domains appeared to nucleate at obvious crystalline imperfections.

The technique has been further refined taking advantage of this nucleation phenomenon by 'manufacturing' a nucleation site. This site was a sand-blasted dimple with a depth of one-third the crystal thickness, and with a diameter about one-fourth that of the electrode. When a dimpled sample is placed in the liquid electrode holder, nucleation of reversed domains is most probable in the dimpled region because it is subjected to a high field compared to that of the surrounding area. Once a nucleation has occurred in the dimpled region, the domain grows out from the dimple through sidewise wall motion. The single domain is roughly square, as has been shown by successive etching of the partially switched crystal. In this way, complete reversal of polarization has been accomplished for the first time with a single expanding domain, starting from a predetermined point on the crystal.

There is some evidence, though meagre, to indicate that impurities have an effect on the velocity of the domain wall motion. The experiments indicate that the velocity v is given by the equation:

$$v = v_{\infty} e^{\delta/E}$$

for over three decades of velocity. The velocity when the field $E = \infty$ is v_{∞} and is of the order of 10 cm./sec. The activation field varies from 2000 to 4000 V./cm. Under these conditions, this polarization reversal is analogous to magnetization reversal in some ferromagnetic materials [*News from Bell Telephone Laboratories*].

Human mechanical power output

In the operation of industrial machinery as well as in a number of other situations, the posture, maximum exertion in a single operation and the work-pattern of the operation, the physical movements to be made during the operation, etc., are found to have a profound influence on the ultimate mechanical output of a person. A systematic approach to some of these factors has been made in two separate reports published recently.

The first, *The Mechanical Power Output of Men* (Report F-A. 1982, The Franklin Institute, 1958), contains the results of studies which will be of assistance in the design, construction and testing of simple mechanical devices for optimal human power transfer in man-machine systems. Data on handwheel or crank, pedal, and whole body-involved work as would present a consistent picture of human power production have been gathered and presented. Under each grouping of power exertion is included a discussion of power output in terms of continuous maximum-effort work, maximum-effort work with rest pauses, self-paced work, and power generated over relatively short intervals. To facilitate the design of a scheme applicable to man-machine systems, mathematical models for transferring power to a useful load when the human operator generates a steady force output and when the force produces is a function of time have been set up. From these models, mathematical expressions for internal muscle force as a function of muscle tension, for characterizing isotonic shortening, for estimating the power exerted in a single contraction, and for dynamic equations of motion for a muscle pulling against a load, have been developed.

The second report, *Space Requirements of the Seated Operator* (WADC, Technical Report 55-159, Aeromedical Laboratory, 1955), details the attempts made to study on models of cadaver material, the geometric, kinematic and engineering aspects of the human mechanism in seated operation, the structure of the limb joints, and the range and type of their motions.

Data on such physical constants as mass of parts, segment centres of gravity, density and moments of inertia have been compiled from 8 dismantled cadavers. The studies have been supplemented by work on living subjects. From this information, specifications were worked out for drafting-board manikins which show correct limb ranges for seated postures.

The range of possible hand and foot movements consistent with the seated posture has been taken from subjects comparable to the model physique of Air Force flying personnel and selected small samples of muscular, thin and rotund builds. Maximum dimensions of the work space for seated individuals were determined; a study of the kinematic factors involved permitted an evaluation of the potential utility of different regions within reach. The applications of the above information to analyses of horizontal push and pull forces, in terms of couples, enabled the evaluation of effectiveness of body mass, leverages and support areas [*Mech. Engng*, **80** (10) (1958), 118].

Cryopumping

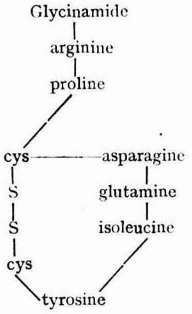
A NOVEL TECHNIQUE, CALLED ' CRYOpumping ', developed jointly by scientists of the Arthur D. Little Inc. and the University of Southern California's Engineering Centre shows promise of producing extremely high vacuums (about a millionth atm.) and effecting substantial savings in research and industrial uses. The first practical, large-scale application of the technique has been in the California University's hypersonic wind tunnel used to test missile models under conditions obtaining at high altitudes of the atmosphere.

Cryopumping produces such a low temperature (—420°F. using helium gas as the refrigerent) that all of the air in a chamber freezes to a solid leaving a high vacuum. A distinguishing feature of the new method is that while the speed of a mechanical pumping system falls off rapidly as the vacuum increases, a cryopump works particularly well when a relatively high vacuum exists. So a combination of both type systems securing the advantages of both methods is used in practice.

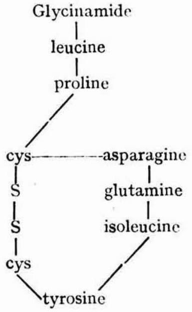
In the cryopump, instead of blowing air over the test models by conventional means, which would require pumps and fans filling almost an entire city block, nitrogen gas is frozen out of the stream which is made to flow from the other end of the chamber over the test objects. Useof nitrogen instead of air eliminates the need to remove moisture from the gas stream. To duplicate high temperature conditions under which missiles would operate at high speeds, the nitrogen is heated electrically when it first enters the tunnel and again just before it flows over the models. After passing over the models, the nitrogen is drawn onto the large metal plates of the refrigerator, where it condenses and freezes. Thus missiles can be tested as though they were flying at 20 times the speed of sound and *c*. 60 miles above the earth. The unique tunnel at the University of Southern California runs on a 50 h.p. motor, and the only moving parts are in the refrigerator. An idea of possible economy can be obtained from the fact that a comparable unit based on a gaseous diffusion pump would require 500,000 h.p. Further the tunnel can run for 10 hr at a stretch while most hypersonic test facilities can operate for only a fraction of a second at top speed and altitude [*J. Franklin Inst.*, **267** (1959), 97].

Vasotocin

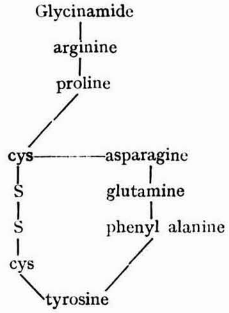
THE SYNTHESIS OF VASOTOCIN, A biologically active structural analogue of the posterior pituitary hormone, has been recently achieved by P. G. Katsoyannis and V. du Vigneaud [*J. biol. Chem.*, **233** (1958), 1352]. It may be recalled that Prof. V. du Vigneaud was awarded the Nobel Prize for Chemistry in 1955 for this outstanding work on oxytocin and vasopressin — particularly their syntheses. Oxytocin has two distinct biological actions — it stimulates smooth muscle contraction (oxytocic activity) and in birds, produces a transient fall in blood pressure (avian depressor activity). Vasopressin produces, in mammals, a pronounced elevation in blood pressure (pressor activity). The new compound, termed arginine vasotocin, possesses the activities of both oxytocin and vasopressin, i.e. it has oxytocic, pressor and avian depressor activities. It is interesting to note that the vasotocin molecule (I) is composed of the two different moieties present in oxytocin (II) and vasopressin (III). It has a cyclic pentapeptide amide portion identical with the one present in oxytocin linked to the tripeptide amide chain present in arginine vasopressin (III). In view of the fact that another analogue, oxypressin (IV) (in which the cyclic system of vasopressin and side chain of oxytocin are present) possesses only feeble biological activity, it is suggested that a strongly basic amino acid in the side chain is one



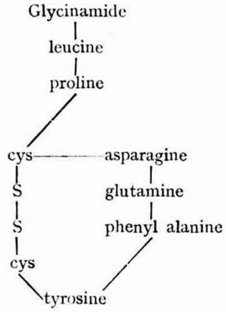
(I)



(II)



(III)



(IV)

requirement for high pressor activity and that both the avian depressor and oxytocic activities reside in the cyclic pentapeptide residue of oxytocin.

Research on bacteriophage

THE SECOND INTERNATIONAL PHAGE Colloquium was held in Royaumont, · Paris, during 28 July to 2 August and was attended by 60 workers from 11 countries. The colloquium was a departure from the normal practice as no papers were read and each session was devoted to the discussion of a given topic under the leadership of a chairman after an introductory talk on the subject by a *rapporteur*. The subjects discussed included: optical and chemical studies on the tail of bacteriophage; the role of viral deoxyribonucleic acid in the interior of the infected bacterium; and the phage and bacterial genetics.

Refined electron, optical and chemical studies have shown that the tail of the bacteriophage consists of three proteinaceous parts: an outermost cylindrical sheath, enclosing a hollow cylindrical core to which tail fibres are attached at the distal end. The tail fibres seem to represent the real adsorption organs of the phage, since isolated tail fibres are fixed specifically to bacteria and contain almost all the serum-blocking power of the phage, in contrast to isolated sheaths and cores which possess neither of these properties. The following clear picture of the infection process has now been drawn from the above facts: after phage and bacterium have collided, the phage tail fibres flail about until they have made a stereospecific fit with the bacterial receptor sites and have anchored firmly to the host surface. The sheath then contracts and pushes the core through cell wall and membrane, so that the viral deoxyribonucleic acid may pass from the head of the phage through the hole in the core into the interior of the bacterium. Once in the interior of the infected bacterium, the viral deoxyribonucleic acid fulfils two tasks. It replicates itself several hundredfold to produce the hereditary substance for the progeny particles and it induces the synthesis of viral protein. A revolutionary advance has been reported in the study of the role of viral deoxyribonucleic acid in viral protein synthesis in inducing *in vitro* the formation of small but significant amounts of phage tail antigens by the addition of purified phage deoxyribonucleic acid to preparations of disrupted bacterial cells.

A new analysis of the population dynamics of genetic recombination in phage requires a generalization of the Visconti-Delbruck theory, not only in that the nature of the elementary recombination act is not pre-supposed but also the pairwise mating-event of the earlier theory is replaced by a ' co-operation ' in which the number of participating particles may be greater than two. From the results of new experiments pertaining to heterozygotes and from crosses at several closely linked genetic loci it is concluded that heterozygotes are formed at the moment of genetic exchange. Furthermore, negative interference occurs at the time of the segregation of the heterozygotes. By mapping hundreds of independent mutants produced either spontaneously or under the influence of certain mutagens, it has been possible to construct a mutational spectrum and thus obtain an image of the relative loci within a single gene. The spectrum of spontaneous mutations shows a few hot spots at which mutants recur with high probability and a number of other sites mutating with lower probability.

Recent studies on bacterial recombination, lysogeny and bacteriocines have revealed that the bacterial fertility factor F, the prophage and the colicinogenic factor have certain features in common which set them apart from other, or ' regular ' bacterial genes. On the basis of these special properties it has been possible to create a new concept, the ' episome ', defined as an exogenous hereditary determinant integrated into the bacterial genome by addition to the chromosome instead of replacement of allelic bacterial loci. Besides its integrated chromosomal state, the episome can also exist in an autonomous state, in which it is replicated independently of the rest of the bacterial genome [*Nature, Lond.*, **182** (1958), 1769].

New route to synthesis of cyclopropanes

A NEW, ONE-STEP, GENERAL METHOD of preparing a large number of substituted cyclopropanes including some with functional groups, from their corresponding olefins and in yields ranging from 10 to 70 per cent, has been developed by the Du Pont Co., U.S.A. The method does not work well with highly hindered olefinic molecules. This method is especially useful for the synthesis of some natural product derivatives like dihydrosterulic acid which has been obtained, in one step, in 51 per cent yield from methyl oleate as the starting material. Dihydrosterulic acid has been made previously from a synthesis involving over ten steps.

The reaction, which is stereospecific, involves the addition of methylene group, through methylene iodide, to the olefin double bond in presence of zinc-copper couple. The products obtained are free from isomeric rearranged products. The reaction works through a three-centre displacement where the double bond reacts directly with an intermediate (iodomethylzinc iodide) formed from divalent carbon (methylene group) and the zinc-copper couple. The method of making the zinc-copper couple has an important bearing on the yield. The most effective couple is prepared by heating a 8: 1 mixture of zinc dust and copper oxide to 500° in a hydrogen atmosphere [*Chem. Engng News*, **36** (49) (1958), 40].

Novocain therapy

THE ENGLISH TRANSLATION OF seven papers on *Novocain Therapy in Old Age* (price $ 12.50) by Dr Anna Aslan, Director of the Institute of Geriatrics in Bucharest, and her co-workers, has recently been published by the Consultants Bureau Inc., New York. These papers, which originally appeared in the West German journal *Die Therapiewoche*, include the results of large-scale clinical application of novocain injections for treatment of the sequelae of old age.

Sustained improvement in cases of senile Parkinsonism, improvement in hearing and in certain reflexes, renewed production of estrogens and of characteristics resulting from stimulation of testes and adrenal glands, regression of signs of senility of the skin such as icthyosis and senile keratosis, repigmentation of existing hair and stimulation of new hair growth, and a reduction in arteriosclerotic symptoms have been reported on novocain therapy.

The physiological aspects of the reported results of novocain therapy include: improvement of the activity of the central nervous system, improved cardiovascular reaction to stress, decreased oxygen consumption and better muscle tone.

The biochemical aspects include: alterations in protein structure and in the ratio of albumins to globulins, increase in cholesterol as compared to lower than normal values prior to initiation of treatment. The hematological aspects include: fewer leukocytes, higher production of granulocytes, increase in the number of monocytes and in the globulin content. Eutrophic action was clearly observable in cases of atrophic ulcer, gastric ulcer, dermatosclerosis, psoriasis, rashes, alopecial areata, and leukoderma.

Mechanism of reserpine sedative action

IN RECENT YEARS EXPERIMENTAL evidence has accumulated on the possibility that reserpine acts as a sedative through release of serotonin. Such a hypothesis has been suggested and supported by the observation that (i) release of serotonin takes place only with Rauvolfia alkaloids which have sedative action; (ii) central antagonists of serotonin, such as lysergic acid diethylamide (LSD), are also antagonists of reserpine and (iii) substances which increase brain serotonin, such as iproniazid, can reverse the sedative activity of reserpine.

Recently the importance of hypothermia, occurring after administration of reserpine, as an explanation of its sedative activity has been stressed. But serotonin too can decrease body temperature. This observation may explain the potentiation of barbiturates by serotonin, since the hypnotic effects of barbiturates are increased when hypothermia is induced. That iproniazid antagonized both serotonin metabolism and hypothermia after reserpine administration has also been shown.

Investigations now conducted at the Institute of Pharmacology, Milan, Italy, support the hypothesis that the sedative action of reserpine takes place only when there is serotonin release. The onset of hypothermia is not always associated with sedation, and it is not correlated with serotonin release.

The sedative action of reserpine was evaluated by the potentiation of sleeping time after administration of pentobarbital (20 mg./kg., intraperitoneally) to female albino rats as test animals. The rats were kept at constant-temperature rooms at 0°, 22°, 29° or 37°C. and injected intraperitoneally with 2·5 mg. of reserpine per kg. After 4 hr, brain serotonin was extracted and measured spectrophotometrically. The observations showed that increasing room temperature from 22° to 37°C. does not change body temperature and sleeping time after pentobarbital but does induce a small increase in the content of brain serotonin. After reserpine is injected, sedation is observed only if serotonin is released and body temperature decreases (22° and 29°C.). At 37°C., body temperature is unchanged and brain serotonin increases after administration of reserpine; under these conditions there is no evidence of sedative activity. At 0°C. reserpine significantly decreases body temperature, with no change in brain serotonin. Thus, at 22°, 29° and 37°C. there is a parallelism between the onset of the sedative activity of reserpine, as indicated by an increase of barbiturate narcosis, serotonin release and hypothermia. In contrast, at 0°C. hypothermia is observed after reserpine injection, without sedative activity or serotonin release. It is not simply a delayed action, for 8 hr after reserpine treatment at 0°C. no decrease in the content of brain serotonin (1·17 ± 0·006 µg./g.) was observed [*Science*, **128** (1958), 1278].

Separation of leucocytes

A SIMPLE METHOD OF COLLECTING pure suspensions of leucocytes is described. Essentially, the technique comprises four stages. In the first stage the erythrocytes are encouraged to form rouleaux and allowed to sediment leaving leucocytes in suspension. In the second stage the resulting suspension is placed as a shallow layer in a wide vessel to the bottom of which many leucocytes adhere. In the third stage the supernatant is discarded and the adherent cells washed free of erythrocytes with buffered saline and finally the white cells are resuspended by gentle agitation in sodium edetate, dissolved in calcium- and magnesium-free buffer.

The actual experimental technique is as follows: A mixture of 3 parts of heparinized blood and one part of 6 per cent 'Dextraven' is placed in test tubes and left at room temperature for 2 hr. Up to 20 ml. of the supernatant is then placed in a Roux bottle the sides of which have been coated with 'vaspar'. After leaving the bottle undisturbed on its side at 28°C. for an hour, the bottle is agitated and the fluid in it discarded. The adherent cells are thoroughly washed three times using 20 ml. buffer each time and 5 ml. 1:10,000 sodium edetate is run in and gently agitated for 15 min. at 37°C. The resulting suspension is then ready for use.

The method combines a moderate yield with considerable purity and has the further advantages that spontaneous clumping does not occur and that cells remain viable and antigenic. Moreover it may readily be adapted for titrating sera for leucocyte antibody [*Nature, Lond.*, **182** (1958), 1801].

Micro-determination of serum calcium

A MICRO METHOD FOR ESTIMATING serum calcium in children which gives accurate and reproducible results (±1 per cent) is reported. The advantages claimed for the process are (1) avoidance of calcium precipitation by oxalate, (2) specificity, (3) accuracy, (4) reproducibility, (5) simplicity, (6) use of available apparatus without any modifications, (7) use of easily available chemicals and (8) reasonable stability of the reagents as stock solutions.

The reagents required for the serum calcium estimation are: (1) saturated murexide solution, (2) piperidine, (3) stock standard calcium (1 mg. ≡ 1 ml.). Analar grade of calcium carbonate is dried at 105°C. for 24 hr. 2·5 g. are weighed and transferred to a one-litre flask. 200 ml. of distilled water and 50 ml. of normal hydrochloric acid are added. When dissolved, water is added to the mark. (4) Working standard calcium (9 mg. per 100 ml.) prepared from the stock solution. The apparatus used were a 'Unicam' S.P. 600 spectrophotometer and auto self-set zero micropipettes.

Three test tubes are labelled T (test serum), S (standard calcium solution) and B (blank). Distilled water (4·9 ml.) is added to tubes T and S and 5 ml. to tube B. The test serum (0·1 ml.) is pipetted into T and 0·1 ml. of the working standard calcium solution into S. Then one drop of piperidine and 0·25 ml. of the saturated murexide solution (centrifuged before use) are added to each of the three tubes and the contents mixed thoroughly. The optical densities of the three solutions are then read in the spectrophotometer at 500 mμ wavelength using the 0·5 cm. cuvettes, the instrument being set at zero with a water blank. Serum calcium is calculated from the equation

$$\text{Serum calcium} = \frac{\text{reading of (test serum} - \text{blank)}}{\text{reading of (Ca std} - \text{blank)}} \times 9 \text{ mg./100 ml.}$$

The method is then extended to standard serum. The corrected calcium concentration of the working standard calcium solution is obtained thus:

$$\frac{\text{Reading of (Ca std} - \text{blank)}}{\text{Reading of (serum std} - \text{blank)}} \times \text{Ca conc. of serum std/mg./100 ml.}$$

The corrected value of the working standard calcium solution is used instead of the value 9 for the calculation of the calcium concentration of test sera [*Nature, Lond.*, **183** (1959), 232].

Disposal of atomic wastes

A MAJOR DEVELOPMENT REPORTED in the field of disposal of atomic wastes relates to the setting up of a large-scale waste calcination pilot plant by the National Reactor Testing Station, Idaho, U.S.A. In the new process, liquid wastes are converted to solid form and their volume reduced to about one-seventh of the original bulk. The calcination facilities are designed to process aluminium nitrate wastes that have decayed for at least 200 days after discharge from the reactor.

Conversion of liquid wastes to solids is accomplished by fluidized bed calcination, using hot air as the fluidizing medium. In passing through the calciner the air becomes contaminated with radioactive materials and is thoroughly decontaminated before it is discharged back to the atmosphere. The calciner is a cylindrical vessel containing at steady state a bed of granular aluminium oxide, obtained from the evaporation and calcination of the waste solution and containing all the fission products received from the fuels. The bed is supported on a perforated or porous plate which serves as a gas distributor. Preheated air is passed upward through the plate to fluidize the bed and agitate the solids. The bed temperature is maintained at 400-500°. The waste solution is injected into the bed through several spray nozzles spaced around the calciner. The liquid droplets, on contacting the hot solid particles, are flash dried and calcined to oxide.

This method fixes the radioactivity of highly radioactive fission products, with decay periods as high as 800 years, in a less mobile form. Also, this type of treatment will not impair the preliminary or subsequent separation of radioisotopes for industrial utilization [*Chem. Age*, **81** (1959), 142].

Spherical kaolin catalyst

KAO-SPHERES, A NEW SPHERICAL Houdry mineral kaolin cracking catalyst, designed to decrease catalyst use and reduce equipment maintenance costs, is being offered by Houdry Process Corporation, Philadelphia. The kaolin catalyst itself provides maximum octane at low cost, high activity, sulphur resistance, high thermal stability and excellent regenerability. The spherical form sharply reduces catalyst chipping and loss in fines. Less maintenance is needed because the Kao-Spheres do not have sharp edges that may cause equipment erosion. The new spherical form is expected to provide refiners, especially catalytic crackers, with a more economical method of operation while retaining all the advantages of the high-octane, low-cost

Houdry mineral kaolin. The catalyst will be especially effective for Houdriflow, and all other moving bed catalytic cracking units [*J. Franklin Inst.*, **267** (1959), 94].

Zeolites as gas storage materials

SOME SYNTHETIC ZEOLITES, KNOWN as molecular sieves, have been successfully used to store gases. Linde molecular sieves, when cooled to liquid air temperature, conveniently absorb gases from a low pressure system, the process being readily reversed by heating. This technique is of particular value where it is required to analyse gas in a low pressure system by gas chromatographic methods or with the help of mass spectrometers. For chromatographic analysis the ampoule containing the collected gas is attached to the inlet of the gas sample loop of the analytical system, which is itself filled with molecular sieve. The gas sample loop is evacuated and cooled in liquid air. The break seal of the ampoule is then broken to allow the collected gas to distil over into the gas sample loop; this is then sealed off and warmed to room temperature to desorb the gas under examination [*Chem. & Ind.*, (1959), 155].

Industrial demand for brucine

ONE OF THE MAIN USES OF BRUCINE, an alkaloid extracted from nux vomica seeds along with strychnine, has been as a denaturant for alcohol meant for use in cosmetics and perfumery. On account of its bitter taste, brucine is an adequate deterrent to the use of the denatured alcohol for potable purposes, but it has no adverse effect on the odour or other properties of the compounded perfumes, etc. India has been one of the major suppliers of nux vomica seeds. During recent years, however, its supply has dwindled, which has resulted in decreasing use of brucine for denaturation of alcohol. Since 1951-52, when India exported 49,687 cwt. of nux vomica seeds valued at Rs 1,180,380, the export figures have been gradually falling and in 1957, only 7929 cwt. of the seeds valued at Rs 99,721 were exported. Another factor responsible for the decreased demand for brucine has been the fall in the use of its co-product strychnine as a rodenticide in U.S.A. and Europe. But there are indications of some new use for brucine having been found in petroleum technology in U.S.A., since the demand for it from petroleum companies has suddenly increased recently, and since brucine is not available in sufficient quantities, active search is being made for substitutes.

Haffkine Institute Diamond Jubilee Souvenir

THE HAFFKINE INSTITUTE CELEbrated its diamond jubilee on 10 January 1959, and to commemorate the occasion, the Institute has brought out an attractively got up souvenir. The 140-page volume carries a series of 9 general articles on the following subjects: Haffkine and the evolution of the Institute (H. I. Jhala); The passing of the present plague pandemic in India (S. S. Sokhey); Statistical aspects of biological standardization (B. Mukerji); Utility of research in Indian indigenous drugs (I. C. Chopra, K. L. Handa and R. N. Chopra); Rabies and antirabies treatment (R. Sanjiva Rao); Dietary deficiencies and liver injury (M. V. Radhakrishna Rao and S. M. Patel); Serological studies in plague — Antigenic structure, serodiagnosis and serotherapy (S. C. Seal); Human haemoglobin and its variants (J. B. Chatterjea); and Good laboratory animals — one of the basic requirements of medical and biological research (W. Lane-Petter). The other eight articles present a brief account of the research work carried out in the various departments of the Institute during the past sixty years. A list of the publications, numbering 456, by the members of the staff during the period 1897-1958 is given at the end of the volume.

Tropical Products Institute, London

THE TROPICAL PRODUCTS INSTITUTE, London, which formerly came under the Colonial Office, will now be governed as one of the research stations of the Department of Scientific & Industrial Research, U.K. This change-over widens the scope of the Institute and now it will be possible for the Institute to give free advice to territories other than the British colonies. The aim of the Institute is to improve the existing industries and to introduce new industries as a result of research into new uses for tropical plant and animal products. At present, the Institute is also engaged in research on the profitable use of ' renewable resources ', including solar energy, and wind and water power.

World List of Future International Meetings

ON 1 JUNE 1959, THE FIRST ISSUE of the new *World List of Future International Meetings* will be published by the Library of Congress, Washington. This monthly calendar will furnish a record of all meetings drawing on three or more nations which are to be held anywhere in the world during the next three years, giving the sponsors and the addresses of organizing committees wherever possible, and with the subjects indexed for convenient use. It will supersede the National Science Foundation's *List of International and Foreign Scientific and Technical Meetings*, which ceased publication with the January 1959 issue. The *World List* will be issued in two parts. Part I, publication of which has been made possible by a grant from the National Science Foundation, will be devoted to meetings on science, technology, medicine, and agriculture. Part II will record meetings in the social, cultural, humanistic, and commercial fields. The *World List* will be available from the Superintendent of Documents, Washington 25 D.C., at a subscription price to be announced.

The General Reference and Bibliography Division of the Library of Congress welcomes notices of any forthcoming international meetings from the respective organizations. The information, together with all enquiries about the *World List* may be sent to: International Organizations Section, General Reference and Bibliography Division, Library of Congress, Washington 25 D.C.

Journal of Chemical and Engineering Data

THE AMERICAN CHEMICAL SOCIETY has started publication, with effect from January 1959, of a new quarterly applied journal entitled

Journal of Chemical and Engineering Data. Predecessor of the new journal was *Industrial and Engineering Chemistry's* Chemical and Engineering Data Series, which was first issued in 1956 on a semiannual basis. The first issue consequently bears the designation, Vol. 4, No. 1.

The journal will include articles on data obtained through new concepts or new methods such as those on phase equilibria, thermodynamics and molecular transport. Articles which deal with characterization of compounds, or which list physical properties as ends in themselves or as aids to other studies or evaluations will also be included.

Nomenclature of Organic Chemistry, 1957

MESSRS BUTTERWORTHS SCIENTIFIC Publications, London, who are official publishers of the International Union of Pure and Applied Chemistry for two years, have brought out a book entitled *I.U.P.A.C. Nomenclature of Organic Chemistry*, 1957. The book contains definitive rules for hydrocarbons, fundamental heterocyclic systems, steroids, nomenclature of biological chemistry and tentative rules for nomenclature in the vitamin B_{12} field. The book is priced at 15*s*.

Announcements

- *The Kalinga Prize* for 1958 has been awarded to Prof. Karl von Frisch, the noted zoologist and science writer. The prize of £ 1000 is offered annually by the Kalinga Foundation and is awarded, on the choice of an international jury named by the Unesco, to anyone who by his writings and work has effectively aided the understanding of science among the general public through interpretation of scientific developments in the layman's language. Prof. Frisch is well known for his researches in the sensory physiology and communal habits of insects and fish. His main interest is in the comparative language studies on bees which led to the establishment of the existence of a perfect bee language.

- *Dr H. J. Bhabha* is among the proposed recipients of honorary degrees to be conferred at Cambridge University's May Week ceremony. Dr Bhabha, who is a Fellow of the Royal Society and an honorary Fellow of Gonville & Caius College, Cambridge, will receive a Doctor of Science degree. At Cambridge the academic year is marked by the conferring of degrees followed by a week of festivities — ' May Week '. This annual event was first held in May 1827.

- *Award of Doctorate Degrees* — The following have been awarded the Ph.D. degree of Poona University for the respective theses noted against their names in parentheses: Shri Murlidhar Venkatesh Kaulgud (*Ultrasonic velocity in liquids and liquid mixtures*); Shri Mandayam Chakravarthi Srinivasan (*Studies of some phytopathogenic bacteria of Bombay and studies on some leaf-spot fungi of grasses and cereals in Bombay State, excluding rusts*); and Shri Sambhaji Krishnaji Dorge (*Land crab control with insecticides*).

INSTRUMENTS AND APPLIANCES

A new differential refractometer

A DIFFERENTIAL REFRACTOMETER which will overcome the difficulty caused by the variation of refractive index with temperature in liquid streams, in plant processes, has been developed. The refractometer can be fitted into a process line, placed in a remote location, or used as a laboratory equipment. The assembly consists of an inner cell and an outer cell arranged so that when light passes through the liquid in each cell, there is refraction at only one surface. This is the surface where light passes from the inner cell to the outer cell. Here the beam strikes a prism and is refracted at an angle that is related to the ratio of the refractive indexes of the liquids in the inner and outer cells. This is the only surface where temperature can affect refraction, and because of the arrangement absolute temperature control is not needed for accuracy. The cell assembly is so constructed that either cell may be installed as an integral part of a process line. Thus no sampling lines or sampling system would be needed unless the system is installed remotely or in a laboratory. The inner cell usually holds the reference liquid [*Chem. Engng News*, **36** (46) (1958), 46].

High stability vibrating capacitor

A NEW VIBRATING CAPACITOR WITH extremely low contact potential drift (less than 0·4 mV. change from 25° to 50°C. and less than 10 mV. in a year) and minimal leakage has been developed by Tracerlab Inc., U.S.A., for industrial use; it is least affected by temperature changes over a broad thermal range and requires no shock mounts. Among its distinctive features are overall steel housing with the capacitor assembly hermetically sealed and filled with inert gas to minimize drift in constant potential. The magnetic driver unit is mounted outside the seal and is completely shielded from the capacitor assembly. The unit, which can be made at economical prices in large numbers, can be useful to makers of electrometer equipment, amplifiers and other equipment for converting d.c. to proportional a.c. voltage for amplification.

Progress Reports

COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH, INDIA

INCREASED ATTENTION TO THE DEVELOPMENT OF research results and proving their feasibility for practical utilization have been the significant features of the work of the Council's laboratories during the year 1957-58. Nineteen laboratories were functioning during the year. Of these the Regional Research Laboratory, Jammu, formerly the Drug Research Laboratory, Jammu-Kashmir, was taken over by the Council on 1 December 1957. The total expenditure of the Council during the year amounted to about Rs 4,85,50,000.

The number of research projects sponsored by the Council and in operation during the year was 280. The investigations under sponsored projects cover a wide variety of subjects, such as radio physics, applied chemistry, biology, essential and vegetable oils, dyestuffs technology, pharmaceuticals and drugs, plastics and cellulose products, public health engineering and mechanical, electrical and wind power technology. The anticipated expenditure, including capital, for research schemes, research centres and block grants was Rs 46.81 lakhs.

Forty applications for patents were filed during the year 1957-58. The number of patents accepted was 56 and the number of patents sealed was 64. The number of processes leased out for commercial exploitation was 13. Six symposia were held under the auspices of the National Laboratories and Research Committees during the year. The subjects covered by the symposia are: (1) Utilization of Indian medicinal plants; (2) Recent plants — developments in foundry technology; (3) Pre-stressed concrete as applied to buildings; (4) Cellulose research; (5) Magneto-hydrodynamics; and (6) Leather auxiliaries. The total number of research papers emanating from National Laboratories and sponsored research during the year was 454.

The important achievements of the National Chemical Laboratory include: isolation and elucidation of the structure of constunolide; synthesis of *cis*-exaltone and exaltolide; new synthesis of 4-hydroxycoumarins; fractionation of rare earths for the preparation of pure ceria, lanthana and didymia concentrates. Pilot plant work was carried out on the preparation of vitamin C, extraction of costus root oil, and refining of *neem* oil.

The National Metallurgical Laboratory was mainly concerned with the problem of replacement of non-indigenous elements and development of substitute alloys both in ferrous and non-ferrous field. Steel, by oxygen injection technique, has been made for the first time in India even though on a pilot plant scale in L.D. oxygen converter. Semi-pilot plant (capacity 1 ton/day) for the beneficiation of low grade manganese ore went into operation.

The Central Fuel Research Institute undertook the study of the petroleum crudes received from the newly found deposits at Naharkatiya in Assam and Cambay in Saurashtra. The crudes have been evaluated by both chemical and physical methods.

Production of good quality calcium carbide from crystalline limestone available from Tirunelveli district in Madras State and the electrolytic nickel cadmium batteries has been achieved by the Central Electrochemical Research Institute, Karaikudi.

Development of a method of refining castor oil, low temperature carbonization of Indian coals and utilization of its byproducts, production of a new pesticide, citicide, are some of the achievements of the Regional Research Laboratory, Hyderabad.

The haemagglutination test previously developed at the Indian Institute of Biochemistry & Experimental Medicine, Calcutta, for the diagnosis of leprosy has been shown to be applicable to contact cases. The test may, therefore, be expected to be of value in preventing the spread of leprosy through infected contacts. The studies on ammonia formation in cerebral tissue under different experimental conditions have brought out certain interesting relationships between the enzyme systems concerned with glutamine and glutamic acid metabolism in the brain and centrally active compounds like cortisone. Several distinctive biochemical characteristics of *Leishmania donovani* have been fully investigated.

A brief account of some of the important researches carried out in National Laboratories and under sponsored research projects is given below.

Physics — The infrared absorption spectra of alpha quartz have been investigated in the region 4-15 μ for crystals of different cuts ground down to 30 μ thickness. Several interesting results, particularly the vanishing of the band at 14 μ with X-cut crystals, which are inexplicable on earlier theories, have been obtained. Debye-Scherrer patterns of frozen pyridine at -180°C. and of its frozen solution in alcohol at -180°C. have been successfully photographed, and it has been observed that frozen pyridine crystallizes in two different habits. Analysis of the patterns by Lipson's method has shown that both these habits belong to orthorhombic system.

Detailed investigations of the benzaldehyde molecule with regard to its absorption, fluorescence, Raman, infrared and emission spectra have been carried out. A tentative vibrational analysis of the emission spectrum has been given and the spectrum interpreted as an allowed transition. The ground state frequencies observed are more numerous than those obtained in Raman and fluorescence spectra. In addition, different frequencies corresponding to combination bands have been recorded. Absorption spectrum of SnS in the visible and ultraviolet regions has been studied, using a graphite furnace. Besides obtaining many additional new bands in the already known B and C systems, a new system has been identified. One system of new bands degraded to the red has been obtained in the extreme quartz ultraviolet region in the case of PbSe. The spectrum has been definitely assigned to the molecule PbSe.

A new method to obtain quantitative estimate of the percentage dissociation of O_2 at high altitude atmospheres has been developed. It is found that dissociation is principally confined to the heights 80-110 km., the fraction of dissociation increasing from 2×10^{-3} at 80 km. to 0·4 at 110 km. Observational work on atmospheric ozone and weather in Kashmir shows that substantial amounts of ozone come down into the troposphere in spring and winter when the low pressure troughs are eastward, thus implying that other stratospheric constituents will also come down into the lower levels under certain recurring phenomena of atmospheric circulation.

Oceanographic investigations on manganese distribution in the marine sediments off the coast at Visakhapatnam indicated that river-derived sediments are comparatively rich in manganese, *c.* 0·1 per cent, and the sediments containing large amounts of calcium carbonate are rather poor in manganese. A study of thermal structure of the coastal waters has shown the existence of upwelling and sinking, in the east coast during different periods of the year. The forecasting of wind-generated waves has been taken up using the methods of wave spectrum analysis from a theoretical study of the wave energy considerations. The various diagrams required for forecasting the waves in deep waters have been prepared.

A new primary frequency standard equipment employing a bar-cut crystal has been set up. With the help of the instrument it is possible to measure time intervals accurate to within 0·5 millisec.

A periodic impulse generator for calibration of time and frequency axis of a sound spectrograph has been designed and constructed at the Central Electronics Engineering Research Institute, Pilani. A light weight, portable, crystal-video receiver capable of responding to pulsed radar signals has been developed for use as a radar detector. A moving coil microphone has been designed and constructed using indigenous materials except the magnet.

A furnace with automatic control for growing single crystals by the temperature gradient method has been fabricated and a two-circle optical goniometer has been set up for determining crystal orientation at the National Physical Laboratory, New Delhi. A new vacuum colorimeter for determining thermal energy of metals at liquid helium temperatures has been developed. A total radiation pyrometer using a concave mirror to concentrate the radiation on a thermopile has been set up.

Chemistry — A new process for the manufacture of ammonium phosphate-sulphate fertilizer (Ammophos II) has been worked out at the National Chemical Laboratory, Poona. It uses ammonium bisulphate in place of sulphuric acid for solubilizing phosphorus pentoxide of rock phosphates. Completely continuous process flowsheets have been evolved for the preparation of pure ceria, lanthana and didymia concentrates. The customary citrate elution technique on Dowex-50 resin has been modified so as to increase considerably the yield factor of the resin for pure lanthanum.

A suitable process has been evolved at the National Chemical Laboratory for the stabilization of Indian dolomite and for manufacturing refractories from the stabilized product. Crucibles of 28 lb. capacity made of silicon carbide and graphite have been subjected to full scale trial and found satisfactory. The patented process has been leased out for commercial exploitation. Sillimanite bricks made from sillimanite waste have given good performance and the process is ready for industrial utilization.

Laboratory-scale preparation of the important synthetic oestrogen, stilboestrol, has been completed. The improvement made in the Dodd's synthesis of the oestrogen relates to the development of a new method for the dehydration of the stereoisomeric forms of 3: 4-dianisylhexan-3-ol to *trans* stilboestrol dimethyl ethers in about 90-98 per cent yield in a single operation. An efficient and simple method has been developed for the separation of sterols from sugarcane wax. Sterols will be utilized for the preparation of steroid hormones. A new total stereospecific synthesis of ferruginol, a diterpenoid phenol, has been accomplished. A four-step synthesis of dihydrojasmone, a substitute for jasmone in jasmine perfume, based on octanone-2, has been achieved. The overall yield is 66 per cent. A new anthraquinone, reported for the first time in nature, has been isolated from the hydroxide-soluble fractions of the acetone extract of *Tectona grandis* Linn. and identified as 1-hydroxy-2-methyl anthraquinone.

2-Hydroxy-3-naphthoic acid has proved useful for the gravimetric estimation of thorium and zirconium in presence of a large number of ions. A new reagent, dinitroso chromotropic acid, has been prepared and successfully employed for the complexometric titration of thorium with versene in presence of a large number of foreign ions. A rapid polarographic procedure for the estimation of arsenic in commercial glass compositions has been developed.

Biology — The results of an attempt to study the metabolic behaviour of individual organic acids in succulent leaves by feeding the starved leaves of *Coleus aromaticus* with sodium malate, sodium citrate, sodium succinate and sodium fumarate indicate that a certain enzymatic system is present in the leaves that are outlined in the Krebs bicarboxylic acid cycle. The activity and properties of catalase obtained from an Indian species of *Blepharisma* show that the enzyme under the influence of poisons like potassium and sodium cyanides shows that it is a respiratory enzyme.

Spectroscopic estimation of manganese in human blood has been taken up with a view to determining whether certain forms of sickness among manganese mine workers are due to excess of manganese in blood. On the basis of X-ray and optial studies of collagen, two structural models for collagen have been proposed. Of these, the transform of the second model has been calculated in detail and found to be in broad agreement with the X-ray pattern.

With a view to correlate the enzyme make-up with virulence and thereby evolve a rational approach to chemotherapy, detailed studies have been undertaken on the metabolism of *M. tuberculosis* var. *hominis* (both $H_{37}R_v$ and $H_{37}R_a$). The results show that $H_{37}R_v$ has the highest aldolase activity, which is not inhibited by dihydrostreptomycin, INH, PAS and sulphones. Among the various transaminases only the α-ketoglutarate-amino acid system is present which is inhibited by INH, but not by other anti-tubercular drugs.

Ultraviolet irradiation of antibody producing cells inhibits antibody production *in vitro*. This inhibition is found to be counteracted by glutathione. The presence of a strong sucrose-splitting enzyme has been demonstrated in cell-free extracts of *Leishmania donovani*. It has also been shown that the enzyme is purely hydrolytic in nature and thus differs from similar or mould enzyme systems. A strong transaminase system has been shown to be present in the organism. This system has great significance as it provides a route for the interconversion of amino acids leading to various types of protein synthesis. For the first time a systematic effort has also been made to establish a proper scientific background to the drug therapy of *L. donovani*.

Investigations on the role of enzymes in the toxic action of snake venoms have shown that cobra venom lecithinase preparations considerably inhibit *in vitro* the oxidative phosphorylating enzyme system of brain and liver tissue; a brain mitochondria has also been isolated. Since oxidative phosphorylation is the main pathway for ATP synthesis, its inhibition would affect the energy metabolism.

Metallurgy — The substitute stainless steels developed at the National Metallurgical Laboratory have been made fully austenitic and non-ferromagnetic. These steels have been shown to possess excellent deep drawing properties consistent with high tensile strength and adequate ductility. Three different nickel-free compositions containing manganese have been worked out for use in coinage. X-ray investigations carried out on a number of carbides extracted from two chromium steels, after various isothermal transformation treatments, indicate that for moderate soaking periods, the carbide corresponding to the composition Cr_7C_3 is generally obtained. A semi-pilot plant for beneficiation of low grade manganese ore, treating a ton of ore per day, has been set up.

A study of the effect of crystal orientation of electrodeposited nickel on the corrosion of mild steel has shown that (210) oriented nickel coating gives the best protection against corrosion in acid solutions. A number of organic chemicals have been tried as vapour phase inhibitors. *Meta*-dinitrobenzene is found to be quite efficient at 75-90 per cent relative humidity but less efficient at higher humidities. Separation of sodium sulphate and sodium chloride in carbonized solid Sambhar bittern has been effected using sodium *n*-octyl sulphate as flotation agent. In single operation, the residue is found to contain 90-95 per cent sodium chloride and the product thus obtained on reflotation gives 80-85 per cent pure sodium sulphate.

Fuel — Much attention has been devoted to the physical and chemical survey of coals and coal preparation studies, with the object of designing central washeries for meeting the coal needs of the new steel plants. A large number of coal blending experiments were done on pilot plant scale for deciding the coal charge in coke ovens of the steel plant.

Investigations on the demineralization of Indian coals have shown that paraffinic base oils have a good wetting activity towards coal particles but little agglomeration capacity. Aromatic naphthenic base oils, however, show large agglomeration capacity, but less wetting effect.

At the request of the Oil and Natural Gas Commission, investigations by physical and chemical methods have been undertaken on the evaluation and processing of Naharkatiya crudes from Assam. The evaluation studies have shown that the crudes are of a mixed nature containing aromatic as well as naphthenic and paraffinic hydrocarbons though, for most of the fractions, paraffinic hydrocarbons are higher than aromatic and naphthenic hydrocarbons.

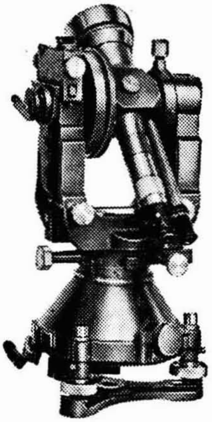
Experiments on catalytic hydrogenation of low temperature tar fractions for the production of diesel oil have shown that 250-300°C. fraction of tar oil is the most suitable for processing into superior quality diesel oil with high percentage of saturates.

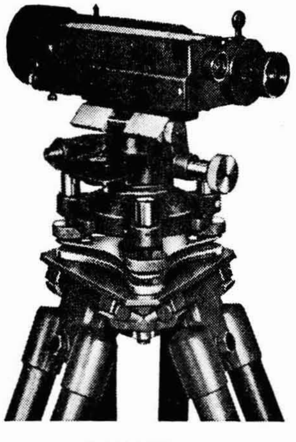
From studies on low temperature oxidation of coal it has been found that oxidation is selectively restricted to the end groups of the coal structure. This study has further led to the conclusion that the side chains in coal structure are longer than hitherto believed. In lignites and bituminous coals, the side chains cannot be shorter than four carbon atoms. In anthracite it appears to be shorter.

Buildings and roads — A plaster with satisfactory properties has been prepared with low grade Bikaner gypsum using hydrolysed keratinous material like hoofs and horns as a retarder. A new type of roof which uses very little cement and steel and is at the same time cheaper than the traditional reinforced concrete has been evolved. The savings in overall cost, cement and steel are estimated to be of the order of 25, 49 and 46 per cent respectively.

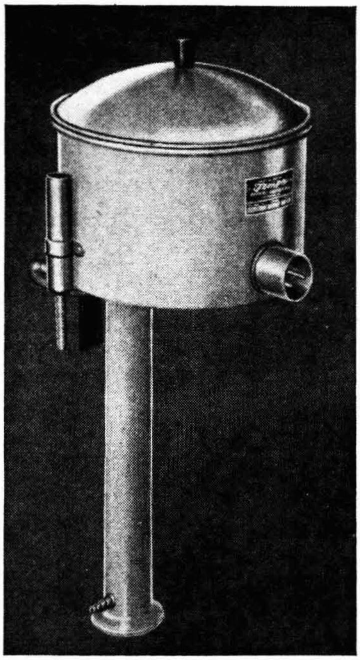
An apparatus has been designed and built at the Central Building Research Institute for determining the acoustic absorption coefficient at normal incidence. Determination of the absorption coefficient of vermiculite mortars, porous bricks, foam concretes and foam glass has been taken up, using this apparatus.

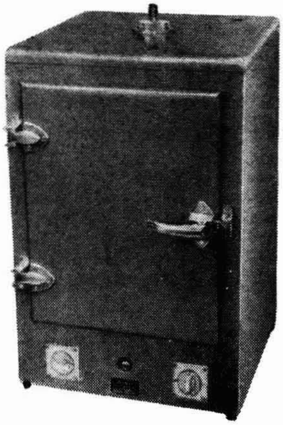
Investigations of actual road failures and foundation analyses of structures have been undertaken with the ultimate object of suggesting possible remedies in the shape of improved construction and maintenance techniques. Of the many chemicals tried for stabilization of clay soil, it has been found that treatment with 1 per cent alum increases the bearing capacity of black cotton soil blended with sand and brick aggregate from 20 to 35 per cent.

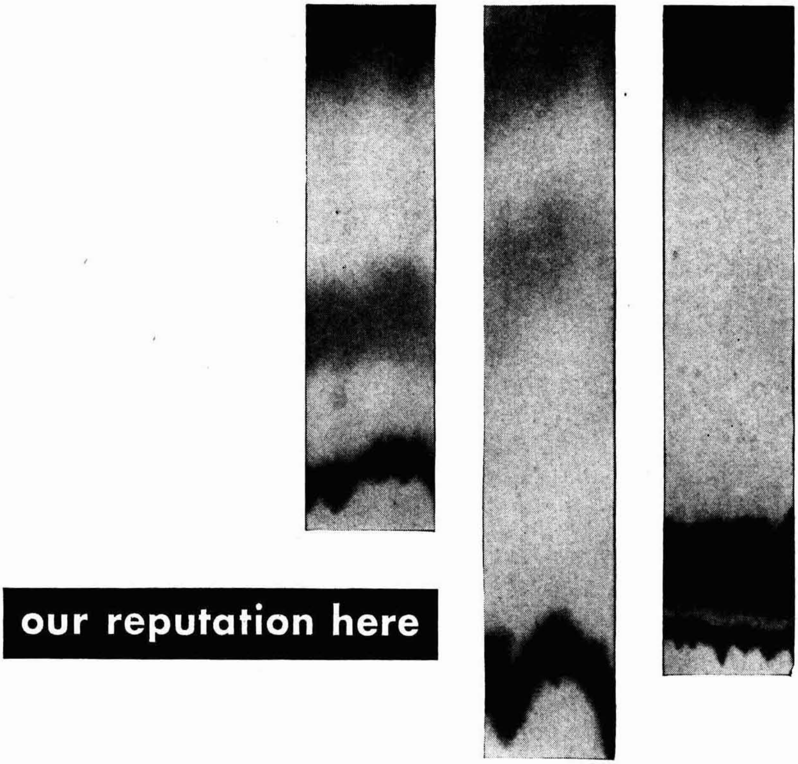


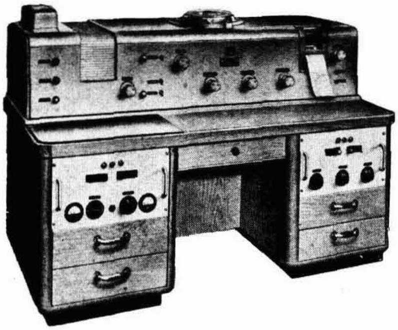



VITAMIN
A









Available from ready stock

- ★ PYREX REAGENT BOTTLES
- ★ GERMAN GLASSWARE
- ★ PORCELAINWARE
- ★ NICKELWARE
- ★ QUICKFIT STANDARD JOINTS & GLASSWARE

Please contact:

RITA SCIENTIFIC Co.

52-58 NEW HANUMAN LANE
BOMBAY 2

Phone: 22358 Telegram: 'TRIAL'

Your Orders and Enquiries — Please

Direct Importers & Principal Agents
for

B.D.H. (INDIA) PRIVATE LTD.
BOMBAY

of

LABORATORY CHEMICALS
STAINS, INDICATORS
AMINO ACIDS
etc. etc.

Contact:

N. SUNDERLAL & Co.

89 PRINCESS STREET, BOMBAY 2

Phone: 28844 P.O. Box 2276 Gram: 'EMETINE'

Bengal Chemical & Pharmaceutical Works Ld.

The Largest Chemical Works in India

Manufacturers of

Pharmaceutical Drugs, Indigenous Medicines, Perfumery, Toilet and Medicinal Soaps, Surgical Dressings, Sera and Vaccines, Disinfectants, Tar Products, Road Dressing Materials, etc.

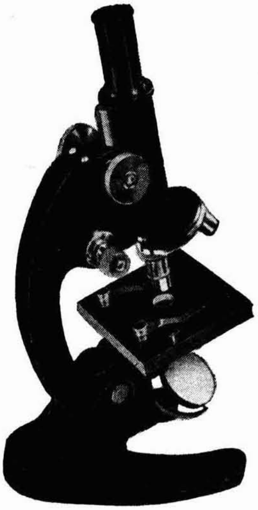
Mineral Acids, Ammonia, Alum, Ferro-alum, Aluminium Sulphate, Sulphate of Magnesium, Ferri Sulph, Ether, Caffeine, Ferri et Ammon Citras, Ferri et Quinine Citras, Sodi Citras, Sodi Iodidum, Magnesium Trisilicate, Potassii Citras, Potassii Iodidum, Stearates of Aluminium, Calcium, Magnesium and Zinc, and various other Pharmaceutical and Research Chemicals.

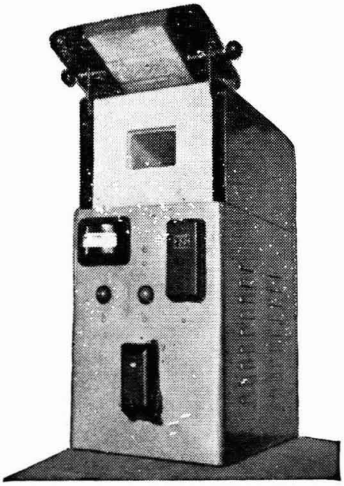
Surgical Sterilizers, Distilled Water Stills, Operation Tables, Instrument Cabinets and other Hospital Accessories, First Aid Box.

Chemical Balance, Scientific Apparatus for Laboratories and Schools and Colleges, Gas and Water Cocks for Laboratory use, Gas Plants, Laboratory Furniture and Fittings.

Fire Extinguishers, Printing Inks.

Office: 6 GANESH CHUNDER AVENUE, CALCUTTA 13
Factories: CALCUTTA • BOMBAY • KANPUR





Printed and published by SHRI B. N. SASTRI, Council of Scientific & Industrial Research, New Delhi,
at the Catholic Press, Ranchi, India

Regd. No. P-842