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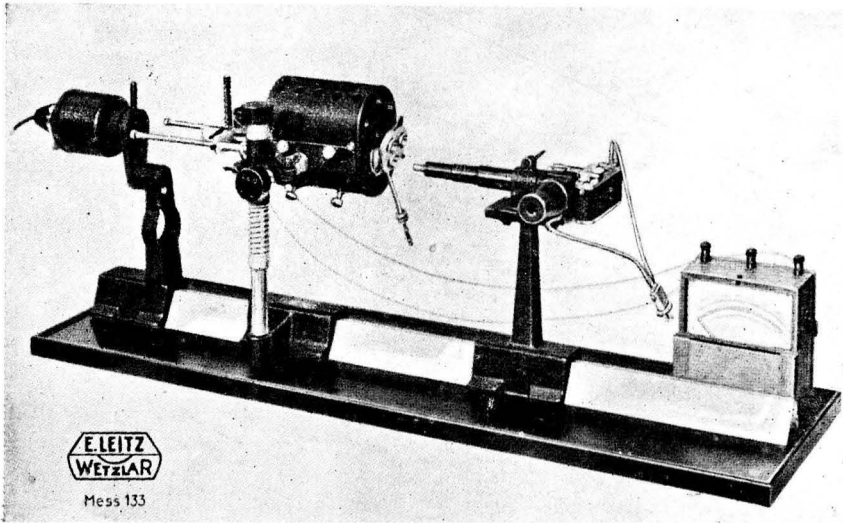


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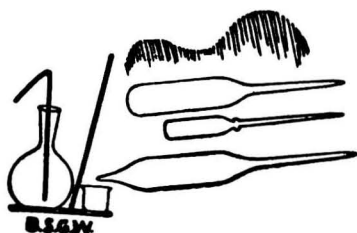
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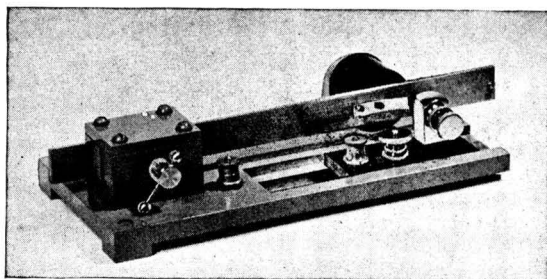
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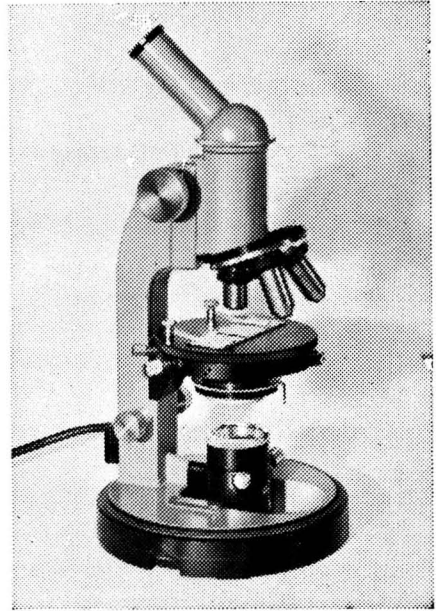
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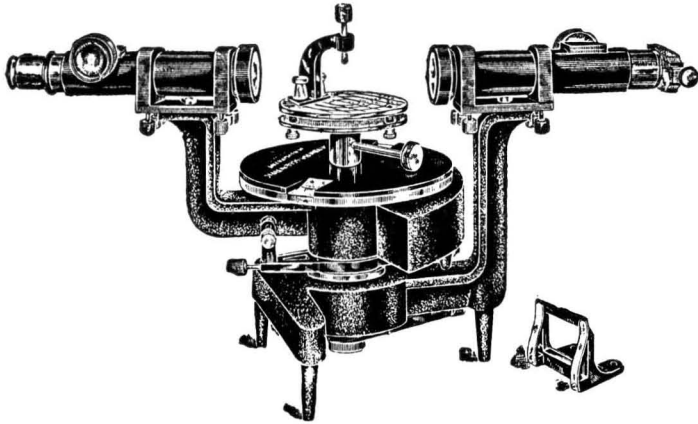
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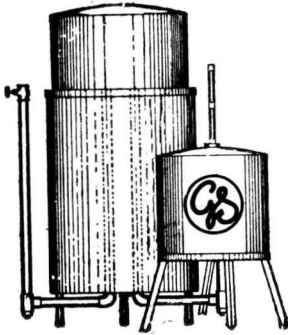
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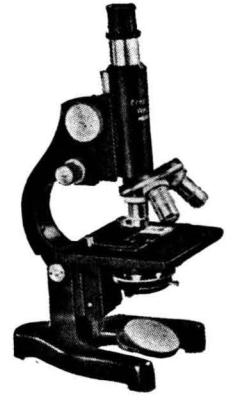
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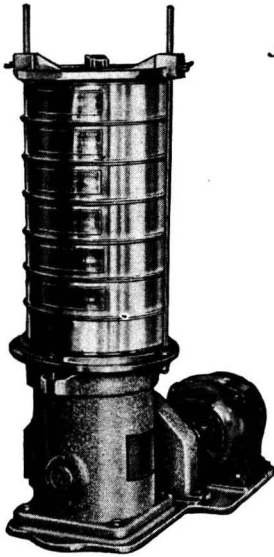
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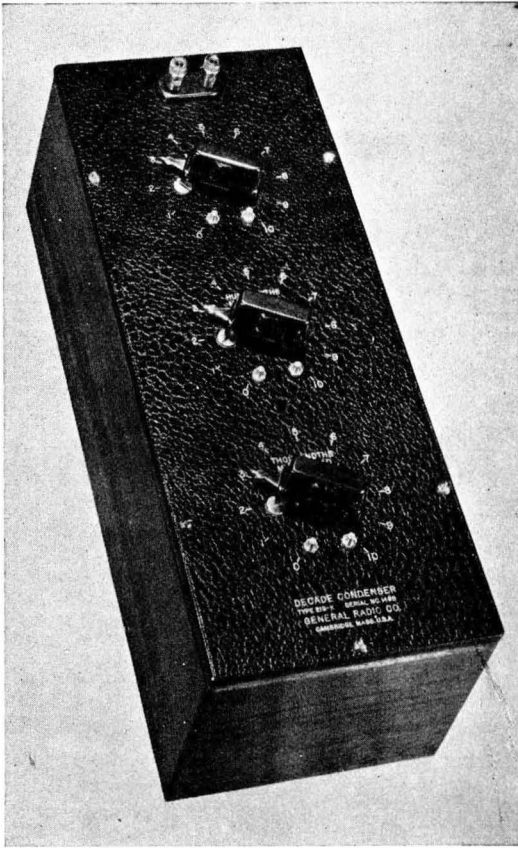
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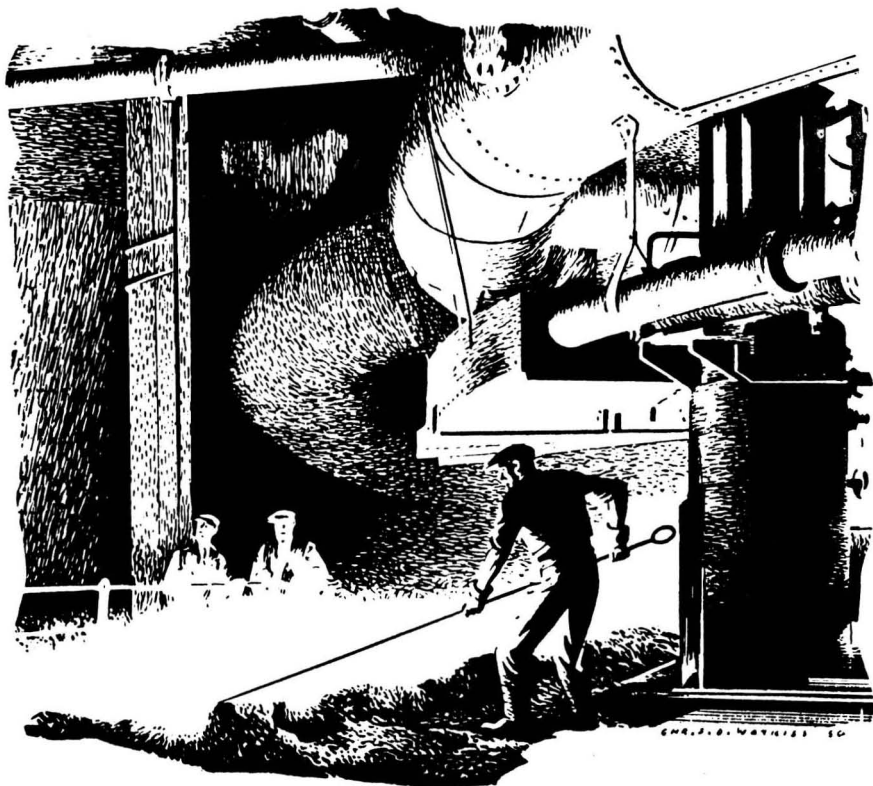
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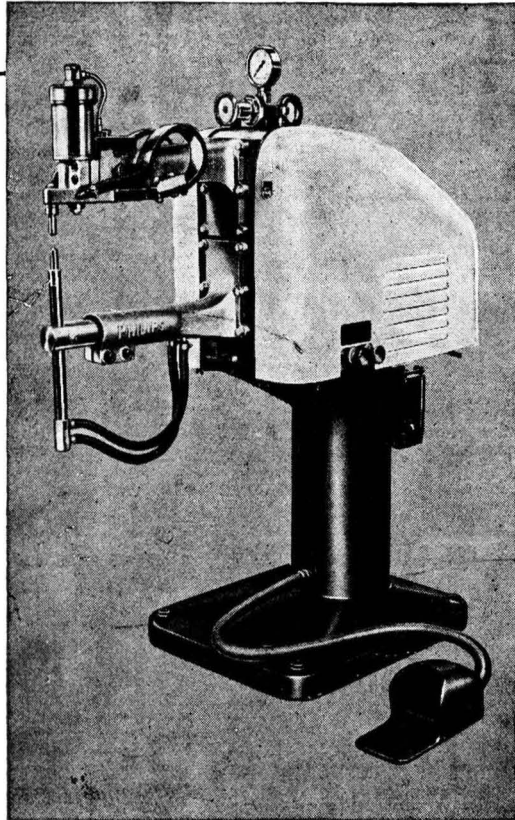
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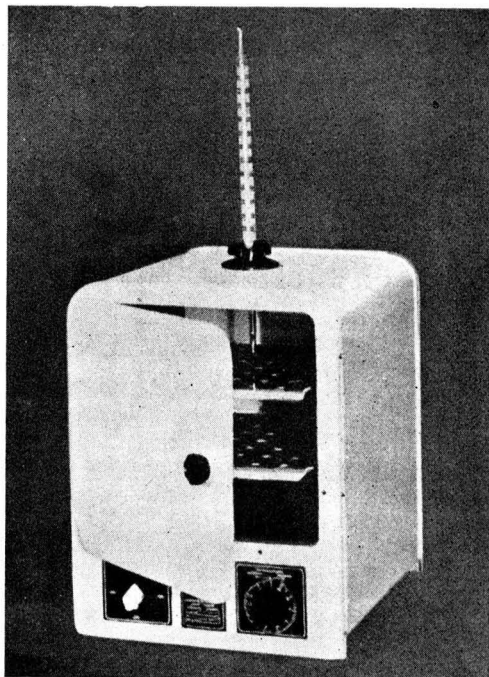
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Preparation of Scientific Papers

THE "Preparation of Scientific Communications" was one of the subjects discussed at the Royal Society Scientific Information Conference, London, 1948. The discussion led to the conclusion that:

"Many defects of scientific articles and delays in publication are due to inadequate preparation of manuscripts submitted to publishing bodies."

The Conference invited learned bodies to initiate a vigorous and sustained programme to improve preparation of papers. The Conference further recommended that:

"All those handling papers in draft form, including heads of departments in universities and technical colleges, and directors of government laboratories, research associations, and industrial laboratories, might be urged, both through their scientific, academic and professional associations and by personal letter, to do their utmost to ensure that:

"manuscript submitted by authors under their direction is written in clear and concise English, and is prepared in accordance with the rules of the journal for which it is intended;

"to the best of their knowledge and belief any contribution passed through their hands, whether as communicator or referee, is worthy of publication on its merits as scientific information alone;

"they help their students and assistants in preparing such materials;

"special efforts are made to save time at all stages of preparation, from the completion of actual research work to final printing, so as to avoid the psychological effect of dilatoriness on all those involved in the chain of publication."

Not only the methodology, but also the content of scientific communication has

come in for discussion. It has been stated that "ninety per cent of the papers are only written to publicize their author's existence".* While the estimate of papers departing from the accepted aim of publication, viz. to add to the existing knowledge, may be open to question, the implication that the content of scientific communications has not received sufficient emphasis in determining publishability is worth noting. It is the responsibility of all those concerned in the chain of publication of scientific papers to see that only significant results are published, and that scientific literature is not burdened with printed papers unless some addition is made to help scientific advancement.

Drafting & Shaping

The shaping of results of research into a concise, readable paper cannot be accomplished in one attempt. The research worker advisedly starts drafting his paper while the work is still in progress as this helps in discovering lacunae which need to be filled up by further work or in following up possible side lines suggested while preparing the draft. In the first draft, the author, who has before him tentatively tabulated statements of results, text illustrations and literature citations, has succeeded only in transferring his ideas to paper. The attention necessary for arranging the ideas and the results in their logical sequence and for giving precision and objectivity to expressions is possible only in the second or possibly the third revision of the draft. The author should assure himself that the significance of his work has been fully brought out and placed in proper relation to what is

* Nature, 1950, 166, 1066.

already known. Except in seminal contributions which come out whole as an egg — perhaps from transintellectual levels — it is a good policy to write out a paper, leave it in cold storage, as it were, for some time, and take it up with a fresh mind for final shaping before it is sent for publication.

Papers should be concise without prejudice to clarity. A concise account is prized by scientists who have to peruse numerous periodicals to collect new data and acquaint themselves with new techniques to aid them in their work. Authors, who are themselves research workers, appreciate the value of brevity, objectivity, precision and logic in published papers, and they have the responsibility to see that their papers are models of these virtues. If facts are distinguished from opinions, and reasoning from wishful thinking, many defects in scientific communications can be eliminated. A properly prepared paper lessens the labour of editors, reduces the cost of printing, and eliminates delay in publication.

C.S.I.R. Committee

These general considerations need to be analysed in relation to the form and content of each part of the scientific paper. Most authors need guidance in the preparation of manuscripts and illustrations for publication and in dealing with their proofs. Following the Royal Society Conference, national organizations in several countries have considered measures for raising the standards of presentation of scientific papers. In India, the Council of Scientific & Industrial Research has taken the initiative in enquiring into scientific publications. While standards have been formulated for the make-up of periodicals and for abbreviations of titles of periodicals, the important question of the preparation of manuscripts and illustrations had not received attention. A Joint Committee of the Council and the National Institute of Science has been set up to study the existing practices and to draft guidance rules for authors. The results of the labours of the committee will be awaited with interest.

Characteristics of the Ionosphere over Calcutta (March 1951)

S. S. BARAL, R. K. MITRA, D. C. CHOUDHURY, A. P. MITRA, R. B. BANERJEE & A. K. SAHA

Ionosphere Laboratory, Institute of Radio Physics & Electronics, University College of Science, Calcutta

THE present note gives the average ionospheric characteristics over Calcutta during March 1951.

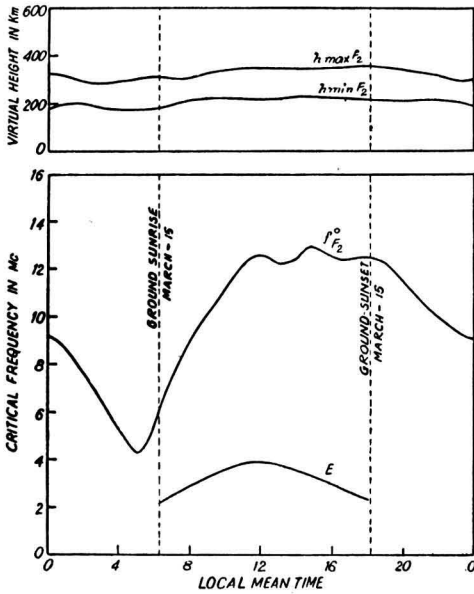
Fig. 1 gives in a graphical form the mean diurnal variation of (i) the monthly average critical frequencies of the E and F_2 regions and (ii) the heights of maximum and minimum electron densities of the F_2 region.

Fig. 2 gives the predicted values of maximum usable frequencies for different distances of transmission by reflection at the F_2 region over Calcutta for June 1951.

Table I gives the different occasions during routine observations when sporadic E was observed and the values of the corresponding penetration frequencies and heights.

The waves reflected from both regions E and F_2 suffered greater absorption during the 24 hr. in the present than in the previous month. The sporadic E ionization occurred mostly during the morning hours. The intensity and frequency of occurrence of E_s were smaller than in the previous month.

BARAL *et al.* : CHARACTERISTICS OF THE IONOSPHERE OVER CALCUTTA



(5 HR. 54 MIN. AHEAD OF G.M.T.)
FIG. 1 — MARCH 1951.

TABLE I

MONTH & YEAR	DATE	HOURS L.M.T.	$f^{\circ}E_s$	h_{E_s}
			Mc.	Km.
March 1951	6	10.00	5.10	135
		7	07.00	2.60
	13	12.00	5.00	135
		09.00	5.10	135
	15	14.00	4.25	135
		07.00	3.00	120
		08.00	3.25	120
	22	18.00	2.95	120
		07.00	3.05	120
	23	08.00	3.45	120
		18.00	4.25	135
		19.00	6.00	135
		20.00	4.50	120
		21.00	4.00	120
22.00		3.25	105	
23.00		3.00	105	

TABLE I— *contd.*

MONTH & YEAR	DATE	HOURS L.M.T.	$f^{\circ}E_s$	h_{E_s}
			Mc.	Km.
March 1951	24	00.00	2.25	90
		04.00	5.25	105
	28	16.00	(12.00)	150
		29	07.00	3.20
	30	08.00	3.75	120
		22.00	3.20	105
	31	23.00	3.00	90
		00.00	2.75	90
		01.00	4.00	90
		02.00	5.20	105
		05.00	3.00	105
		06.00	4.50	120
		07.00	3.00	120
		09.00	(8.00)	135
10.00	(8.00)	135		

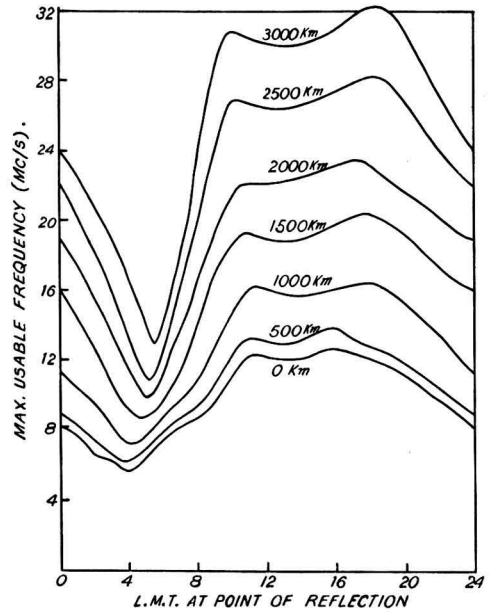


FIG. 2 — PREDICTED M.U.F. VIA F_2 LAYER DURING THE MONTH OF JUNE 1951.

Centenary Celebrations of the Geological Survey of India

A. K. DEY & M. S. VENKATRAM

Geological Survey of India

THE Geological Survey of India celebrated its first hundred years of existence in January 1951. In the first place, why 1951? Geology had already been studied in India for at least a generation, the first geological map on record having been made in 1820 (Dr. H. W. Voysey mapped the Hyderabad region in 1820), while the collections now housed in the geological galleries of the Indian Museum at Calcutta, and in charge of the Geological Survey, had as a nucleus the museum of the Royal Asiatic Society of Bengal, dating back to 1784. Even the name Geological Survey of India was first used by the Assistant who took charge of the effects of D. H. Williams after his death in November 1848, and Williams had been selected by a Committee appointed by the East India Company in 1837 to investigate the coal and mineral resources of India; he had been in India since 1846.

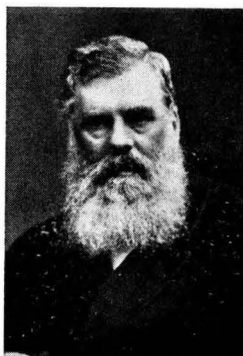
On the other hand, formal organization, on lines which were to persist, did not arrive until 1856. There was, therefore, some measures of disagreement, when the cele-

bration of the centenary was first mooted, on the actual year to be observed.

As a compromise, the appointment as Superintendent in 1851 of Dr. Thomas Oldham (Director of the Geological Survey of Ireland), named as successor to Williams and Dr. McClelland, who had been continuing William's field work, was chosen for the activities of the Survey which have not since that date suffered any interruption.

A Record of Achievements

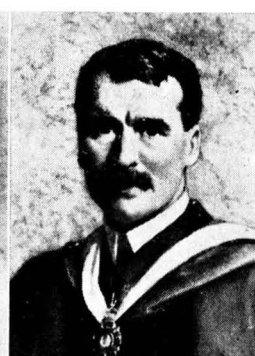
In the first five years, even before setting up a formal organization, and while there was not even a headquarters office, Oldham, with the assistance of a small staff, had extended the coalfield surveys for which the Department had originally been intended. Several fundamental scientific discoveries were soon made. In the following 20 years Oldham, till his retirement in 1876, promoted reconnaissance surveys in almost every part of India and some parts of Burma and adjoining countries, so that, soon after he left India, the first compilation of a geological map could be published.



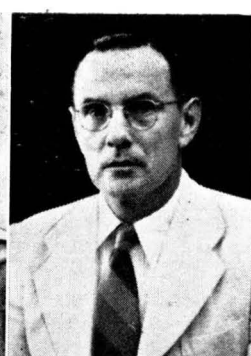
THOMAS OLDHAM, F.R.S.
(Superintendent, 1851-76)



W. T. BLANFORD,
F.R.S.



SIR T. H. HOLLAND, F.R.S.
(Director, 1903-10)



W. D. WEST
(Director, 1945-51)

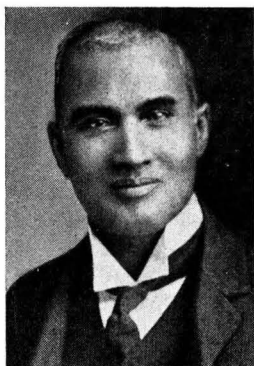


A GROUP OF OFFICERS OF THE GEOLOGICAL SURVEY OF INDIA BEFORE 1860.

The work of the pioneers of the first half century laid the secure foundations of India's geological knowledge. H. B. Medlicott's Himalayan surveys in 1859-61 and later by C. S. Middlemiss brought forward facts about the great mountain's physical structure which later, during the past 25 years, were interpreted by G. E. Pilgrim and W. D. West (Simla Hills), D. N. Wadia (Kashmir) and J. B. Auden (Krol Belt) according to modern conceptions of mountain building. C. L. Griesbach's work in and around Spiti, H. Warth's discovery of Cambrian trilobites and Wynne's pioneer survey in the Punjab Salt Range and F. Stoliczka's classification (later revised by H. H. Hayden) of the fossiliferous rocks of the Upper Sutlej and Spiti Valley and explorations in the Indus Valley in Ladakh were the outstanding scientific features of much enthusiastic work in the Himalayas and northern India that attracted most outside attention. F. R. Mallet's work on Darjeeling-Bhutan and Assam provided the basis of all further work in those regions. The credit of discovering in 1881 the alu-

minous laterite (later confirmed as bauxite) occurrences in India also goes to him. V. Ball laid the foundation of our geological knowledge of the Chotanagpur region. He was the author of pioneer work on Indian economic geology. Hackett made important contributions to the geology of Rajputana which were continued by A. M. Heron and others in the last fifty years.

No one has influenced the lines of Indian geology or moulded the working principles of the science better than W. T. Blanford. He was the greatest naturalist that this country ever had. Among the earliest major contributions to world geology was the recognition by W. T. and H. F. Blanford and Theobald of the glacial origin of the Talchir boulder-beds, and their correlation with similar formations in Australia, Brazil and South Africa. Later, when the plants of the Lower Gondwanas were studied by O. Feistmantel and Triassic vertebrates were discovered in the rocks, the vast ancient continent which included those countries received the name Gondwanaland, from the name given in India to the deposits from



P. N. BOSE

which its existence had been deduced. This discovery may be said to have led much later to Wegener's continental drift hypothesis. The discovery, and correlation with Europe, of the marine formations of Spiti, etc., in the Himalayas, was a first step to the conception of the Tethys Sea.

Owing to the disturbed state of parts of northern and central India for some years after 1857, the original plan of systematic mapping westward across the heart of the country had to be modified. A party under H. F. Blanford started work in southern India in 1857 and surveyed the Nilgiri Hills, Cuddalore, Tiruchirapalli (Trichinopoly) and other areas. The cretaceous fossils collected from Tiruchirapalli earned world-wide celebrity through the researches of Stoliczka and Blanford. T. W. H. Hughes carried out pioneer work in the coalfields of Peninsular India. To William King, Bruce Foote and Thomas Holland were due important economic discoveries in the south.

P. N. Bose was the first Indian officer to join the Survey in 1880. He located most of the principal iron ore deposits in Madhya Pradesh and also some manganese ore deposits; but his discoveries of the Mayurbhanj iron ore deposits, after his retirement from the Department, led to the establishment of the *Tata Iron & Steel Works* at Jamshedpur. La Touche's investigations in Northern Shan States in Burma led to the discovery of graptolites. La Touche will, however, be always remembered with gratitude for the bibliography of works on Indian geology including an index of minerals of economic value to which frequent references are made. The outstanding scientific work of Thomas Holland was his discovery of a dark bluish-grey hypersthene-bearing granite in Madras in 1893. Holland christened the rock *Charnockite* in honour of Job Charnock, the founder of Calcutta, whose tombstone in St. John's Churchyard, Calcutta, was discovered about the same time to be made

of the same rock and who was thus the unconscious means of bringing the first specimen to the city. Holland's memoir on this suite of rocks became a classic. The study of the great Assam earthquake in 1897 led to the discovery of the three main types of earthquake waves by R. D. Oldham, a discovery that has proved useful in the investigation of the interior of the earth.

H. Falconer and P. T. Cautley laid the foundation of the Indian vertebrate palaeontology between 1835-45 by discovering the Siwalik faunas, to which R. Lydekker and G. E. Pilgrim of the Survey made valuable additions. *Stegodon ganesa*, the forerunner of the present-day elephant, but much larger and with huge tusks, depicted on the postage stamp issued in commemoration of the centenary, was an inhabitant of the Siwalik area.

Thomas Holland, as Director of the Survey, restated the aims of the Department originally defined half a century earlier by Oldham, as assistance in the development of the country's mineral resources, and study of the mineral deposits, while continuing scientific researches and systematic mapping. This is still the basis of the Survey's work, though to its scope must now be added the investigations of ground water supplies and of sites and structural materials for engineering projects. He, in 1906, was one of the founders of the Mining and Geological Institute of India, to promote the liaison of geology with the mineral industry.

To Sir H. H. Hayden goes much credit for the geological knowledge of the Himalayas, Afghanistan and Tibet; he initiated the study of the Himalayan glaciers, thus becoming the Father of Himalayan Glaciology. L. L. Fermor's examination of the manganese ore deposits of the central part of India, apart from economic results, led to his description of a number of new minerals on the one hand, and to the unravelling of a complex Archaean belt on the other. Vredenburg's revision of Tertiary molluscan fossils was to prove of service in the deciphering of the geology of oilfield regions from Burma to Iraq. Pilgrim's work on the Siwalik vertebrate fauna led to the revision of the stratigraphy and, therefore, to the better understanding of the structure and geological history of a region in which more detailed surveys by H. M.

Lahiri, V. H. Boileau and G. Kohli led to the location of possible oil-bearing structures in the Punjab (I). Pilgrim and E. H. Pascoe also contributed to the interpretation of the geology of the Persian Gulf countries, now among the world's most productive oilfield regions. Unfortunately, World War I restricted general activities; most of the work for several years was confined to major economic minerals (mica in India, tungsten, etc., in Burma), in the midst of Hayden's term of office as Director, and the post-war boom encouraged the continuance of such diversion. The prosperous years after the war saw an expansion of activity. Coggin Brown made valuable investigations into the mineral resources of Burma, and his lucid interpretation of mining rules advanced the development of mines in India and Burma. He wrote a number of special brochures giving reviews of occurrences, uses and marketing of minerals and mineral products. Tipper's original work on rare-earth minerals in India is the basis of our knowledge relating to radioactive minerals, and Cotter will be remembered for his work on the main

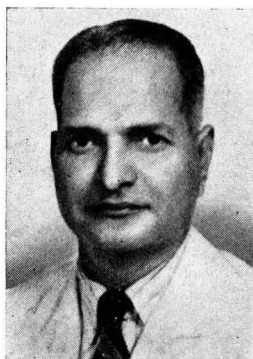
Tertiary basin of Burma. C. S. Fox made valuable contributions to economic geology and engineering problems; the latter work has since been continued by J. B. Auden.

H. C. Jones, J. A. Dunn and M. S. Krishnan have added considerably to our knowledge of the geology and mineral resources of Singhbhum and adjoining areas, H. Crookshank, to the geology of the Satpura basin and Bastar, and E. R. Gee, to the geology of N.-W. India (before partition); P. K. Ghosh (Sr.) investigated the charnockitic rocks in Bastar and Koraput.

The world economic depression between the two world wars led to heavy retrenchment of staff. The loss of experienced officers through the retrenchment of 1931 was sorely felt during World War II and, to cope with the additional work, the Department had to be expanded. As Director, C. S. Fox was mainly concerned with the reorganization of the Department for World War II, when most of its energies were devoted to the exploration, working and development of strategic minerals under the guidance of the Utilization Branch created



A GROUP OF OFFICERS OF THE GEOLOGICAL SURVEY OF INDIA AT THE END OF 1950.



M. S. KRISHNAN
(Director, 1951)

by him. It was unfortunate that the Branch was closed down before the result of its labours could be assessed.

E. L. G. Clegg, who succeeded Fox as Director, and who in 1943 set up a training camp to speed up the supply of new junior officers and to continue the war work of the Department, unfortunately fell ill

within a year of assuming office, and died shortly after. H. Crookshank was officiating Director for some months in 1944-45, and J. A. Dunn was in charge for nearly the remainder of 1945; both these officers made proposals for the expansion of the Department and, as a first step, the Mineral Development and the Engineering Geology Circles were set up by Crookshank; Dunn founded the Geophysical Section in 1945.

W. D. West, on assuming office as Director at the end of 1945, put into effect the proposals already made, and accepted by Government. The new set up included:

Mineral Development Division (including Geophysical, Mining and Drilling Sections).

Engineering Geology & Ground Water Division (especially major engineering projects).

Five (now six) Field Circles for systematic mapping and preliminary investigation of minerals, etc. (before the Specialist Sections take over); ultimately there will be a Field Circle for each State or States Union.

Rare Mineral Section (now transferred to the Atomic Energy Commission).

Headquarters Specialist Sections — Petrology; Palaeontology; Palaeobotany (new); Chemical (much expanded).

Special investigations resulting directly from the partition of India, with the consequent loss of the Punjab Salt Range as a source of supply, have been for new sources of gypsum for the Sindri Fertilizer Project,

and rock-salt in Mandi. A number of investigations was carried out, in almost every part of India, on minerals and engineering problems. The Department is engaged in the study of all the major engineering projects — both with regard to the stability of dams and the mineral resources either likely to be submerged or capable of being developed with the power to be generated. Other mineral investigations have been aimed at making India self-sufficient.

Under the Second Five-year Plan presented by West, still further expansion — both of organization and of work — is aimed at. The Geological Survey of India enters on its second century of existence with a great tradition of scientific and economic discoveries and with the determination not only to live up to its past reputation but to enhance it by a further period of devoted service to India's material prosperity and advancement of knowledge.

For a short period in 1949, while West was on leave, M. S. Krishnan was appointed officiating Director — the first Indian to hold the post — but had to attend the United Nations Scientific Conference on the Conservation and Utilization of Natural Resources in the U.S.A. J. B. Auden took charge of the Department, in addition to his duties as Superintending Geologist, Engineering Geology and Ground Water Division, until Krishnan's return.

One looks back with pride at the impressive record of the work of the Geological Survey of India from the early days when it had its own herd of trained elephants for the transport requirements of its slender staff, whose numbers could be counted on the finger tips, to its present-day growth with a scientific staff of about 170, of which 136 are geologists and the remainder chemists, geophysicists and mining engineers. In the early days, as the course and treatment of tropical diseases were unknown, the mortality of those who went into the jungle was so high that assurance offices declined to accept insurances on the lives of officers of the Survey stating that "no premium whatever could cover the risk". The impressive service rendered by the geologists of the past formed the background to the centenary of the Geological Survey of India, and the Government of India issued invitations to 21 foreign countries and 13 foreign Geological Societies to send delegates to

India to attend the centenary celebrations. It was in the fitness of things that the Government of India, true to their traditional hospitality, decided to treat the foreign delegates as State guests throughout their stay in India. The following delegates attended:

Mr. M. A. Condon, Prof. S. W. Carey, Mr. R. F. Thyer and Mr. K. J. Finucane (Australia); Dr. K. H. Enderl (Austria); Dr. Ba Thi (Burma); Dr. B. R. Mackay (Canada); Dr. N. G. Baptist (Ceylon); M. Claude Journot (France); Dr. Alfred Bentz (Germany); Mr. Tomofusa Mitsuchi (Japan); Dr. C. H. Edelman (the Netherlands); Mr. J. C. Ferguson (Southern Rhodesia); Dr. W. J. Pugh (U.K.); Dr. W. D. Johnston (U.S.A.) and Prof. G. Bogomolov, Prof. M. Varentsov and M. Ivan Tarasov (U.S.S.R.), besides Sir Lewis Fermor representing the Geological Society of London and the Mineralogical Society of Great Britain and Ireland, and Dr. A. M. Heron, former Directors of the Geological Survey of India.

Itinerary & Visits

It was intended to hold the centenary celebrations in Calcutta with the 38th session of the Indian Science Congress, and the 1st session of the Pan-Indian Ocean Science Congress. Though the sudden change in venue of the Indian Science Congress to Bangalore upset the original plan, the centenary was celebrated in Calcutta. All the delegates who could have normally attended the Indian Science Congress could not do so on account of this change of venue. However, with the exception of Messrs K. J. Finucane, Claude Journot, J. C. Ferguson, Dr. K. H. Enderl and Dr. W. J. Pugh, all the delegates attended the Indian Science Congress session at Bangalore. While at Bangalore, they visited the Kolar Goldfield where there are some of the world's deepest mines. The delegates were entertained at a lunch by the Kolar Gold Mining Companies.

On their way to Calcutta, the delegates made a two-day halt at Madras. Arriving at Madras by air on the 8th morning, they visited the quarries of charnockite rocks at St. Thomas Mount and Pallavaram on which Holland wrote his classic memoir. It will not be out of place to record here what Sir Lewis Fermor remarked while visiting the Pallavaram hill quarries with the delegates. He said that as these hill quarries have

become a place of pilgrimage for the geologists since Holland wrote his famous memoir on the rocks, it was appropriate that on the Pallavaram hill there should be a museum containing specimens of charnockites and associated rocks. In the afternoon, the delegates attended a tea party given in their honour at the office of the Southern Circle, Geological Survey of India, at Mylapore. They spent some time in the museum attached to the office, examining rocks and minerals collected by the members of the Department from all over South India. Later, in the evening, the guests witnessed a dance recital provided by the pupils of the Saraswathi Gana Nilayam at the Museum theatre. The entertainment was impressive and the delegates spoke in appreciative terms. The arrival of foreign geologists at Madras roused public interest in the Department which, though doing useful work, seldom comes into the limelight. Very few citizens could have known that the Geological Survey of India has a museum in Madras until they heard that the delegates visited it. On the following day, the guests visited the famous monoliths of Seven Pagodas (Mahabalipuram) and in the evening they visited the Geological Department of the Presidency College, Madras, where they were entertained at a tea party. On the following day they (escorted by Dr. A. K. Dey) arrived at Calcutta by air. At the airport they were received by Dr. W. D. West and other senior officers of the Geological Survey of India.

On the 11th, the delegates visited the office of the Geological Survey of India, and saw the geological galleries and special exhibits displayed at the Indian Museum, Calcutta. The exhibits showed the progress of the Geological Survey of India during the hundred years of its existence. Series of geological maps, charts, photographs depicted the marked progress. The other exhibits included geophysical instruments with explanatory charts showing their application. The exhibits under Engineering Geology gave an idea of the vast amount of work carried out by the Geological Survey of India in connection with some of the major engineering projects now in progress in the various parts of the country. The geological work done in connection with the Damodar Valley Project in Bihar, Bhakra-Nangal Project in Punjab (I), Kakrapar and Koyna

Projects in Bombay, Lower Bhawani Dam-site and Tungabhadra Project in Madras and Hyderabad, Kosi Dam-site in Bihar-Nepal, the Hirakud Project in Orissa, and the Marora, Ramganga and Pipri Dam-sites in Uttar Pradesh were explained with maps, charts and models. The publications of the Geological Survey of India — the Records, Memoirs, Bulletins, Palaeontologia Indica and special publications — were displayed. In connection with its centenary celebrations the Geological Survey of India published a short history of the Geological Survey of India, a handbook, and a guide to the special exhibits.

In the afternoon, the delegates attended the 45th Annual Meeting of the Mining, Geological & Metallurgical Institute of India, where Dr. W. D. West extended to them a hearty welcome. Later, Dr. B. R. Mackay, Senior Geologist, Canadian Geological Survey, and Dr. W. J. Pugh, Director, Geological Survey of Great Britain, gave lectures respectively on Coal in Canada and An Ancient Shore-line of Great Britain at the Indian Museum. Afterwards, the delegates were guests at the Annual Dinner of the Mining, Geological & Metallurgical Institute of India at the Bengal United Service Club. Sir Lewis Fermor, a former Director of the Geological Survey of India, who was the Chief Guest at the function, replying to a toast proposed by the President of the Institute, Dr. D. N. Wadia, said that he was associated with the Institute since 1906 as a foundation member. During this period, India had progressed much in scientific development and the most amazing growth in science had been in geology. When he visited the Geological Survey of India office, he found that they were manufacturing some of the apparatus used by the Department here.

Dr. W. D. Johnston of the U.S.A., in proposing the toast of the Geological Survey of India, referred to many points of similarity between the Geological Survey of India and the United States Geological Survey, and hoped that when 28 years hence the United States Geological Survey would celebrate its first centenary it would look back with the same pride of accomplishment that the Geological Survey of India was feeling.

On Friday the 12th, a visit was made to Job Charnock's tombstone at St. John's Churchyard, Fort William, the Victoria

Memorial and Tollygunge Club. The tombstone of Job Charnock is of interest to geologists since Thomas Holland named his original hypersthene-granite in honour of Job Charnock.

Sir Lewis Fermor unveiled the bust of Dr. Birbal Sahni in the Invertebrate Palaeontological Gallery of the Indian Museum. This was followed by entertainment and fireworks in the lawns of the Indian Museum, and two lectures at the Museum, one by Dr. Alfred Bentz, President, German Geological Society, on Petroleum Exploration in Germany and the other by Prof. S. W. Carey, Professor of Geology, University of Tasmania, on The Orogenic Girdle of Gondwanaland.

The Ceremony

The commemoration ceremony was held at 3 p.m. on Saturday the 13th January at the Museum, the Hon'ble Shri N. V. Gadgil, Minister for Works, Mines and Power, presiding. His Excellency Dr. K. N. Katju, Governor of West Bengal, was the Chief Guest. His Excellency Sir Maharaj Singh, Governor of Bombay, and Mr. S. N. Buragohain, Deputy Minister, Works, Mines and Power, Government of India, were also present among many others.

At the outset, a former Director, Sir Lewis L. Fermor, representing the Geological Society, London, and the Mineralogical Society of Great Britain and Ireland, Dr. A. M. Heron, also a former Director, and the Superintending Geologist of the Geological Survey of India, were introduced. One hundred girls taking one hundred burning tapers then went round the pandal in a long procession and thereafter garlanded the overseas delegates and distinguished invitees. Verses from the *Vedas* were sung which was followed by the unveiling of the geological map of India and the Department's new crest colourfully lighted by neon lamps.

Messages of congratulation to the Geological Survey of India received from various scientific societies, eminent scientists and noted individuals were read out. Dr. S. L. Hora on behalf of the Royal Asiatic Society of Bengal, Sir Lewis L. Fermor on behalf of the Geological Society of London and the Mineralogical Society of Great Britain and Ireland, Mr. Tomofusa Mitsuchi, Director of the Geological Survey of Japan, on behalf of the Japanese Government, Prof. G. Bogomolov on behalf of the U.S.S.R. and the

Russian Academy of Sciences, Dr. D. N. Wadia on behalf of the Mining, Geological & Metallurgical Institute of India read out messages from their respective Societies expressing deep appreciation of the work of the Geological Survey of India during the past years. Sir Lewis also announced the award of the Lyell Medal of the Geological Society of London to Dr. W. D. West in recognition of his work in India. Other messages received were from the Geological Survey, United States; Geological Survey of Norway; Australian Mining and Metallurgical Department; the Hon'ble Shri Sri Prakasa, Commerce Minister of the Government of India; Sir C. V. Raman; Sir S. S. Bhatnagar, and General Cariappa, Commander-in-Chief, Indian Army.

The Hon'ble Shri Jawaharlal Nehru, Prime Minister of India, sent the following message :

"I had long been looking forward to attending the centenary celebrations of the Geological Survey of India, and I am sorry that my visit to England should come in the way of my doing so. It is just forty years now that I took my degree in Cambridge, and among my subjects was geology. Since then I have been engaged in other activities of a varied nature. But my interest in geology has continued. This was another reason why I wished to associate myself with these centenary celebrations.

"In India today geology is of very great importance and I am quite sure that we should increase the activities of the Geological Survey and widen its work. I hope that these celebrations will attract public attention and make people realize the great importance of geological work in this country. The development of our mineral wealth should be a first priority and it is through geological work that we can do so.

"I welcome the eminent scientists who are going to attend these celebrations. Science is international and it is good that in these days of international friction scientists can meet as friends and colleagues, and consider problems from the larger viewpoint of the world and the progress of humanity."

In his address, the Hon'ble Shri N. V. Gadgil said that the Geological Survey of

India had contributed in no small measure to the progress of the science of geology during the past century. It would always stand to the credit of geologists of India that during past 100 years they had not been behind the geologists of other countries. It was India's aspiration that they should now be ahead of others. In the course of its career, good traditions of service had been established by the Geological Survey of India. He had no doubt that these traditions would be carried further, and now that India had achieved full freedom, the Survey's activities should expand in all directions. In the last few years efforts had been made to recruit more staff and to put the Geological Survey on a basis appropriate to its growing activities and importance. There had been a better appreciation of the rôle the Survey had to play in the life of the community and he had no doubt that this would soon be evident in some tangible form.

Dr. Katju praised the achievements of the Geological Survey of India and said that whatever might be said about the political objectives and the administrative structure of the Government of British India, the scientific institutions built by it, such as the Geological and Archaeological Departments, did their work regardless of political considerations.

Dr. W. D. West, Director, Geological Survey of India, recalled that in spite of the great hardships which the geologists who went to the jungles in the past had to undergo, they laid the foundation of the science in India on which they were now building their edifice. Continuing, Dr. West said that now under the inspiration of a National Government the scope of the work of the Survey had been considerably extended and, in addition to investigating the country's mineral wealth, it was also devoting more attention to the ground water resources of the country, while its advice from the geological standpoint was sought in connection with the many multi-purpose and other engineering projects which are now being designed and constructed. Though Government was naturally most concerned with the economic aspect of the Survey's work, it should be said to the credit of the Government of India that it had always recognized purely scientific work as an important duty of the Survey and had

regarded advancement of science not only as something to be encouraged for itself, but also for furthering and rendering more valuable economic work. During the past few years the Survey has been expanding to a size it has never known before.

The function concluded with the singing of the National Anthem.

In the evening members of Ghosh's College of Physical Education entertained the delegates and visitors to athletic and yogic feats. The Geological Survey Recreation Club had also arranged music and dances in honour of the delegates, and the day's function terminated with a stand-up dinner.

In the morning on Saturday the overseas delegates called on Dr. K. N. Katju at Government House, after which Dr. D. N. Wadia unveiled the clay relief of P. N. Bose (the first Indian to join the Survey) in the Geological Survey office. Later on the delegates visited the Royal Asiatic Society of Bengal.

On Sunday morning the delegates made an air excursion to the approaches of the Himalayas through the courtesy of *Messrs Doodwala & Co.* In the afternoon there were group photographs while in the evening an At Home was given by the Geological Institute of the Presidency College, Calcutta, at which Dr. W. J. Pugh, Director, Geological Survey of Great Britain, and other overseas delegates to the Geological Survey of India centenary celebration, addressed the members.

Accompanied by Messrs V. P. Sondhi, A. M. N. Ghosh and Dr. A. K. Dey, the foreign delegates left Calcutta on tour to important mining centres in West Bengal, Bihar and Madhya Pradesh by a special train at 11.30 in the night. On the following morning they saw the sand stowing plants of the *Equitable Coal Co.* at Bhaladih; in the afternoon they visited the Indian School of Mines & Applied Geology at Dhanbad, the Government Fertilizer Plant at Sindri, and the National Fuel Research Institute at Jealgora. Next morning, arriving at Kodarma, the party first visited the Tilaiya Dam-site forming a part of the overall development of the Damodar River Valley in Bihar and West Bengal and then went to Messrs Chatteram Horilram's mica factory at Kodarma, followed by a visit to Chrestien Mica Industries' Kalakthambi mica mine in the Kodarma Reserved

Forest. On the 17th, the party, after seeing an exposure of Talchir boulder-bed near Chapri, about 6 miles north-east of Bokaro, went to see the open-cast mining of the 100 ft. Kargali seam of Bokaro Coalfield, and afterwards to Konarbandh, 7 miles from Bermo railway station, to see the foundation of the thermal plant, Damodar Valley Corporation, being laid, and the model of the power station area. They arrived at Tatanagar on the following morning and visited the *Tata Iron & Steel Co.'s* Works, water works and Dimna artificial lake. Dr. John Mathai of the *Tata Iron & Steel Co.* referred to the useful work of the Geological Survey of India and hoped that the traditions established would be maintained. While thanking the *Tata Iron & Steel Co.* on behalf of the delegates, Dr. Bentz observed that they saw the iron works without an iron curtain. The next morning Tata's iron ore mines at Noamundi were visited. The party arrived at Nagpur on the 20th morning and proceeded to see the Kandri manganese ore quarry in Madhya Pradesh, worked by the *Central Provinces Manganese Ore Co.*, and on the way to the Geological Survey of India Training Camp at Deolapar, saw Ramachandra Temple at Ramtek. The party spent two days at the Training Camp examining the Archaean rocks which have been, according to Dr. W. D. West, intensely folded, with the production of *nappe* structure. To certain exposures the delegates had to travel in small double bullock carts, which they enjoyed. At Deolapar the delegates saw the camp life of the Geological Survey of India and were satisfied with all the arrangements made.

All were impressed with the mineral potentialities of the Indian Union, particularly the 100 ft. thick coal seam in Bokaro, the iron ore of Noamundi that would last for centuries, and the mica deposits. The delegates were gratified at the arrangements made by the Geological Survey of India, and the hospitality extended. The extensive tours greatly added to their information and the knowledge of the country. Appreciating the arrangements, Mr. Finucane said that Australia would welcome visitors from the Geological Survey of India or from the Geological Departments of Indian universities. Dr. Pugh remarked that it was a good thing that the Geological Survey of Great Britain had already celebrated its

centenary as otherwise he would not know how to make similar arrangements. Dr. Mackay, referring to the training camp, said that there was an arrangement in his country by which postgraduate students were attached to the Canadian Geological Survey party to map under the guidance of the senior officers of the Survey. This scheme is beneficial to both; the students receive stipends during the period of their work with the Survey and gain experience while the Survey gets more work done without additional staff.

On the 22nd evening the Nagpur Branch of the Mining, Geological & Metallurgical Institute of India entertained the delegates at a dinner at which Sir Lewis proposed the toast of the Institute saying that he was the oldest member of the Institute present and that he saw the inauguration of the Nagpur Branch in 1924 and noticed that the progress of the Institute's Branch has been in keeping with the growth of the manganese industry. Referring to the development of manganese mining in Madhya Pradesh, he said that where he could once walk across the ground are now the great quarries and the manganese mines. Dr. Pugh said that the Institute was an offspring of the Geological Survey of India and, therefore, intimately associated with the centenary celebrations. It will, no doubt, in the next few years celebrate its Golden Jubilee when the Geological Survey of India will confer on it its affectionate blessings. Incidentally, he referred to the distinctive work of Dr. West at Deolapar and observed that the academic side of the Geological Survey should not be divorced from its economic activities; otherwise it would be like capital without assets.

On the way to Delhi, the delegates visited places of historical and archaeological interest at Agra, Fatehpur Sikri and Secundra on the 24th January. At Delhi, they visited the Kutub Minar and Tughlakabad on the forenoon of 25th January and the National Physical Laboratory during the afternoon. On the 26th January, they attended the Republic Day Parade in the morning, and the tea party given by the President of India in the evening. They also visited Rajghat in the morning of the 27th, and the Engineering Exhibition and the Asian

Museum in the evening. The Hon'ble Shri N. V. Gadgil, then Minister for Works, Mines and Power, gave a lunch to the delegates, on the 27th, which was attended, among others, by the Hon'ble Shri Jawaharlal Nehru, Prime Minister of India, and the Hon'ble Shri Sri Prakasa, the Minister-designate for Natural Resources and Scientific Research. The delegates began to disperse from the 28th January 1951.

The central and dominating figure that was primarily responsible for the organization and execution of the centenary celebrations was Dr. W. D. West. The Government of India sanctioned a specific sum to meet the expenses, but what was more gratifying was the appreciation shown by the mineral industry on this occasion. The industry felt that it was a privilege to be associated with the organization on an occasion like this as the benefits it had received through the work of the Survey was invaluable. Everywhere the delegates were received with warm hospitality. The *Burmah Oil Co.* and the *Assam Oil Co.* voluntarily made generous contributions to meet a part of the cost of the centenary, which kindled the spark in others, and those who contributed with equal generosity included:

Chrestien Mica Industries, Ltd.; *Chatturam Horibram Ltd.*, *The Central Provinces Manganese Ore Co. Ltd.*; *The Bengal Coal Co.*; *Martin Burn Ltd.*; *Tata Iron & Steel Co. Ltd.*; *Serajuddin & Co.*; *A. K. Sarkar (Industries) Ltd.*; *Shaik Moula Sharaf*; and *Doodwala & Co.*

At the close of the celebrations, Dr. W. D. West announced that the mica magnate Mr. Ramkumar Agarwala had promised a munificent donation for instituting a medal in connection with the Geological Survey of India centenary. The medal is to be awarded for the best work on the geology of the Gondwanaland by scientists of the countries which were once united together and formed the Gondwanaland.

January 1951, in which month the centenary of the Geological Survey of India was celebrated, ended with the departure of the last of a continuous succession of British heads of the Survey, Dr. W. D. West. On February 1st, Dr. M. S. Krishnan took office as the first Indian Director.

Bauxite Deposits in Orissa

S. C. CHAKRAVARTY

Geological Survey of India

THE Khariar Highlands are situated on the western border of the present State of Orissa (*vide* Survey of India Topo. Sheet Nos. 64 L/6, 7 and 8; scale 1" = 1 mile) and consist of a series of hill ranges aligned north-south with a high plateau in the centre rising to more than 3,000 ft. above the mean sea level.

The occurrence of bauxite on Khariar Plateau was first recorded by Dr. C. S. Fox* in 1923. In 1942-43 Dr. A. G. Jhingran of the Geological Survey of India carried out a rapid reconnaissance of the plateau and suggested further investigation of certain areas in this region. Accordingly, the following four laterite-capped hills were investigated by the author:

(1) Kondomal Hills 3160 and 3101 — 64 L/7 (20° 16' 10" : 82° 27' 45"); (2) hills west of Sainipara — 64 L/7 (20° 18' 30" : 82° 27' 30"); (3) Barapet Dongar Hill 3302 — 64 L/7 (20° 19' 45" : 82° 27'); and (4) hills near Sandbahli — 64 L/8 (20° 12' 55" : 82° 25' 35").

The highlands are made up of Pre-cambrian sandstones, occasionally gritty, and quartzites with shales and quartz veins. They are overlain by laterite with which bauxite is associated. The bauxite, however, is nowhere exposed on the surface. Shallow pits dug at selected spots revealed the presence of pockets and lenses of bauxite of varying degrees of purity beneath the soil mantle and laterite capping.

Bauxite from Bara Kondomal and from the depression between Bara and Sona Kondomals yielded on analysis 51.68 per cent to 52.47 per cent and 61.48 per cent of alumina respectively. Stray boulders of bauxite from the surface of Sainipara Hill yielded 53.98 per cent alumina. The ore is good but the quantity is small. Bauxite from Sandbahli and Barapet is rather poor in quality.

The Kondomal deposits, the most promising of all the four, may be divided into

two groups: (a) *in situ*, i.e. from the pits near the summits of Bara and Sana Kondomal Hills, and (b) *detrital*, as in the depression between Bara and Sana Kondomals. All the samples from group (b) yielded more than 50 per cent alumina, which is not always the case with samples from pits from Bara and Sana Kondomals. The alumina content of the samples from the shallow pits (averaging 5' in depth) dug in Kondomal Hills appeared to be uniform throughout.

Assuming that the deposits are homogeneous and continuous and an average depth of 4' 4" for the deposit *in situ*, and 6' 3" for the detrital deposit, the reserves can be put at 3,01,500 tons.

The central portion of Kondomal Hills looks promising. More detailed prospecting is necessary for obtaining a correct estimate of the total reserves of bauxite.

Water for boring may be obtained by constructing a small dam across the stream flowing down Kondomal Hills.

Transport facilities in this area are unfavourable. If reserves of the order of a couple of million tons are proved, an aerial ropeway may be constructed for the first

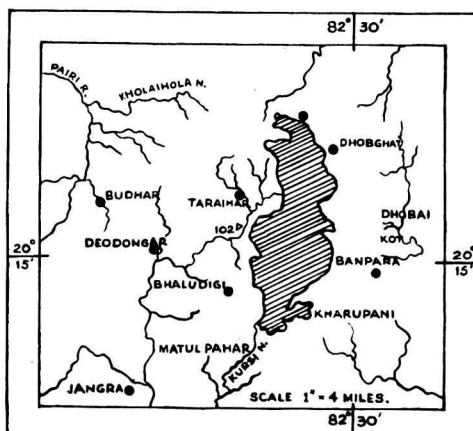


FIG. 1 — BAUXITE DEPOSITS IN THE KHARIAR HIGHLANDS OF ORISSA.

* Fox, C. S. : *Mem. G.S.I.*, 59, Pt. 1, 1923.

stage, i.e. from the top to the bottom of the plateau over a distance of 4 miles, as the alternative road transport will not be feasible due to the steep gradient of

the scrap faces of hill ranges. At the second stage, the ore may be taken out to Khariar Road railway station over a distance of 46 miles along the existing fair weather road.

Experimental Salt Farm & Salt Research Station, Wadala

MATA PRASAD

Royal Institute of Science, Bombay

THE average quality of salt produced in India is poor, and in some places it is so low that the salt is unsuitable for human consumption. The Salt Research Committee of the Council of Scientific & Industrial Research considered the question of improving the quality of salt and recommended that salt research stations and model farms should be established at various centres in India with a view to (i) demonstrate the scientific methods of manufacture for improving the quality of salt, (ii) conduct investigations on the economic layout of salt works, and (iii) study all other aspects connected with the improvement of the salt industry.

The Government accepted these recommendations and established a Salt Research Station and Experimental Salt Farm at Wadala, Bombay, in November 1949. A laboratory for production control was set up this year.

Quality of Salt Produced in Bombay

Analyses of samples of sea salt (TABLE I) produced at some salt works around Bombay show that calcium sulphate, magnesium sulphate and magnesium chloride are the common impurities, the total percentage of these salts being 5.3 to 6.8. This is due to the defective layout of salt works and lack of control during manufacture.

The ratio of condensing to the crystallizing areas in many of the salt works is 1:1 or 1:2. This results in feeding brine of low density to crystallizers and calcium sulphate separates out with common salt. Further, since the bitterns are not drained out,

	LIGHT OR MAPI SALT %	HEAVY OR VAJNI SALT %	FLAKE OR KUPPA SALT %
NaCl	91.34	92.58	93.92
CaSO ₄	1.20	1.02	0.86
MgSO ₄	2.31	2.12	1.80
MgCl ₂	3.21	3.18	2.64
Insolubles	0.82	0.89	0.25
Undetermined	1.12	0.41	0.53

	BEFORE REMODELLING, acres	AFTER REMODELLING, acres
Reservoir	16.5	20.90
Condenser	13.0	21.05
Crystallizers	21.0	7.15
Platform	2.0	1.20
Uncultivated land	2.0	4.35
	54.5	54.65

magnesium salts find their way into the salt. The beds of crystallizers are not properly prepared and sufficient care is not taken while scraping the salt with the result that insoluble impurities, such as clay and grit, find their way into the salt.

Experimental Farm

The Sulemanshah Salt Works at Wadala has now been remodelled. The total area of the works is 54 acres; it is fed by two sub-creeks. Table II shows the distribution of the acreage before and after remodelling. The new layout is shown in Fig. 1.

The pan area comprising of about 825 small pans has been levelled. This work was not completed during 1949-50; small cuts were made into the embankments, and pans were used as condensers during the season.

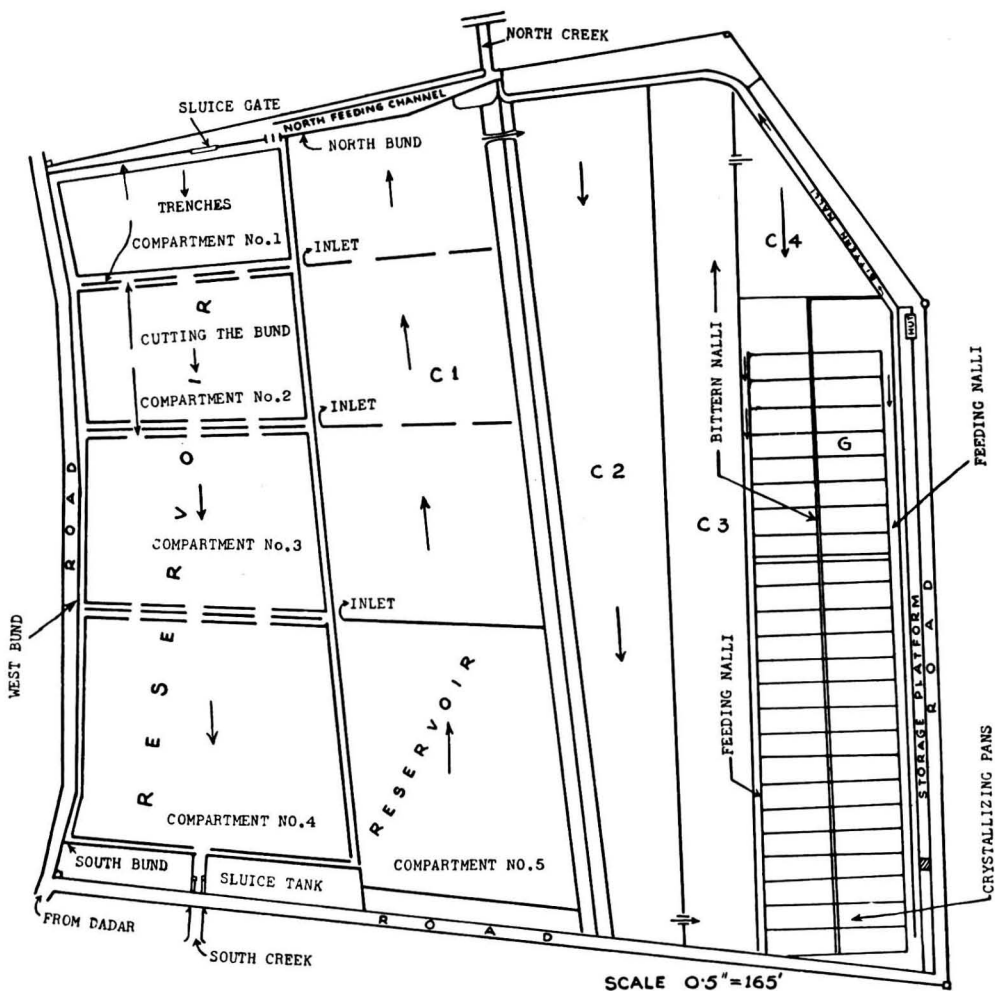


FIG. 1 — EXPERIMENTAL SALT FARM, WADALA.

The embankments not only prevented free flow of brine but diminished the effective evaporating surface also. The embankments have since been removed and the area of 14 acres thus gained has been used to increase the size of the original condenser and the reservoir.

The whole condensing area of 21 acres has been divided into 4 compartments (C 1, C 2, C 3 and C 4 in FIG. 1) of 8.63, 6.5, 4.45 and 1.47 acres respectively. Some of the old pans with a total area of 7.15 acres were remodelled into 48 pans, each 125' x 40'. Only 32 pans have been cons-

tructed this year. The original level of the crystallizing pans was almost the same as that of the condenser; in the new crystallizers the beds have been deepened by 6". The earth thus excavated has been used to strengthen the platform which was washed away during the previous years and was in an unserviceable condition. Hard-bed crystallizers were prepared by tamping the soil.

Method of Manufacture

Sea brine of 2.5°-3°Bé. is admitted into the 5 compartments of the reservoir (R),

where it gets concentrated to 4°-5°Bé. It is then admitted into condenser C 1, divided into 3 compartments, where the density rises to 5°-7°Bé. The brine is led in succession to condenser C 2 (10°-11°Bé.), condenser C 3 (17°Bé.) and condenser C 4 where the density reaches 24°Bé. Two feeding channels supply brine from C 4 to the crystallizing pans. Sufficient brine of 24°Bé. is obtained in about 2 months since the taking in of the first tide.

Two types of salt have been manufactured using the multiple irrigation system : (i) the Kurkutch and (ii) the Baragra salt.

(i) *Kurkutch Salt* — The initial level of 24°Bé. brine in the crystallizers is 2" to 2½" in the beginning of the season and later reaches to 3" to 3½". The brine is allowed to concentrate up to 28°Bé. Fresh brine is admitted from time to time to maintain the concentration of the brine in the pan below 28.5°Bé. The salt which separates out every day is allowed to collect in the pan itself and the crust of the salt formed in this way is hard. After about 6-7 weeks the crust is broken by pick axes or *pavdis*. The salt is then heaped in 3 or 4 ridges in the pan and the bitters drained out through the bittern channel. The salt is lifted to the platform and stored in heaps. The analysis of this salt is given in Table III. It was observed while breaking the crust that the bed of the pan was affected and the salt was slightly coloured. To obviate this, the top layer of the salt was extracted in such a manner that ¼"-½" crust of the salt remained undisturbed at the bottom of the pans. The salt thus extracted was almost free from insoluble matter and was white in colour. The bottom crust left in the pan was removed at the end of the season.

It will be observed that the magnesium salt content of the product obtained is high as it was not properly drained and washed.

TABLE III

	KURKUTCH (1949-50) %	PARTIALLY EXCAVATED KURKUTCH (1949-50) %	PARTIALLY EXCAVATED KURKUTCH (1950-51) %
NaCl	95.60	96.73	97.99
CaSO ₄	0.62	0.50	0.49
MgSO ₄	1.81	0.72	0.72
MgCl ₂	2.30	1.92	0.78
Insolubles	0.15	0.09	...
Undetermined	...	0.04	0.02
Moisture	9.15	7.00	4.61

TABLE IV

	BARAGRA SALT (1949-50) %	PARTIALLY EXCAVATED BARAGRA SALT (1949-50) %
NaCl	95.37	96.75
CaSO ₄	0.82	0.59
MgSO ₄	0.80	0.37
MgCl ₂	2.96	2.23
Insoluble	0.05	0.03
Undetermined	...	0.03
Moisture	5.05	5.00

The output was too large to be drained on the embankment of the pans. The bitters are now being drained out once in 4 weeks, and fresh brine of 24°Bé. is let in. The salt is lifted leaving a crust of ¼" on the bed of the pans. By adopting this procedure the salt gets automatically washed. It is drained on the embankment for 2-3 days and lifted to the platform. The content of magnesium salts has thus been considerably reduced (TABLE III, last column).

(ii) *Baragra Salt* — For the production of Baragra salt, which is manufactured also at Kharaghoda, hard crystallizer beds had to be prepared and deep pans were required to permit a layer of brine 4"-6" deep on the surface of the crystals. The initial level of brine was 3"-4" and the salt was allowed to crystallize for about two weeks. The salt was raked by special wooden rakes and spread uniformly the next day. The process of raking and spreading was continued on alternate days till all the salt was harvested. A small quantity of brine was allowed to flow into the pans continuously and the density of the brine in the crystallizers was maintained below 28° Bé. The level of the brine above the surface of the crystals was 4"-5". Small crystals which were raked every day adhered to each other and formed bigger crystals (½" size) by agglomeration. The bitters were drained out after about 2½ months and the salt removed to the platform. There was, however, no need to break the crust as the crystals were kept loose by raking and spreading. The crystals of Baragra salt produced were not as transparent and as hard as those obtained at Kharaghoda. The analysis of the salt sample is given in Table IV. In this case also a layer of salt ½" thick was left at the bottom and only the top layers were harvested.

The total quantity of salt manufactured during the season 1949-50 was about 31,000 md. out of which 3,000 md. were of Baragra type. The yield compares favourably with that obtained in other salt works in the Wadala circle, with the advantage that the purity of the salt is much higher. The prevailing view that the greater the number of pans the higher is the yield has been shown to be erroneous as the yield has been sustained despite the reduction in the number of pans. Some of the salt manufacturers in Wadala area have adopted the procedure worked out at the model farm.

Cost of Production

The total number of workers engaged during the last season was 15, and the cost of production worked out to As. -/11/3 per md. This is slightly higher than the average cost

of salt of 92-94 per cent purity produced in Wadala circle. Attempts are being made this year to reduce the cost of production. The entire quantity of salt was sold out and the white Kurkutch and Baragra salts had good market demand.

Work in Progress

Experiments were conducted to examine the effect of the addition of Solivap Green on the production of salt. The yield of salt increased by 33 per cent, but the salt produced was coloured. Experiments are being continued this season also with reduced concentrations of the dye.

Attempts will be made to recover gypsum and bittern salts. The quantity of bitterns discharged is too small to be used for the recovery of magnesium chloride, magnesium sulphate and potassium chloride.

Condensation of Saturated Vapours — Part II

K. S. CHARI & B. S. KULKARNI

Department of Applied Chemistry, Osmania University, Hyderabad (Deccan)

IN a previous communication¹, Nusselt's theory of film condensation of vapours was discussed, wherein it was suggested that modifications could be effected in some of the assumptions underlying his theory, which could bring the assumed conditions more in line with those actually present and thus bring the calculated values more in accord with the observed results.

In the present paper, heat transfer mechanism of film condensation on vertical tubes has been discussed with special reference to the temperature of the wall and probable cases have been analysed with formulations of expressions suitable for design purposes. Attempt has also been made to indicate the most probable distribution of temperature on the tube wall under normal conditions of steady heat abstraction.

Consider a vertical condenser tube (FIG. 1) of length L , surrounded by a saturated vapour

at a steady temperature T , and assume that conditions exist for film condensation as by presence of a cold medium inside the tube. Considerations are limited to the vapour side of the wall only and to stream-line flow

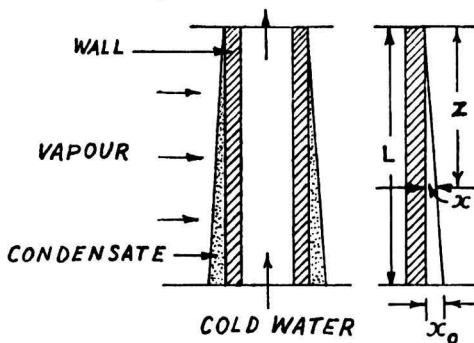


FIG. 1

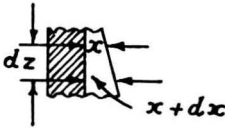


FIG. 2

of the condensate. At any time after the steady state is reached, a steadily flowing layer of condensate is built up on the condenser wall, having increasing thickness in its flow, with no thickness for an infinitesimally small length at the top of the condenser and maximum thickness at the bottom, as explained previously¹.

On a horizontal section (FIG. 2) at a distance z from the top of the tube, where the thickness of the condensate layer is x , and the temperature drop across the layer is Δ , it was shown¹⁻⁴ that the heat transferred, dq , over a differential length dz of the condenser could be evaluated as :

$$dq = \frac{\pi D \rho^2 g \lambda}{\mu} x^2 dx = \frac{k}{x} \cdot \Delta \cdot \pi D dz \dots(1)$$

where,

- D = diameter of the tube,
- ρ = density of the condensate,
- λ = latent heat,
- μ = viscosity of the condensate,
- k = thermal conductivity of the condensate,
- x = thickness of the condensate layer,
- g = gravity constant.

On rearranging the above equation and setting the limits for integration as :

$$x = 0 \text{ when } z = 0, \\ \text{and } x = x_0 \text{ when } z = L,$$

we obtain

$$\frac{\rho^2 g \lambda}{k \mu} \int_0^{x_0} x^3 dx = \int_0^L \Delta \cdot dz \dots\dots\dots(2)$$

Assuming with Nusselt that physical properties of the condensate remain constant, the integration of this most pivotal equation of the whole theory depends on how Δ is expressed in terms of z or, in other words, how the temperature is distributed over the wall with reference to length. No theoretical approach has so far been made to analyse this. Nusselt got over the difficulty by assuming Δ to be constant over the entire length of the tube. As discussed before¹, this assumption is probably correct for very

short lengths of condensers or where the wall is cooled by boiling liquids. For normal condensers, such as those cooled by liquids flowing up or down the tube, where a progressively increasing or decreasing temperature is imposed on the cold side, other probabilities will have to be ascertained, which should, on the one hand, more closely approximate to the actual temperature distribution and, on the other hand, afford a suitable solution of equation (2). Three cases arising out of such probabilities will now be discussed and equation (2) solved.

Case I : The temperature drop Δ is assumed constant (Nusselt) ; case II : the temperature drop is assumed linear with length, so as to give arithmetic mean value of Δ ; and case III : the temperature drop is assumed exponential with length, so as to give logarithmic mean value of Δ .

Case I : The temperature drop Δ assumed constant = Δ_c — For this case, equation (2) is easily solved to obtain Nusselt's familiar equation :

$$\frac{\rho^2 g \lambda}{k \mu} \int_0^{x_0} x^3 dx = \Delta_c \int_0^L dz$$

$$\therefore \frac{\rho^2 g \lambda}{k \mu} \cdot \frac{x_0^4}{4} = L \cdot \Delta_c \dots\dots\dots(3)$$

Substituting for x_0 as :

$$x_0 = \sqrt[3]{\frac{3 \mu \Gamma}{\rho^2 g}} \dots\dots\dots(4)$$

and defining

$$h_m = \frac{\Gamma \lambda}{\Delta_c L} \dots\dots\dots(5)$$

where Γ = peripheral liquid rate of flow, in mass units per unit time per unit wetted perimeter, equation (3) reduces to :

$$hm \left(\frac{\mu^2}{k^3 \rho^2 g} \right)^{\frac{1}{3}} = 1.467 \left(\frac{4 \Gamma}{\mu} \right)^{-\frac{1}{3}} \dots\dots(6)$$

which is Nusselt's equation.

Case II : The temperature drop linear with length — In this case, if the temperature drops at the top and at the bottom of the condenser of total length L are denoted as Δ_1 and Δ_2 respectively, the temperature drop Δ at any point z from the top is given by :

$$\Delta = \Delta_1 + \frac{\Delta_2 - \Delta_1}{L} z$$

Substituting this value of Δ in equation (2), integrating and rearranging as before, we get,

$$\frac{\rho^2 g \lambda}{k \mu} \cdot \frac{x_o^4}{4} = L \Delta_{a.m.} \dots\dots\dots(7)$$

where $\Delta_{a.m.}$ is the arithmetic mean of the terminal temperature drops. It will be seen by comparison that equation (7) is of the same form as equation (3), having $\Delta_{a.m.}$ substituted for Δ_c .

Case III: The temperature drop Δ exponential with the length of the condenser — Expressing for this case

$$\Delta = \Delta_1 e^{\frac{z}{L} \log \frac{\Delta_2}{\Delta_1}}$$

and proceeding as before, one obtains

$$\frac{\rho^2 g \lambda}{k \mu} \cdot \frac{x_o^4}{4} = L \cdot \Delta_{l.m.} \dots\dots\dots(8)$$

where $\Delta_{l.m.}$ is the logarithmic mean of the terminal temperature drops. The equation (8) is again of the same form as equation (3).

The limitations of case I (Nusselt) have already been indicated¹. The other two cases are based on the familiar methods of approximating a mean value when the exact mean value is unknown. The theoretical implications of these cases, however, must be clearly understood. At the extreme top of the tube, the thickness x of the condensate has all along been assumed as tending to zero. Therefore, at the limiting point where $x=0$, a finite value for the temperature drop Δ_1 , with no resistance in between, will mean infinite rate of heat transfer. Such a rate of heat transfer, which must result in condensation, cannot be reconciled with zero thickness of the condensate. Therefore, a finite value for Δ_1 at the extreme top of the condenser in cases I and II is inconsistent with $x=0$. On the other hand, in case III, a zero value for Δ_1 makes the logarithmic mean

$$\Delta_{l.m.} = \Delta_2 - \Delta_1 / \log \frac{\Delta_1}{\Delta_2}$$

imaginary and absurd, unless Δ_1 is assumed arbitrarily to have a value higher than unity.

In view of the above, Δ_1 must be zero when $x=0$ for the cases to be practical. On this basis an important theoretical advance can be made in deducing mathematically the temperature distribution along points on the vapour side of the wall, as all the necessary conditions exist to calculate

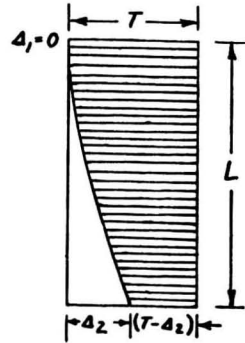


FIG. 3

the value of Δ at any point on the tube for a given length of the condenser and for a given quantity of the total rates of condensation.

Case IV — Consider the condenser in Figs. 1 and 2, of total length L , transferring heat at a steady total rate of Q , with temperature drop $\Delta_1 = 0$ at the top and Δ_2 at the bottom. On any elemental area ($\pi D \cdot dz$), of the condenser the following relations hold (*vide* equation 1) :

$$dq = \frac{\pi D \rho^2 g \lambda}{\mu} x^2 dx = \frac{k}{x} \cdot \Delta \cdot \pi D \cdot dz$$

i.e. each elemental area along the tube is transferring a quantity of heat, through the thickness of the condensate and under the temperature drop present on the area, according to the above equation.

For assessing the distribution of temperature along the tube, the heat transferred over the entire condenser could be imagined as collected by the rise in temperature of an imaginary liquid of specific heat c and initial temperature $(T - \Delta_2)$ flowing past the tube at a weight rate of w , and getting heated to T , without offering any thermal resistance (FIG. 3).

$$\therefore Q = wc [T - (T - \Delta_2)] = wc \Delta_2 \dots\dots(9)$$

On any elemental area,

$$dq = wc d\Delta = \frac{\pi D \rho^2 g \lambda}{\mu} x^2 dx \dots\dots(10)$$

and for the entire condenser,

$$Q = \int_0^{\Delta_2} wc d\Delta = \int_0^{\Delta_2} \frac{\pi D \rho^2 g \lambda}{\mu} x^2 dx \dots\dots(11)$$

$$\text{or } Q = wc \Delta_2 = \frac{\pi D \rho^2 g \lambda}{3\mu} x_o^3 \dots\dots\dots(12)$$

For obtaining a general equation, limits may be set as 0 to Δ and 0 to x respectively, so that

$$\int_0^\Delta wcd\Delta = \int_0^x \frac{\pi D\rho^2 g \lambda}{\mu} x^2 dx$$

or $wc\Delta = \frac{\pi D\rho^2 g \lambda}{3\mu} x^3 \dots\dots\dots(13)$

Substituting for wc from equation (12), we get,

$$\Delta = \frac{\pi D\rho^2 g \lambda \Delta_2}{3\mu Q} x^3 \dots\dots\dots(14)$$

This is a general relationship between Δ and x expressible in terms of known quantities after substitution of the value for Δ_2 as given below. Similarly, from equation (1) and (10),

$$\frac{wc}{\pi Dk} \cdot \frac{x}{\Delta} d\Delta = dz$$

Substituting for x from equation (14), and for wc from equation (12), we get,

$$\frac{Q}{\pi Dk\Delta_2} \left(\frac{3\mu Q}{\pi D\rho^2 g \lambda \Delta_2} \right)^{\frac{1}{3}} \frac{d\Delta}{\Delta^{\frac{4}{3}}} = dz \dots\dots(15)$$

If the equation is integrated between the limits of $\Delta = 0$ and Δ and corresponding limits of $z = 0$ and z , we get,

$$\frac{Q}{\pi Dk\Delta_2} \left(\frac{3\mu Q}{\pi D\rho^2 g \lambda \Delta_2} \right)^{\frac{1}{3}} \int_0^\Delta \frac{d\Delta}{\Delta^{\frac{4}{3}}} = \int_0^z dz$$

or $\frac{3Q}{\pi Dk\Delta_2} \left(\frac{3\mu Q}{\pi D\rho^2 g \lambda \Delta_2} \right)^{\frac{1}{3}} = z \dots\dots(16)$

which gives a general relationship between Δ and z at any point, after substituting the value of Δ_2 in known quantities.

The value of Δ_2 in known quantities is obtained by integrating equation (15) over the entire length L , thus :

$$\frac{Q}{\pi Dk\Delta_2} \left(\frac{3\mu Q}{\pi D\rho^2 g \lambda \Delta_2} \right)^{\frac{1}{3}} \int_0^{\Delta_2} \frac{d\Delta}{\Delta^{\frac{4}{3}}} = \int_0^L dz$$

or $\frac{3Q}{\pi Dk\Delta_2} \left(\frac{3\mu Q}{\pi D\rho^2 g \lambda} \right)^{\frac{1}{3}} = L$

or $\Delta_2 = \frac{3Q}{\pi DLk} \left(\frac{3\mu Q}{\pi D\rho^2 g \lambda} \right)^{\frac{1}{3}} \dots\dots(17)$

Combining equations (14) and (16), one obtains :

$$\Delta^{\frac{1}{3}} = \frac{\pi Dk\Delta_2 z}{3Q} \left(\frac{\pi D\rho^2 g \lambda \Delta_2}{3\mu Q} \right)^{\frac{1}{3}} = \left(\frac{\pi D\rho^2 g \lambda \Delta_2}{3\mu Q} \right)^{\frac{1}{3}} x$$

or $\pi Dk\Delta_2 z = 3Qx \dots\dots\dots(18)$

which is a general relationship between x and z at any point on the tube, expressible in Q and L , after substituting for Δ_2 .

As the temperature drop over the length of the tube varies according to equation (16) from $\Delta = 0$ to $\Delta = \Delta_2$, a mean value Δ_m can now be obtained as :

$$\Delta_m = \frac{1}{L} \int_0^L \Delta dz \dots\dots\dots(19)$$

Substituting for Δ , we get,

$$\Delta_m = \frac{1}{L} \int_0^L \frac{(\pi D)^4 \rho^2 g \lambda k^3 \Delta_2^3 z^3}{(3Q)^4 \mu} dz$$

$$= \frac{(\pi D)^4 \rho^2 g \lambda k^3 \Delta_2^3 L^3}{4(3Q)^4 \mu}$$

which, on substitution for Δ_2 , reduces to :

$$\Delta_m = \frac{3Q}{4\pi DNk} \left(\frac{3\mu Q}{\pi D\rho^2 g \lambda} \right)^{\frac{1}{3}} \dots\dots\dots(20)$$

From the above mathematical analysis of the wall temperature, important deductions could be drawn and summarized as follows :

For any vertical condenser condensing saturated vapours with film-type condensation under steady conditions :

(a) the thickness of the condensate layer on the tube varies *linearly with length* of the condenser and not as one-fourth power of the length as deduced by Nusselt ;

(b) the temperature drop across the condensate layer varies as the *third power of length*. It will also be clear that instead of assuming a mean value of the temperature drop, the mean value as well as the temperature drop at any point on the vapour side of the wall can now be *calculated* if the total quantity of heat passing through the wall and the length of the wall are known ;

(c) the mean value of the temperature drop is one-fourth the value of the temperature drop across the condensate layer at the bottom of the condenser ;

(d) for various condensers with a given heat flux (Q), the mean value of the temperature drop varies inversely as the length and for condensers of a given length, the mean temperature drop varies as $4/3$ power of the heat flux ;

TABLE I

Liquid oxygen at -297.4°F .; density = 71.1 lb./cu. ft. ; viscosity = $0.46 \text{ lb./(hr.) (ft.)}$; thermal conductivity = $0.1205 \text{ B.T.U./hr. (sq. ft.) (}^{\circ}\text{F./ft.)}$; latent heat = 91.7 B.T.U./lb. ; acceleration due to gravity = $4.18 \times 10^8 \text{ ft./hr.}^2$; $D = 0.0521 \text{ ft.}$; $L = 1.31 \text{ ft.}$

No.	HEAT FLUX, $\frac{Q}{\text{B.T.U./hr.}}$	Δ_m OBSERVED, $^{\circ}\text{F.}$	Δ_m CALCD. $^{\circ}\text{F.}$	$\frac{\Delta_m \text{ OBS.}}{\Delta_m \text{ CALCD.}}$
1	44.9	0.15	0.1629	0.917
2	53.6	0.25	0.2593	0.966
3	81.4	0.30	0.3603	0.835
4	110.3	0.37	0.5400	0.686
5	125.7	0.62	0.6430	0.966
6	143.2	0.73	0.7639	0.956
7	170.3	0.94	0.9636	0.975
8	201.2	1.24	1.2040	1.030
9	206.7	1.29	1.2480	1.033
10	239.1	1.58	1.5160	1.042
11	242.9	1.55	1.5470	1.001
12	273.7	1.76	1.8140	0.971
13	308.1	2.04	2.1250	0.961
14	384.8	2.61	2.8580	0.916
15	428.0	2.97	3.2940	0.903
16	555.0	4.47	4.6580	0.961

(e) considering Δ_2 , Q and L of equation (17) and Δ_m , Q and L of equation (20) as variables for different condensers, the equations can be used for design purposes if any two of the three variables are independently known.

For the verification of the above analysis such data from literature has to be selected as will conform to the conditions of condensation assumed in the above derivations. Such sets of data have been recently published⁵ for heat transfer from condensing oxygen and nitrogen vapours on vertical surfaces. The surface temperature of the tube ($15\frac{3}{4}$ " long, $\frac{5}{8}$ " o.d. and $\frac{3}{8}$ " i.d.) was obtained from the arithmetic mean of the four thermocouple readings. The observed values of the mean temperature drop across the film of condensate of oxygen vapour is shown in Table I.

In order to calculate the mean value of the temperature drop by using the equation (20), the physical characteristics of liquid oxygen at the mean condensate temperature are required, besides values of the heat flux, Q . Reliable values for the density of liquid oxygen at -297.4°F . have been given by Kammerling *et al.*⁶ The values for the viscosity of liquid oxygen are given by a number of workers⁷⁻⁹; however, the values as given by Rudenko⁷ appear to be more reliable and hence are used in the verification. For thermal conductivity of liquid oxygen, the values as reported by Hammann¹⁰ and the required latent heat data as published in literature¹¹ have also been utilized.

The published data, given in metric units, had to be converted to English units for employing them in these calculations. The converted data is shown on the top of Table I.

Using the results of Haselden *et al.*⁵ and making use of the physical data given at the top of Table I, the mean temperature drop across the condensate film was evaluated, using equation (20). The results so calculated are given in Table I, which compare favourably with the observed values. The last column in the table gives the ratio $\Delta_m \text{ obs.}/\Delta_m \text{ calcd.}$ and in most of the cases, the ratio is very nearly equal to unity. Barring the readings No. 3 and 4, which vary considerably from the calculated results, the rest of them show a remarkable agreement with the observed values. Leaving the two readings which fall out, the mean value of all the readings given in the last column is 0.971 instead of unity.

A similar procedure was adopted for evaluating the mean wall temperature for the case of condensation of nitrogen vapour on the same condensing surface using the results of Haselden *et al.*⁵. The physical characteristics were obtained from the published data. The values of density of nitrogen were obtained from literature¹¹. The data for the viscosity of liquid nitrogen at the boiling point are published by Rudenko⁷ only. Since his results for the viscosity of oxygen appeared more reliable than the data published by others, his results for nitrogen were also accepted as satisfactory. Values for the thermal conductivity of liquid nitrogen have been reported both by Hammann¹⁰ and also by Borovik *et al.*¹², but, by comparison of the methods adopted, it appeared that the apparatus used by Hammann was less subject to error⁵ and hence his results were used. The latent heat data are taken from the International Critical Tables. The physical data, after correction and conversion to English units, are given at the top of Table II.

The observed results of Haselden *et al.* have been compared with the calculated values using equation (20) and have been shown in Table II. Although the agreement is not as good as in the case of the results on condensation of oxygen, the error involved is well within the limits tolerated for all the experimental work of the type undertaken by Haselden *et al.*

TABLE II

Liquid nitrogen at -300.4°F .; density = 50.5 lb./cu. ft. ; viscosity = $0.3824 \text{ lb./ (hr.) (ft.)}$; thermal conductivity = $0.12 \text{ B.T.U./ (hr.) (sq. ft.) (}^{\circ}\text{F./ft.)}$; latent heat = 85.7 B.T.U./lb. ; $g = 4.18 \times 10^8 \text{ ft./ (hr.)}^2$; $D = 0.0521 \text{ ft.}$; $L = 1.31 \text{ ft.}$

No.	HEAT FLUX, $\frac{Q}{\text{B.T.U./hr.}}$	Δ_m OBSERVED, $^{\circ}\text{F.}$	Δ_m CALCD., $^{\circ}\text{F.}$	$\frac{\Delta_m \text{ OBS.}}{\Delta_m \text{ CALCD.}}$
1	59.3	0.27	0.286	0.977
2	99.1	0.59	0.568	1.037
3	157.6	1.09	1.054	1.033
4	218.3	1.74	1.629	1.067
5	292.6	2.79	2.406	1.155
6	367.8	3.74	3.264	1.144
7	425.0	4.23	3.959	1.118
8	460.6	4.92	4.398	1.118
9	473.8	5.27	4.575	1.150
10	539.6	6.22	5.442	1.142

The remarkable agreement between the observed and the calculated values lends much support to the new analysis of film condensation presented in this paper. The analysis has further attempted to give a clearer picture of the mechanism of heat transfer than what was so far available and has clearly defined the contours of the various important variables.

Summary

The heat transfer mechanism of film condensation of saturated vapours is discussed. Limiting considerations only to the vapour side, expressions suitable for design purposes have been derived, assuming the transfer of heat from the vapour to the cooled surface to be by pure conduction and the temperature drop across the film of condensate to be

(1) constant, (2) linear with length and (3) exponential with length.

A new mathematical approach to the problem of condensation of vapours is made, which enables evaluation of the variation of the thickness of the condensate layer and the distribution of the temperature along the length of the tube, lending a method for the evaluation of the mean temperature of the wall. The mean temperature so calculated is verified from recent experimental data available.

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Cellulose Pulp in Inorganic Chromatography

SCHWAB AND JOCKERS¹ APPLIED THE TECHNIQUE of chromatography for inorganic analysis, using alumina for the adsorption of inorganic ions. The use of cellulose as an adsorbent is more recent and it has found application in the separation and purification of inorganic compounds. Cellulose pulp from Whatman ashless tablets has been employed in the Chemical Research Laboratory, Teddington, for the separation of uranium from other metals².

Cellulose pulp obtained by treating absorbent cotton with dilute nitric acid (5 per cent, v/v) has been successfully employed in these laboratories as a substitute for pulp from Whatman tablets. Comparative

studies with solutions containing (UO_2)⁺⁺, Fe^{+++} , Cr^{+++} and Cu^{++} using the pulp prepared in this laboratory and Whatman pulp have confirmed the suitability of the former for chromatographic work.

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M. M. SINGH

National Chemical Laboratory
Poona
January 29, 1951

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Food Processing & Preservation— Some Recent Developments

M. N. MOORJANI & D. S. BHATIA

Central Food Technological Research Institute, Mysore

FOODS can be preserved by canning, dehydrating, smoking, salting, pickling, refrigerating, and by incorporating preservatives. With the growth of the urban population and the rise in standards of living of the people, the demand for preserved and processed foods has increased, and food technologists have developed new techniques of processing which ensure in the preserved materials not only all the nutrients but also the flavour, texture and appearance of fresh foods.

Freezing

The quality, flavour, colour and vitamin content of most frozen foods is superior to that of foods preserved by other methods; freezing is likely to become the most important method of food preservation.

Considerable research in the freezing of pre-cooked foods had been carried out before the war, but it was during the war, when the shortage of metal became acute, that attention was diverted from canning to freezing. The advantages of freezing pre-cooked foods are saving in labour and time for servicing and saving in space for transport by rail and air.

Frozen Fruit Juices — A freezing process for concentrating citrus juices has been developed by *Florida Citrus Cannery Co-operative*, Lake Wales, Florida, U.S.A.¹, and a low temperature evaporator of unusual efficiency has been designed. Water is evaporated from deaerated citrus juices in a tubular heat exchanger, utilizing the heat obtained during the compression of ammonia. The water vapour is condensed in a second tubular heat exchanger by the cooling resulting from the evaporation of liquid ammonia. Concentration of the juice is effected under high vacuum and low temperature (50°-70°F.). This is followed by blending with unconcentrated juice, slush freezing, canning and hard freezing at 0°F. The fruit product has a high vitamin C content and an excellent flavour.

A unique food freezer with an output of 1.5-2 tons per hour has been developed by the *Food Machinery Corporation of U.S.A.*², which automatically and continuously freezes food in domestic size cartons.

Freeze concentration developed by the *Commonwealth Eng. Co. of Ohio, U.S.A.*³, has been successfully applied to a wide variety of fruit juices including those of apple, cherry, grape-fruit, lime and orange. The separation of water as ice is controlled in such a way that a clean separation of ice and concentrate is brought about and the nutritive and aromatic constituents are retained in the juice concentrate.

Freeze Drying — In this process⁴, the product is frozen, and the separated ice is sublimed rapidly under high vacuum. The labile substances are unaffected and the material does not harden or suffer any other adverse change. Citrus juices, meat, meat products and many other foods can be dried and stored with advantage by this method.

Dehydro Freezing — The space and weight advantages of dehydrated products with the quality retention of frozen ones are combined in a new process developed by Howard and Campbell⁵. The removal of about two-thirds of the water present in the foodstuff is followed by freeze storage, resulting in a product which is easy to reconstitute. The process has been applied to peas, carrots, asparagus, cherries, apricots and potatoes.

Dehydration

Spray drying is unique for two reasons: The drying time is brief — generally a few seconds — and, due to the rapid evaporation of water, the solids are not heated to a high temperature. These are important considerations in the processing of heat-sensitive foods.

Compression — The volume of dried fruits, vegetables, eggs, soups and flours can be reduced to about 60 per cent their original

volume without injury to the product or deterioration in quality by compression⁶. Storage characteristics are likewise unaffected.

Cooking & Sterilization

Dielectric Heating — The use of dielectric heating has been proposed for the pasteurization of milk⁷, wines⁸ and beer⁹, and for the thawing of frozen foods¹⁰, sterilization of bread¹¹ and blanching of vegetables¹².

Radar Energy — Raytheon Manufacturing Co. of Waltham, Mass., U.S.A., have developed a radar oven with a magnetron tube, generating microwaves at a frequency of 3,000 megacycles with a power input of 2,000 watts, which can raise the temperature of relatively small quantities of food (2 lb. or less) from room temperature or -10°F . to 140°F . in a minute or less depending on the weight, thickness and type of material. Radar cooking overcomes the possibilities of nutritional losses which occur during the conventional methods of cooking. Proctor and Goldblith¹³ have applied radar energy for baking cakes, cooking meat and fish and for blanching vegetables.

Electronic Sterilization — X-ray irradiation offers a means of sterilizing foods. The penetrating electrons of ultra-short duration emitted from a capacitron^{15,16} have been utilized for sterilizing a wide range of medicinal preparations and foodstuffs.

The Van de Graaff electrostatic generator, rated at 3 million volts constant potential, delivers high energy Roentgen rays and cathode rays which can be used for sterilizing foods. Dunn *et al.*¹⁷ indicated the possibility of sterilizing fluids continuously by exposure to the electron beam from an Van de Graaff generator for a predetermined period. Proctor and Bhatia¹⁸ have indicated the possibility of sterilizing lean fish fillets by cathode-ray irradiation without loss of amino acid content.

Electronic sterilization has found wide application in the pharmaceutical industry, but its application to the food industry is still limited. Irradiation imparts a "radiation taste" to certain foods which is not desirable.

Preservation with Antibiotics

Anderson and Michner at the *Western Regional Research Laboratories*, Albany, California, U.S.A.¹⁹, have suggested a preservation treatment for foods which may revolutionize the current canning practice. The treatment consists in (a) the destruction of non-spore-forming bacteria, yeast, fungi and enzymes by mild heat treatment; and (b) the destruction of spore-forming bacteria with mild heat and subtilin or other antibiotic, singly or in combination. The cooking time is shortened, the need for pressure-heating equipment is eliminated, and the quality of the food is maintained. Preliminary trials have shown that foods with subtilin and mild heat remain in a good condition for several months. The method is still under investigation.

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Metallization & Electroplating of Wood, Glass & Plastics

S. K. ROY & B. C. KAR

National Metallurgical Laboratory, Jamshedpur

PROCESSES for the electrodeposition of metals have been developed and extensively adopted in art and industry. Methods for the deposition of metals on non-metals have not, however, attained a comparable stage of commercial success. The problem of metallization has attracted considerable attention as success in this field would help conservation of metals. Further, by virtue of the high corrosion resistance of metallic coatings on non-conducting materials, metallized articles would find numerous applications in industry.

For the electrodeposition of metals on a non-conductive substance, the surface of the latter must be rendered conductive. Wood is usually graphitized and glass and plastics are metallized as a preliminary to electroplating.

Conducting Coatings

The articles, after cleaning and degreasing, are coated with an adhesive over which a conducting layer of graphite¹, copper², lead, silver or bronze is applied. Lacquers, varnishes, turpentine oil, bees-wax and road pitch thinned by turpentine oil have been employed as adhesives. Wooden articles are polished and varnished twice or thrice with turpentine oil and powdered graphite applied uniformly over the surface with a camel hair brush. Metal powders are mixed with shellac or cellulose lacquers and sprayed over the surface. The conducting coating is then electroplated with copper, the copper deposit serving as an intermediate coating for top finish with other metals. The composition of the copper bath and the operating conditions are:

Copper sulphate	160-250 gm./litre
Sulphuric acid (sp. gr. 1.88)	40-75 gm./litre
Current density	20-25 amp./sq. ft.
Anode	Copper
Voltage	2-4 volts
Temperature	25°-30°C.

Nickel, silver, chromium, etc., may be deposited on the copper coat by using standard plating baths.

Film Coating by Reduction

Narcus³ developed a process for the deposition of silver films on plastic surfaces by applying the reducing action of formaldehyde on ammoniacal silver nitrate. The preliminary treatment of the surface for ensuring adherent films has been discussed. Among the reducing agents available, only a few have proved useful for practical application. These include: invert sugar, dextrose, lactose, formaldehyde, acetaldehyde, tartaric acid and sodium potassium tartrate, and amino alcohols. Silver nitrate solution (40 gm./litre) is mixed with excess of ammonium hydroxide to obtain a clear solution. The article to be silverized is dipped in the solution and formaldehyde (40 per cent) added, the temperature being maintained at 22°-25°C. The deposition of silver is complete in half an hour. Articles thus silvered are withdrawn from the bath, washed with water and dried. Copper is then deposited on the surface for which purpose two acid baths have been employed:

I

Copper sulphate	160 gm./litre
Free sulphuric acid (sp. gr. 1.88)	2 c.c./litre
Current density	18-20 amp./sq. ft.
Anode	Copper
Voltage	2-3 volts
Temperature	25°C.

II

Copper sulphate	250 gm./litre
Sulphuric acid (sp. gr. 1.88)	12 c.c./litre
Current density	14-15 amp./sq. ft.
Anode	Copper
Voltage	2-3 volts
Temperature	25°C.

The copper-coated surface is buffed and electroplated with the desired metal by standard procedures.

Sodium hydrosulphite⁴ has been used as reducing agent for the deposition of copper from cuprammonium salt. To obtain good results the pH of the solution is maintained at 8-9 and the temperature at 24°-28°C. The film deposited on glass is found to be less adherent than that on plastics. The conducting copper film is rinsed with water, washed with alcohol and dried. Different metals are then deposited according to standard methods.

Deposition of silver and copper films on wood surfaces has not proved satisfactory in practice as the metallic films do not adhere firmly to the surface. Graphite coating gives uniformly satisfactory results.

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2. CARDIAND: *Trans. Electrochem. Soc.*, 1944, **85**, 97.
3. NARCUS: *Trans. Electrochem. Soc.*, 1945, **88**, 371.
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Non-Technical Notes

ORANGE OIL

ORANGE OIL IS USED FOR FLAVOURING CONFECTIONARY, for perfuming soaps and tobacco and as an ingredient for eau-de-cologne. The raw material required for extracting the oil, viz. fresh orange peel, is available at fruit processing factories. The improved sponge process developed by the Council of Scientific & Industrial Research is simple, efficient and suitable for adoption in factories engaged in processing oranges. Orange oil has a ready market within India.

The peel of Nagpur oranges contains c. 1.85 per cent oil and that of Coorg oranges, 2-3 per cent. Using the improved sponge process, it is possible to extract from Nagpur orange peel, a high grade oil in a yield of 1.45 per cent. An inferior oil can be obtained from the residue by steam distillation.

Equipment

A mincing machine, two sponges, a few enamelled buckets and basins, and separating funnels are the items of equipment required. The total cost of equipment is estimated not to exceed Rs. 1,500.

Production Cost

The production cost of the oil is determined by the availability and price of orange peel.

The price of peel at Nagpur was, recently, Rs. 2 per md. and this has been taken as the basis in calculating costs.

Hand-pressed Oil

	Rs.	as.	p.
1 md. orange peel @ Rs. 2/-			
per md.	2	0	0
Labour	5	0	0
Recurring expenditure	0	8	0
TOTAL	7	8	0

Yield of oil, 1.1 lb.

Cost of oil per lb., Rs. 7/1/-

Steam-distilled Oil from Residue

Residue after hand pressing			
Fuel	1	0	0
Labour... ..	1	0	0
TOTAL	2	0	0

Yield of oil, 0.3 lb.

Cost (approx.) of oil per lb., Rs. 6/11/-

Sun-dried peel, soaked in water and minced to a pulp, yields on steam distillation 4-6 per cent oil on the weight of the peel. The cost of production of oil by this process is approximately Rs. 5/8/- per lb. The oil is somewhat inferior to that obtained by the sponge process.

REVIEWS

SCHIMMEL ANNUAL REPORT ON ESSENTIAL OILS, AROMATIC CHEMICALS AND RELATED MATERIALS, 1947-1948 (Schimmel & Co. Inc., New York), 1951, pp. 125. Price \$3.25

The latest Schimmel Report covering the two years 1947 and 1948 is a valuable record of research and technical developments in the field of essential oils and aromatic chemicals.

The Report remains essentially unchanged from the previous issues in the presentation of contents. The alphabetical arrangement has been retained and this would be helpful to those using the work for reference. One departure, which will be welcomed, is the inclusion of a brief foreword to the Essential Oils section drawing attention to the more outstanding developments covered. A paragraph of similar intent opens the section dealing with Research on Aromatics.

It is interesting to note that, in spite of considerable activity in the synthesis of aromatic materials and the wide use of such products, interest in natural essential oils has by no means abated and some of the most interesting items in the book deal with investigations of new oils. For instance, one item deals with the essential oil from the leaves of *Clausena anisata*. The oil contains 75 to 90 per cent anethol, and it can be used in place of aniseed oil for many purposes, although the odour is somewhat different. Another development in this category is the oil from goldenrod (*Solidago odorata* Ait.). This oil can be produced economically on a commercial scale, and used in place of anise oil with which it resembles both in flavour and odour. The unabated interest in natural volatile oils has been repeatedly brought home to the reviewer in his extensive literature search in connection with the compilation of the Dictionary of Indian Raw Materials & Economic Products.

Some of the items relating to research on the chemistry of essential oils which appear in this Report may be mentioned here. Nerolidol, a sesquiterpene alcohol which is valuable for use in perfumery,

was found to be the principal constituent of cabreuva oil. This is one of the rarer essential oils obtained from the wood of *Myrocarpus* species found in Brazil.

The parent substance of the essential oil of garlic was isolated and identified as a new amino acid containing a sulphoxide group. This amino acid is converted by the enzymes in garlic to allicin, the antibacterial principle of garlic. Loss of an atom of oxygen transforms allicin into diallyl disulphide which is the main constituent of garlic oil.

Jasmone, a ketone which is familiar as a constituent of the oil of jasmine, was found to occur in peppermint oil from *Mentha piperita*. The superior odour of this type of peppermint oil in comparison with *M. arvensis* (Japanese peppermint) oil is attributed to the presence of jasmone and of menthofuran, neither of which is present in the oil of *M. arvensis*.

An epoxide of caryophyllene, which was isolated from clove oil, proved to be identical with a sesquiterpene oxide previously found in lavender oil. It was demonstrated that caryophyllene present in clove oil does not occur as such in the clove buds but is formed during the steam distillation of the oil.

Research on the synthesis of perfume materials included two investigations of unusual interest—one on the synthesis of the irones occurring in extracts of orris root, and the other on the development of the acyloin condensation into an efficient method of ring closure for the synthesis of large ring ketones having a musk odour. Muskone, which has a methyl group on the ring, and civetone, which contains a double bond, were synthesized by this method in addition to the series of simple macrocyclic ketones.

The Report is rich in interest and maintains the thoroughness which characterized its predecessors. The illustrations are varied, well chosen and handsomely reproduced, lending additional interest to a well turned out volume. Every one seriously interested in the field of aromatic chemicals would welcome this Annual Report.

CELL PHYSIOLOGY AND PHARMACOLOGY, by J. F. Danielli (Elsevier Publishing Co. Inc., London), 1950, pp. viii+156. Price \$3.00

One of the famous physiologists of the late nineteenth century, Prof. Pavlov, emphasized the need for the study of "cell" physiology, as distinguished from "organ physiology", then studied by most workers in the field. Since then, many outstanding contributions have been made both in the basic sciences and in the biological sciences so that we, in the middle of the twentieth century, are coming to realize more and more that the underlying characteristics of life are of a colloid chemical nature, that the structure of the matter for most vital processes is not the relatively gross structure of cells, nucleus, chromosomes, etc., but the fine structure of protein, molecules, protein or polysaccharide chains, enzyme complexes or membranes. The whole concept of life phenomenon in its protean manifestations, and of the modifications that can be brought about in them by external stimuli and drug actions are undergoing vital changes. At this time, both for the teacher as well as the researcher in the field of cell physiology and pharmacology, a book of the type presented by Prof. J. F. Danielli would be most welcome. It is undoubtedly a very worth-while presentation and to the reader most thought-provoking.

Based upon lectures given at University College, London, the author has given very stimulating examples and arguments on cell physiology and pharmacology in six readable chapters entitled: (1) Cell as a Physico-chemical Unit, (2) Possible Actions of Drugs on Surfaces, (3) Membrane Permeability and Drug Action, (4) Enzymes and Drug Action, (5) Action of Narcotics and (6) Responses of Cells on the Biological Level. It is not possible to bring out all the fine arguments marshalled by the author in offering explanations regarding the nature of drug actions of various types but, as a pharmacologist interested in these fields, the reviewer can say with confidence that many a research investigator in cell pharmacology would certainly find lots to make him think seriously on some of his own problems and might offer some acceptable and plausible explanations for his own data which could not otherwise be explained by him. All

workers on cell physiology and pharmacology would agree that the subject is extremely complicated and that many more man-hours should be devoted to biological research of this type which aims at unravelling the very fundamentals of interaction of a drug with a "cell", rather than to purely chemical research, as is frequently directed towards synthesis of compounds supposed to have biological activity based only on similarity of chemical structure. The reviewer also agrees with the author when he postulates that when more is known about the fundamental biology of the cell and its reaction to known stimuli, "the hit or miss technique, which is now the main basis of the search for new drugs, will be eliminated. For chemists this will mean much diminution of effort — probably 90 per cent or more of time used for synthesis of useless compounds can be eliminated. And for biologists, there will be a corresponding diminution in the time spent in testing inactive compounds."

That the book will be welcome to the research worker, there can be no doubt. In view of the increasing attention now being centred towards the elaboration of new drugs and in view of the large number of researchers in these fields, the book can also be considered an appropriate and timely publication. Many senior workers had been looking for the type of material now available in this book for years and they will certainly appreciate Prof. Danielli's commendable efforts in the borderline field of physical chemistry and biology. All workers in the field of cell physiology, biochemistry and pharmacology should possess this book in their personal or institutional library. The format is good and the subject and authors index and the references at the end of each chapter provide ready access to other literature for elaborate study.

B. MUKERJI

HANDBOOK OF BROADCASTING, by Waldo Abbot (McGraw-Hill Book Co. Inc., New York), Third Edition, 1950, pp. xi + 494. Price \$5.00

This is an expanded and completely rewritten edition of the well-known textbook on broadcasting first issued in 1937, the second edition of which was published in 1941. A comparison with the second

edition will indicate the extent of new ground opened up during the last decade in the field of radio, which has made this third edition, as claimed by the publishers, a completely new text-book. The consciousness that radio is constantly developing through new ideas and inventions pervades the work, and impresses the reader in every chapter; when the work was first written fourteen years ago, and even when reissued four years later, radio had been synonymous with amplitude modulation, but the present edition has had to explain the fundamentals of frequency modulation, facsimile broadcasting, television and a host of other innovations, all of them now well established in their own right.

A book of this range could not succeed without a clearly formulated objective and a determined pursuit of it at every stage. The book is not for the radio technician; it asserts and goes on to prove in most convincing detail that broadcasting is a serious and highly specialized profession, requiring in the student a background of basic information about every aspect connected with it. The profession itself cannot be taught only by text-books and lectures, but by actual experience before the microphone. For a study of broadcasting in the United States, these specifications have been more than amply fulfilled in this work. The author has disclaimed any intention to editorialize or to evaluate broadcasting as a social force; enough, however, has been gathered into the compass of the work to show that the responsibilities cast on the user of the medium and the problems of administration would remain basically the same in all types of mass communication which are democratic in approach.

The structure of broadcasting in the United States, having been built entirely by private enterprise, has not been described with precision sufficient to carry the distinction to readers familiar with conditions in other parts of the world. American law courts decided that transmission of intelligence was commerce, and authority for the establishment of the Federal Radio Commission in 1927 was derived from the Constitution which confers on Congress the right to regulate commerce. The Communications Act of 1934, which established the Federal Communications Commission, enunciated the principles that

the air shall be public property, radio industry should be privately owned and operated and free speech on the air should be preserved. The general and loosely held belief that there is no censorship of any kind over broadcasting in the U.S.A. would bear examination even for students in America. It deserves to be better known that the right of a station to go on the air is a privilege granted by license, contingent on the proof that operation is in the public interest, convenience and necessity; refusal of licenses for lack of satisfactory assurances could, and does, operate as censorship of a kind. The voluntary code drawn up by the National Association of Broadcasters and the effort to standardize certain taboos, represent an endeavour towards self-regulation which, in effect, tend to the same results as in public service broadcasting. Commercial enterprises utilizing advertising media appeal to basic human instincts like self-preservation, ambition, personal pride, search for pleasure, etc.; but public good-will depends on the merchant assuming the rôle of public benefactor. Such residue of commercial interest as may be left in the programme output is disregarded (and sometimes even eliminated with the aid of special gadgets), as experience has shown. "Fairness" in presenting opposing view points is now made a condition for operating radio stations; before the F.C.C. reversed its earlier "Mayflower" decision in June 1949, editorial views had been prohibited altogether.

The selling effectiveness of commercial radio cannot be tested unless the extent to which sales would not have been made otherwise could be isolated. An industrial economy based on mass-production techniques would depend for continued prosperity on the goods being absorbed as fast as they are produced; it should always remain a question whether commercial radio was the product of salesmanship following mass production or itself made possible such rapid industrialization. There were 2075 AM, 744 FM and 92 TV stations on the air in 1949. 429 million dollars were realized from sales of time. The purchasing power of the entire audience has been estimated at 8,000 million dollars. Figures for 1949, compiled by O. H. Caldwell, estimated the number of radio sets in use at 81 millions,

compared to 74 millions in 1948. In 1947, 35,000 full-time employees drawing an aggregate of 2½ million dollars a week were working in radio stations, and it is believed that at present nearly a million would be employed in TV stations alone.

The universal availability of broadcast material too makes it an article of mass production; when the material is employed to sell goods and to run down competition, mass advertising techniques have had to be evolved. Market and consumer research has been organized to a great degree of elaboration as the sole link now left between the individual buyer and the manufacturer. The book under review has not dwelt on this aspect of commercial radio, and the methods of studying potential and listening audiences and the effectiveness of time sales for the advertiser; the publications listed for reference under the chapter "Radio and T.V. Advertising" include reports on opinion research, but an examination of some of the methods devised by the Schwerin Research Corporation, C. E. Hooper Inc., NRI, Pulse Inc., the National Opinion Research Centre, The Broadcast Measurement Bureau, etc., for quantitative and qualitative analysis of the audiences shared by various networks and the rating of programmes would have given completeness to the picture of a highly developed system of broadcasting.

As a description of broadcasting in U.S.A., the reader would also have appreciated some statistical data about the principal networks and their affiliates, as on the date of publication. In 1948, 36 per cent of the stations were affiliated with newspaper interests, and this link American broadcasting has had with the Press would also have deserved attention in a handbook so comprehensively planned.

As a work presenting the specialized aspects of radio as a profession, the handbook has rendered invaluable service to the student as well as to the listening public. Radio speakers the world over would profit by the lessons on speech so effectively presented. It is time the platform speaker learnt that there is no place for orations in the living room of a home, and the microphone exposes insincerity and platitude. It should be a humiliating thought that a decision not to listen is an absolute vote

cast in private. The Lazarsfeld Report on Opinion Research observed that radio cannot be complacent, for the radio of tomorrow will be the radio of today's critic. The handbook affords indication of directions in which broadcasting practice is apt to rest content with imperfections, e.g. in acoustics, recordings, announcing, etc. The valuable exposition of programme building, the problems created by domestic audiences of all wealth brackets at various hours of the day in rural and urban areas, and the avoiding of excessive or selective appeal, in a mass approach to every individual listener as an entity—would repay careful study. The chapter on law as it affects broadcasting, though mainly confined to libel and copyright, suggests interesting side issues like the conflict of laws, when a publication or performance which is broadcast can be heard in several States. The estimate of radio as a vocation will remain valid for all parts of the world; radio cannot be looking for persons who make excuses, and the candidate is advised to subordinate all other interests to the job, at least until he has outlived his period of usefulness to radio.

The high standards associated with all works issued by the publishers have been maintained in the handbook; this edition has incorporated carefully selected photographs which would enhance the interest of the general reader.

G. T. SASTRI

LEITFAEHIGKEIT UND LEITUNGSMECHANISMUS FESTER STOFFE (CONDUCTIVITY AND CONDUCTION MECHANISM IN THE SOLID STATE), by E. Justi (Verlag Vandenhoeck & Ruprecht, Goettingen), 1948, pp. xii + 348.

The conduction of electricity in solid substances forms the basis of the whole of electro-technology. The process of conductivity has been interpreted only recently even though its applications have been in existence for a long time. Theoretical interpretations have been possible because of the study of the atom structure.

The book is a lucid record of the lectures delivered by the author, based on his experimental investigations which are in accord with contributions made by other scientists. The themes are developed chronologically and illustrated by experiments and diagrams

and concluded off with the mathematical treatment of the problems.

The first part of the book explains the nature of electrical conduction with the help of numerous experiments and subsequent evaluation of the validity and limits of Ohm's law, the variation of metallic ions, thermionic oscillation, changing pressure, temperature and magnetic field. In parts two and three are described the relation between the electric conductivity and other physical properties of metals and then are discussed the thermo-electric effects and applications of thermo-elements. In the fourth part, the phenomena of conductivity are treated in the light of the electronic theories. In the fifth and sixth parts are treated the fundamentals of electric current transmission, the mechanism involved by the passage of the current through crystal rectifiers and semi-conductors. Part seven deals with the phenomenon of supraconductivity, the course of the electric resistance of pure metals and alloys near the absolute zero point. This part includes a description of experiments with continuous current and of an apparatus for continuous current constructed by the author. Up to now the phenomenon of supraconductivity could not be explained satisfactorily; perhaps the electronic theory of Heisenberg may bring a new understanding of this problem. However, it is remarkable that while the theory is still undeveloped, it has found an application in the construction of a bolometer, an apparatus which excels in highly sensitive radar equipment.

The last part deals with the photo-conductivity and the theories involved in it. It also deals with the conductivity of ions in solids and the problem connected with direct conversion of thermionic into electric energy.

To each part is added an index comprising the literature up to date. As is mentioned in the preface by M. V. Lañe, the book will find many admirers.

J. GIDEON

MATERIALS OF CONSTRUCTION FOR CHEMICAL PROCESS INDUSTRIES, by James A. Lee (McGraw-Hill Book Co. Inc., New York), First Edition, 1950, pp. vii + 468. Price \$ 6.50

The book has been written in a distinctive style. The processes of manufacture have been taken in alphabetical order. They have

been described briefly and, in most cases, flow sheets have been given. Materials of construction necessary for each item of equipment — pipings, pumps, etc. — have been mentioned, but no details have been provided except in the case of processes for the manufacture of acetic acid, chlorine, sulphuric acid, phosphoric acid, and a few others. Methods of fabricating equipment with different materials of construction have not been dealt with. The process of fabrication is important as many plant manufacturers have difficulty in handling stainless steels and monel in this country. Many processes described in the book have not been put into industrial operation in India, and the special materials mentioned will have to be imported from abroad.

The book can be recommended to all chemical engineers, industrial chemists and plant and equipment manufacturers concerned with rational utilization of materials of construction.

H. L. ROY

Publications Received

PRINCIPLES OF PHASE EQUILIBRIA, by F. E. W. Wetmore & D. J. Le Roy, McGraw-Hill Book Co. Inc., \$ 3.50

NEW ADVANCES IN PRINTED CIRCUITS, U.S. Department of Commerce, 40 cents

PROPERTIES OF LUBRICATING OILS & ENGINE DEPOSITS, by C. A. Bouman, Macmillan & Co. Ltd., 15s.

TEXT BOOK OF QUANTITATIVE INORGANIC ANALYSIS, by Kolthoff & Sandell, Macmillan & Co. Ltd., 30s.

SOURCEBOOK ON ATOMIC ENERGY, by Samuel Glasstone, Macmillan & Co. Ltd., 24s.

WORLD POWER CONFERENCE (SECTIONAL MEETING), Central Board of Irrigation, Rs. 25 per set, Re. 1 per paper

FIRST CONGRESS ON IRRIGATION & CANALS, Central Board of Irrigation, Rs. 15 per set, Re. 1 per copy

FOURTH MEETING OF INTERNATIONAL ASSOCIATION FOR HYDRAULIC RESEARCH, Central Board of Irrigation, Rs. 12 per set, As. -/12/- per paper

PROBLEMS IN PHYSICAL CHEMISTRY FOR ADVANCED STUDENTS, by Y. G. Kele, G. B. Kolhatkar & R. G. Jag, Dastane Bros. Home Service Ltd., Rs. 5

ESSAY IN PHYSICS, by Albert Einstein, Basil Blackwell, Oxford, 7s. 6d.

NOTES & NEWS

Vacuum Fusion Furnace

RELIABLE VACUUM FURNACES ARE essential in the study of gases present in metals. A new vacuum furnace developed at the *Bell Telephone Laboratories* is specially suitable for the study of small samples of metals of the order of 1 gm. (*Bell. Labs. Record*, 1951, 29, 18). Accurate results have been obtained for continuous runs for periods as long as 6 hr. at temperatures varying from 2,400° to 2,650°C.

A clear quartz tube, 2" outside dia. and 6.5" long, is suspended from two glass hooks by means of platinum wires inside a 3" Pyrex glass envelope. Inside the tube is a graphite crucible supported in the vertical position by graphite powder loosely packed to aid in retaining the heat generated in the crucible and to permit the free flow of gases to be pumped out. An opening at the bottom of the 3" Pyrex glass envelope provides access for inserting and removing the quartz tube and is fitted with a glass plug. A glass disc attached to the plug acts as a heat shield and provides additional protection in case of spattering molten metal. Samples of the metal to be studied can be admitted to the crucible without interfering with the vacuum. A branch tube leading off at right angles to the vertical tube connects with a group of closed tubes, in which as many as 10-12 samples may be stored. With the aid of a magnet, ferrous samples can be moved from the storage tubes to the crucible. Non-ferrous samples are placed in cups of magnetic material; they can be made to discharge their load into the crucible by manipulating the magnet.

This design of the all-glass furnace eliminates massive metal details, quartz to metal or quartz to glass joints, rubber or lead gaskets, the use of cements for attaching dissimilar materials and also provision for radiation yields, ceramic supports and water cooling. Besides it is simple yet easy to construct, assemble, dismantle and clean.

To operate the furnace, the crucible is first "out-gased" by

applying high frequency power and heating the empty crucible to 2,400°C. for 2 hr. Removal of gases is accomplished with a two-stage mercury diffusion pump coupled to a high-speed mechanical pump.

Identification of Rubbers

THE APPLICATION OF X-RAY diffraction methods to the identification and study of natural and synthetic rubber stocks is discussed in a recent paper (*ASTM Bull.*, 1951, No. 171, 71).

The investigations include the following applications: (1) Film techniques for the identification of solid compounding ingredients for subsequent use in qualitative analysis of rubber stock patterns; (2) film techniques for qualitative identification of representative rubber types; (3) film techniques for the quantitative estimation of crude and reclaimed rubber mixtures; and (4) Geiger counter spectrometer techniques for the qualitative identification of representative rubber types.

The powder method of X-ray diffraction analysis was used in these studies. The pattern of the rubber stocks, prepared for the determination of the compounding ingredients, were obtained by centering a small strip of rubber in the camera. The sample is rotated continuously during the exposure to assure randomization of reflecting planes and consequently smooth diffraction rings. A visual comparison of the rubber stocks and compound ingredient patterns was made to determine which of the compounding ingredients could be detected in the rubber stocks. A comparison of six commercial compounding ingredients, namely *Palletex (SRF)*, *Micronex, P-33 (FT)*, *Philblack A*, *Statex B* and *Thermax*, indicated that they are all nearly similar, being low-crystallinity carbon.

To determine the optimum conditions for clear identification, diffraction patterns for representative rubber stocks under various combinations of stretching and low temperature ageing were investigated. At room temperature, *Hevea*, *GR-M* and *GR-I*

produce fibre patterns on stretching, and the patterns can be readily differentiated from one another. Ageing and freezing of *Hevea* stock produces a pattern containing sharp diffraction rings similar to the type produced by randomly oriented crystalline materials. In the case of *Thiokol FA*, a fibre pattern is obtained by either ageing, stretching, and freezing or stretching at room temperature and freezing. While the fibre patterns obtained for *Thiokol FA* and *GR-M* are similar, they may be differentiated by considering the conditions necessary to produce them. *GR-S* and nitrile rubbers did not yield characteristic patterns under any of the conditions of treatment.

The results obtained on the X-ray spectrometer indicate that the six stocks considered in this test can be made to yield distinctive patterns when examined in the stretched condition. This is accomplished through consideration of the location, intensity, breadth, and shape of the characteristic reflections of the different stocks. Traces run on the six cold-resistant stocks showed the characteristic rubber reflections similar to the standard types.

Results on the semi-quantitative estimation of constituents in mixtures of crude and reclaimed rubbers indicate possibilities of extending X-ray diffraction applications to mixtures of other representative rubber types.

Further, problems which could be investigated by X-ray diffraction methods include: (1) quantitative determination of mixtures of the several rubber types with a view to setting up working curves to be utilized in the analysis of unknown mixtures; (2) establishment of combined X-ray diffraction and optical emission spectroscopy techniques for the quantitative analysis of compounding ingredients, and (3) determination of crystallinity induced as a function of elongation and relaxation under various conditions for representative rubber stocks and mixtures.

Radioactive Indicators for Blast-furnace Refractory Wear

A METHOD IS DESCRIBED TO detect brick wear in blast-furnace refractories using radioactive isotopes emitting strongly penetrating γ -radiations.

The wear is determined in two ways: (1) a pellet of radioactive

material is inserted in the refractory sufficiently near to the shell for the radioactivity to be detected outside the furnace, the cessation of this activity would indicate that the refractory has been worn away. (2) If the position of the refractory is too far from the shell of the blast-furnace to make detection through the wall practicable, conditions can be arranged so that, when the refractory wears away, the exposed pellet dissolves in the iron and can be detected when the iron is tapped. Both methods are now being used in England. Seventeen pellets have been installed in four furnaces; positions chosen include behind the stack armouring, in the stack 15' below the stockline, in the stack at linted level, in the brickwork between slag and metal notch, and in the tap-hole roof.

A γ -source is considered most suitable and "cobalt 60" has been chosen. With a half-life of 5.3 years, it emits γ -rays of 1.1 and 1.3 million electron volts (m.e.v.) and has a high excitation cross-section. Besides, it has a high melting point and alloys easily with iron. Portable or mains-operated counters are available to detect the radiations emitted.

Calculations show that an activity of 10 m.c. can be detected through 2' of firebrick or carbon, 6" of ramming and $\frac{1}{2}$ " of mild steel plate shell. For every extra 6" of brick, the source should be trebled so that 90 m.c. would be necessary if 3' of firebrick or carbon is used.

Certain problems arise in choosing suitable containers for cobalt pellets to make them stay in position. Ideally, they should be impervious to gas penetration and cobalt vapour, and yet should disintegrate quickly when in contact with molten slag or metal. Experiments using cobalt in unsealed alumina crucibles in a carbon brick indicate that cobalt pellets may remain in sufficient quantity for adequate detection for a number of years (provided the brickwork remains intact), when placed in unsealed alumina crucibles in the hotter regions of blast-furnace brickwork.

A Sheet-galvanizing Unit

A SMALL GALVANIZING UNIT, HOLDING about 6 cwt. of zinc, has been constructed at the British Iron & Steel Research Association Observatories to study the various

aspects of the hot-dip galvanizing of sheets. The construction of the unit has been described (*J. Iron & Steel Inst.*, 1951, 167, 46).

The pot and the parts of the unit including the side gears are made from dead soft steel to minimize alloying action. The pot is welded from $\frac{3}{4}$ " thick steel. Ordinary low-carbon steel sheets are used for the flux box as they are cheap and easy to replace. Six sheet speeds, viz. 6, 9, 15, 18, 27 and 40 ft./min., are obtained using a three-speed gear-box and sprocket driven by a 3 h.p. motor. Lower speeds give better coating distribution.

For heating the pot, gas burners with flames impinging obliquely on heat-resisting steel sheets, hung at the sides and front between the gas flames and the pot, are used. This avoids local overheating of the pot.

Sheets galvanized in this plant have been examined for coating, distribution, structure, and adhesion. The standard size of sheet used is 30" \times 7 $\frac{1}{2}$ ". Bent strips up to 20' long and the same width have also been successfully treated.

Gas Turbines

THE PAPERS PRESENTED AT THE symposium on High-temperature Steels and Alloys for Gas Turbines, organized by the British Iron & Steel Institute (Feb. 21-22, 1951), are of interest to India especially in view of the importance attached to the development of gas turbine units in this country. The progress of metallurgical research during the last decade was surveyed during the symposium, and some of the papers disclosed hitherto unpublished results.

The development of alloys capable of withstanding high temperatures has rendered possible the use of high operating temperatures and thereby increased the overall efficiency of turbines. Data on high temperature properties of Nimonic-80, G-18-B, R-20, H-40, H-46 and many other steels and alloys of importance to gas turbines, were presented. It may be of interest to note here that G-18-B made by *W. Jessop & Sons* is the material used in Derwent machines one of which is to be installed at the Indian Institute of Science, Bangalore. A new alloy, Jessop G-32 which is a cobalt-base alloy, is fully ageing in the temperature range of 750°-800°C.

Certain chromium-base alloys possessing excellent properties in the range of 900°-1,000°C. have been developed, but their ductility at room temperature is low and further research is called for to obtain a material with improved properties.

The problems of high temperature oxidation and formation of scale on turbine blades were discussed in detail.

The use of ceramics for turbine blading was considered, and the necessity for research to improve the ductility and resistance to thermal shock was emphasized.

Other notable developments to which attention was drawn during the symposium were: The lost wax process for precision casting of nozzle guide vanes; application of centrifugal casting and centrifugal die-casting methods to gas turbine work; fabrication methods for heat-resisting and creep-resisting steels and alloys.

One of the papers presented at the symposium dealt with Sweat Cooling for cooling turbine parts. The cooling fluid is forced through the pores of the component parts.

Sir Frank Whittle delivered a stimulating lecture on Turbine Problems in the Development of the Whittle Engine. Sir Frank reviewed the work on jet propulsion and the Whittle Engine to the development of which he has made notable contributions.

M. L. GHAI

Indian Coal for Synthetic Petrol

THE RESULTS OF INVESTIGATIONS on the location and reserves of second and third grade coals suitable for the manufacture of synthetic petroleum undertaken by the Geological Survey of India in 1949 have been published in the form of a report (*Bull. Geol. Surv. India*, Series A, No. 1, 1950). The objective was to locate coal of a particular grade, which could be cheaply and rapidly mined by open cast methods in sufficient quantity to produce 1 million tons of oil annually for at least 30 years. A further requirement was a supply of water at the localities selected for the establishment of synthetic oil plants; the quantity of water required is about 20 times the coal mined. Adequate transport facilities for coal by road, rail or river have to be assured. Four areas were selected for detailed exploration.

It is estimated that for manufacturing one million tons of synthetic oil, an annual supply of about seven million tons of both coking and non-coking varieties of the second and third grades of coal (with ash content varying from 17 to 25 per cent) which could be economically mined by open quarrying methods, would be required over a period of at least 30 years.

Two sites were provisionally selected — one near Ondal in the Raniganj coalfield and the other near Ramgarh which is centrally situated in respect to the Bokaro, Ramgarh and Karanpura coalfields. In the Toposi-Jambad-Kajora and Dudal areas in the East Raniganj coalfield, several coal seams suitable for quarrying have been selected. These seams have a maximum thickness of 40', have low angles of dip and the ash content of the coal varies from 12 to 20 per cent. The reserves of coal up to overburden thrice the thickness of the seams are over 200 million tons. In the eastern portion of the Bokaro coalfield, seams up to a thickness of 100' have been observed while in the western part, the thickness seldom exceeds 35'. The dip varies from 5° to 20°. The coals are of both coking and non-coking varieties and the ash percentage is between 15 and 30. The reserves are estimated at over 200 million tons. In the Ramgarh coalfields some of the coal seams are over 50' thick and the angle of dip varies from 5° to 15°. The coals are of the non-coking type and vary in quality; the reserves are of the order of 55 million tons. In the Karanpura coalfield, the seams are up to 50' thick, the angle of dip varies from 10° to 25° and the ash content is between 11 and 33 per cent. The reserves total about 100 million tons.

The problem of transporting large quantities of coal can be solved by taking out railway sidings from the railway lines passing through or near the coalfields. In the Ondal area, the proposed aerial ropeways for supplying sand for stowing could be used on the return journey for transporting coal. A sufficient supply of water will be available in the East Raniganj coalfield throughout the year from the Damodar river when dams have been constructed. The water supply position in the Bokaro, Ramgarh and Karanpura coalfields

has to be assessed from a survey of the catchment area.

From the information collected and presented in the report, the establishment of a synthetic oil plant in the Ondal area appears to be a practical proposition. In the Bokaro, Ramgarh and Karanpura coalfields, the possibilities of erecting either one central plant at a site suitable from the point of view of raw materials and water supply or several smaller plants in different coalfields, can be stated only after assessing the water resources of these areas.

Coal-tar Creosote as a Wood Preservative

THE ANNUAL PRODUCTION OF creosote by continuous distillation of tar in India now amounts to about 3,500 tons. Scientific data on Indian creosote necessary for evaluating its usefulness as a wood preservative are not available. The Forest Research Institute initiated, 8 years ago, researches in Indian creosote, and the results of laboratory and service tests collected so far have been incorporated in an interim report (*Bull. No. 144, Studies on Coal-tar Creosote as a Wood Preservative*, Price Rs. 3-14). Data on physico-chemical constants, accelerated service tests, field trials, toxicity, permanence (physical and chemical stability) and penetrating powers of various grades (low and high boiling oils with and without tar acids) of creosotes and creosote-fuel oil mixtures have been included. *Sal* (*Shorea robusta*) saplings were used for the accelerated service tests and *sal* sleepers, for field trials. *Sal* sapwood blocks were used for toxicity tests, *Polystichus sanguineus* being the test fungus.

The sleepers were treated by the Full Cell and Open Tank processes. A few sleepers were also treated by the Lawry process; for the treatment of billets, the Rueping process was also employed. The average absorption of the preservatives by the different groups of sleepers varied from 1.2 lb./cu. ft. to 9.7 lb./cu. ft. The highest absorptions were noticed in half-round sleepers which also had the highest sapwood content, followed by sapwood rectangular sleepers; the heartwood had the best absorption. In billets, the average absorption obtained was 21.8 lb./cu. ft. and the average minimum, 3.1 lb./cu. ft.

Toxicity tests showed that (a) heavier creosotes and heavier creosote fractions are more toxic and permanent; (b) it is not necessary to set limits to the presence of tar acid in creosote specifications. A determination of the surface tensions of creosotes, distillation fractions and mixtures, and investigation into the swelling of *semul* (*Bombax malabaricum*) blocks (2"×1"×1") impregnated with creosotes showed that the presence of tar acids in creosote does not facilitate penetration. The heavier creosotes are more permanent. Oxidation tests indicated that besides tar acids, other unsaturated compounds influence the benzol insoluble contents of creosotes.

Accelerated service tests show that heavier creosotes and creosote fractions give good results; in most cases 75:25 and 50:50, creosote: fuel oil mixtures give the best results. This confirms the soundness of the practice of using creosote-fuel oil mixtures in this country. The practice of using 50:50 mixtures is a sound one as there can then be sufficient latitude in the specification.

Treated sleepers installed in both wet and dry localities are in satisfactory condition at the end of 9 years; the rejection is 1 per cent in the wet localities and 6 per cent in the dry localities. Half-round sleepers have shown no rejections.

Cotton Colorimeter

A NEW AUTOMATIC COTTON COLORIMETER for use in cotton quality specification has been developed in the laboratories of the U.S. Department of Agriculture (*Text. Res. J.*, 1951, 21, 33). The instrument is intended to serve as an aid in cotton classification.

The colorimeter is based on the application of the Hunter colour and colour-difference meter to problems of raw cotton measurement. It is self-standardizing; it permits direct reading on a two-dimensional scale, measures automatically and shows values graphically and simultaneously for reflectance and yellowness in a range of 40-90 per cent *Rd* and 0 to 20 units of $+b$ (*Rd* and *b* are Hunter's co-ordinates). The cotton grade diagram used on the instrument is based on measurements of standards passed at the 1946 International Grade Standards Conference and in effect

since August 1947. The grade of cotton is determined by the colour of the fibre, amount and kind of foreign matter, and roughness or smoothness of ginning preparation. Colour measurements of cotton samples are made on the basis of the composite appearance of the sample. For cotton already carefully selected for use in the standards, measurements of either the colour or the amount of foreign matter in a sample permit an accurate prediction of its grade.

The new instrument has been used in the grades standard work for a series of cottons carefully selected to represent a normal combination of colour, leaf and preparation for the grade each represents. The specimen to be examined is placed over the sample window and the operator steps on a foot switch. Two indicators under the chart diagram move to a position of balance automatically, one in a vertical direction to indicate the change in reflectance of the sample, *Rd*, the other in a horizontal direction to indicate a change in degree of yellowness of the cotton, *+b*. Since a chart of the colour of the grade standards appears on the glass panel, the operator can check a test sample against a particular position within each grade and then pass or reject it on the basis of a comparison of results with the position of the standard indicated on the instrument chart.

It is emphasized that the instrument is only an aid to the classifier; it cannot replace him. It sees the average colour of whatever appears on the face of the sample placed on its sample window. If the conditions under which a sample is tested are not the same each time, the measurements should not be compared. The colour range of the instrument described is selected for cotton only; however, the underlying principles are completely adaptable to use for other limited ranges of colour in either two or three dimensions.

Activation of Bauxite

A DETAILED STUDY OF DEHYDRATION and activation of bauxites is described (*Chem. Age*, 1951, **64**, 175).

Elimination of water in American bauxites (mainly gibbsite and hydrargillite varieties or the trihydrate) is effected in three stages: the first at 200°-250°, the second at

250°-300°, and the third at 450°-480°C. X-ray examination of diasporite (α) and boehmite (γ) varieties indicated that as a result of water elimination, diasporite yields exclusively α - Al_2O_3 and boehmite γ - Al_2O_3 . Decomposition of boehmite starts at 450° and is complete at 600°; further transformation of γ - α of the oxide begins at 900° and finishes at 1,150°. The presence of impurities or inclusions in the alumina lattice structure involves appreciable differences in the effects of thermal treatment.

Samples of clear bauxite from Cussano Murto and red bauxite from Dragoni (Italy) were analysed. Both were of the boehmite variety and differed mainly in their iron oxide content which, chiefly as hematite, was present in large amount in the red Dragoni type. Dehydration was found to take place at about 480°C. The resulting oxide was γ variety which only at a temperature above 900°C. changed into the α form. Dehydration was accompanied by vigorous and substantial swelling with consequent high porosity, increase in specific area and adsorbent power.

Iron-constantan Thermocouples

THE TEMPERATURE-EMF TABLES for thermocouples issued by the Bureau of Standards, U.S.A., from time to time, have been used extensively in science and industry, not only to convert thermocouple voltages into the equivalent measured temperatures, but also in the preparation of purchase specifications for thermocouple wire and in defining the relation between impressed emf and scale reading for pyrometers. In practice, the calibration of an individual thermocouple is ordinarily given in terms of deviations from such a reference table. These reference tables do not present an accurate data of commercially available thermocouples. A new reference table to achieve greater uniformity and accuracy has been proposed (*N.B.S. Tech. News Bull.*, 1950, **34**, 174).

The Bureau examined eight different lots of matched iron and constantan wires. The thermal emf's of the various wires versus platinum were measured from 32° to 1,800°F. and the corresponding thermal emf's for the iron-constantan thermocouples were computed. Besides, chemical and

spectrographic analyses of the iron samples and hardness determinations were made. The spread in the thermal emf's of the iron-constantan thermocouples below 1,400°F. was not large compared to usual commercial tolerances even though the iron samples differed among themselves by as much as 0.8 millivolt at 1,400°F. (equivalent to 20°F. in the indication of an iron-constantan thermocouple) and the constantan samples differed similarly. The new table is proposed to be based upon the temperature-emf relation of thermocouple A-1 as this thermocouple deviates least from the 1913 table in the range of normal use (32° to 1,500°F.).

Before adopting the table, the Bureau invites comments from the interested parties with special reference to the following: The desirability of industry-wide standardization on a single reference table for iron-constantan; acceptance of the 1913 table or a close approximation to it, for this purpose and the inconvenience resulting from the abandonment of the RP 1080 table. The comments may be addressed to the National Bureau of Standards, Temperature Measurement Section, Washington 25, D.C.

Permeability of Leather

THE ABILITY TO TRANSMIT WATER vapour is one of the important and desirable properties of leather in shoe manufacture. A new method used at the *U.S. National Bureau of Standards* (*Tech. News Bull.*, 1950, **34**, 163) to determine the amount of water vapour that will pass through a leather sample in a given time is described. The method is a modification of the approved procedure of the American Leather Chemists' Association.

A water vapour permeability cell consisting of a circular aluminium cup with a flange is used. The cup is filled with the desiccant (CaCl_2) and the leather sample made to fit tightly into a raised rim on the edge of the cup. A circular copper template is then fitted directly over the cup. Molten microcrystalline wax is poured around the groove formed by the template and the flange and the copper template are removed when the wax has hardened. The complete cell is hung in a cabinet maintained at the desired relative humidity and temperature. By a

special mechanism, the cell is weighed at definite intervals without removal from the cabinet. The slope of the resulting curve, indicating the increase in weight of the cell with time, gives the water vapour permeability of the sample in gm. per sec. sq. cm. of the exposed area.

The test takes only 6 hr. as against 4 to 5 days required in the A.L.C. procedure and gives more accurate results. Observations indicated that the water vapour permeability of leather depends upon a number of factors including thickness of sample, grease content and the relative humidity and temperature of the atmosphere. It is greatly reduced by the presence of natural glyceride greases. There is no correlation between water vapour permeability and air permeability.

Studies with sulphonated oils, rubber and acrylate resins treated leathers showed that the materials decrease water vapour permeability in the following order of increasing magnitude: sulphonated oils, acrylate resins, rubber and the glyceride greases. Flexing of the specimen has no influence on the water vapour permeability of degreased leathers; for leather containing grease, there is an increase in water vapour permeability on flexing.

“ The Metal Market Review ”

THE THIRD ANNUAL NUMBER (1951, price Rs. 5), in its 36 informative article, surveys the developments in the Indian metallurgical industry. In the context of the shortage of metals caused by stockpiling by the nations of the world, India's mineral resources and their planned utilization demand special attention. “ The Metal Market Review ” has rendered valuable service by drawing attention to the immediate and long-range problems of the ferrous and non-ferrous industries.

The Review is divided into six sections, each dealing with a primary topic, discussed under appropriate sub-heads by specialists. The number is copiously illustrated and neatly got up.

“ Directory of International Scientific Organizations ”

A DIRECTORY OF INTERNATIONAL Scientific Organizations providing essential information and intended

for the use of specialists has been published by UNESCO.

The Directory, which covers 240 pages, groups international organizations under three chapters—basic sciences, applied sciences and miscellaneous. The applied sciences are subdivided to cover agricultural, engineering and medical sciences. Under “ miscellaneous ” are to be found such bodies as the International Union for the Scientific Study of Population, the International Federation of Library Associations, and the International Scientific Film Association.

At the end of each chapter, and under the heading “ Regional ” are listed organizations whose activities are limited to a particular geographical area.

The following particulars are given under separate headings: aims of each organization and information on its special activities; governing bodies, officers and members; member states or national organizations and individual members; commissions set up within certain organizations with details of their work; special facilities of certain organizations such as laboratories and museums; financial resources; frequency of meetings of the organizations or of their governing bodies; provisions governing voting procedure; list of periodicals and documents published; relations with U.N. Specialized Agencies and international bodies; a brief history of the organization—origin, meetings held, work carried out, formation of committees, etc.; information such as date and place of forthcoming congresses, programme of action, etc.

The Directory is published in English and French and is priced \$1.00, 6s. or 300 francs.

Purchase of Scientific Materials & Films

THE GOVERNMENT OF INDIA HAVE agreed to allow import, without a licence, of certain items of scientific materials and scientific films, ordered with the UNESCO Scientific Material Coupons and UNESCO Film Coupons. These coupons are on sale from the Ministry of Education, Government of India, New Delhi. The S.-E. Asia Science Co-operation Office, New Delhi, has also a supplementary stock of the two types of coupons. The coupons are usable like the UNESCO Book Coupons and

orders are to be placed with manufacturers and distributors participating in the scheme.

“ Vacuum ”

THE NEW QUARTERLY, “ VACUUM ”, will be warmly welcomed by scientists all over the world. It is a journal with a purpose, and is devoted to a field of research and development whose importance has increased during the recent past, and is increasing at an accelerated pace. It is the first English periodical devoted to developments in vacuum research and engineering.

The first number which appeared in January 1951, gives an idea of the manner in which *Vacuum* serves the research worker. Authoritative articles by vacuum specialists in all parts of the world keep the reader in touch with the latest vacuum procedures employed with success in various arts and sciences. The comprehensive abstracts of vacuum work compiled from world publications by a specialized abstracting organization and the detailed classification index facilitate early reference and permanent recording. The research worker, is thus assured that the literature on the use of vacuum, so important in science and industry, now found scattered in periodicals devoted to fields as diverse as engineering and pathology, is made available to him in a classified and indexed form.

The journal is published by Messrs W. Edwards & Co. (London) Ltd., England, and the annual subscription is £1 10s.

“ Bombay Technologist ”

THE “ BOMBAY TECHNOLOGIST ” (Vol. I, February 1951) is the first issue of the official organ of the Department of Chemical Technology, University of Bombay. Started in 1934 as a small section, the Department of Chemical Technology has now come to occupy a unique position as a research centre for advanced chemical technology. The Department receives substantial financial support from the Government, the industry and various statutory bodies including the Council of Scientific & Industrial Research.

The “ Bombay Technologist ” will, among other things, feature the annual reports of the Technological Association, summaries of

lectures delivered under its auspices and of papers read in the research colloquium, and abstracts of M.Sc. Tech. and Ph.D. theses. We congratulate the Technological Association on undertaking the publication of the "Bombay Technologist", and wish the Association every success in its endeavour.

Announcements

International Conference on Atomic Energy — A conference represented by about 20 countries including Australia, Canada, France and the U.S.A. will be held at Oxford from July 16 to 21, 1951 to discuss applications of radioactive isotopes in industry, medicine and agriculture, and for the exchange of information on the beneficial uses of atomic energy.

The Royal Institute of Chemistry: Bangalore Section — At the Second Annual Meeting of the Bangalore Section of the Royal Institute of Chemistry, held on 5th April 1951, the following office-bearers were elected: Chairman, Prof. K. V. Giri; Vice-Chairmen, Mr. H. Shiva Rao and Dr. C. V. Natarajan; Hon. Treasurer, Mr. I. S. Patel; Hon. Secretary, Dr. T. L. Rama Char.

UNESCO Coupons — The validity of all UNESCO Coupons (for books, films and scientific material) has been extended for an indefinite period. All coupons at present in circulation, irrespective of their date of issue, will remain valid until such time as UNESCO recalls them by public announcement, allowing a 6-month interval for the return of the coupons.

UNESCO has now issued a new comprehensive coupon, which can be used for the purchase of publications, films, and scientific material, and which will replace the old "book", "film" and "scientific material" coupons. The same validity terms are applicable to all coupons at present in circulation, irrespective of their date of issue.

Prize for Mohwa Seed Decorticator — The Indian Central Oilseeds Committee has announced a prize of Rs. 2,000 for the design of a hand-driven decorticator for mohwa seed suitable for use in villages. The capital cost of

the machine should not exceed Rs. 100. Competitors will be required to demonstrate the working of the machine. Full particulars may be had of the Secretary, Indian Central Oilseeds Committee, Jamnagar House, New Delhi.

WHO Awards — The Darling Foundation Committee of the World Health Organization have awarded the Darling Foundation Prize jointly to Prof. H. T. Shortt and Dr. P. C. C. Garnham of London for their work on the life-cycle of the malaria parasite in man and the monkey.

Prof. René Sand of Brussels has been nominated for the L'œon Bernard Foundation Prize as a pioneer medical philosopher, historian and teacher. Prof. Sand has devoted his life to promoting the philosophy and practice of human ecology and is the author of authoritative publications on the subject.

Canadian Scholarships — The Government of Canada have offered 25 scholarships and fellowships to Indian students under the technical co-operation scheme of the Colombo Plan for training and research in agriculture, civil, electrical, mechanical and chemical engineering, geology, forestry, hydro-development, social security and welfare, and education.

The selection of candidates will be made by the Ministry of Finance, Department of Economics Affairs, Government of India.

Exhibition Scholarship — The 1951 science research scholarship of the value of £350 per annum announced by the Royal Commissioners for the London Exhibition of 1951, has been awarded to Shri Kamla Kant Pandey, Research Scholar at the Indian Agricultural Research Institute, New Delhi. The scholarship which is tenable for two years is awarded each year to an Indian student for research studies in science in the U.K.

Errata

This Journal, 1950, 9B, No. 2, February 1950, article entitled "Studies in the Chemotherapeutic Derivatives of Acridine Series: Part I — Some Derivatives of 2-

iodo-7-methyl-9-substituted Aminoacridine", page 27, R.H. column, line 4, for 2-methoxy-5-iodo read 2-methoxy-6-iodo; page 29, L.H. column, line 14, for 5-iodo-N-*p'*-methylantranilic acid read 5-iodo-N-*p'*-methyl phenylantranilic acid; 1951, 10B, No. 4, April 1951, "Part III — Synthesis of Some Derivatives of 3-Methoxy-7-iodo-9-aminoacridine", page 85, R.H. column, line 7, for γ -diethyl-amino, read δ -diethyl-amino; line 21, for δ -diethyl-amino, read γ -diethyl-amino; line 26, for (C₈H₉O₇N₃), read (C₈H₉O₇N₃)₂; line 28, for di-*n*-propyl aminopropyl, read γ -di-*n*-propyl aminopropyl; line 35, for γ -di-*N*-butyl-amino, read γ -di-*n*-butyl amino.

1951, 10B, No. 4, April 1951, article entitled "Colorimetric Determination of Phosphorus in Coal & Coke Ash", page 87, interchange the legends to Figs. 1 and 2.

1951, 10B, No. 4, April 1951, note entitled "South Indian Tannage — Use of Myrobalan", page 99, R.H. column, line 22, for 40° Bé, read 40° Bk; page 100, L.H. column, Table I, for before tanning, after tanning, read before myrobing, after myrobing.

1951, 10B, No. 4, April 1951, note entitled, "Liquid Phase Production of *p*-Cymene from Indian Turpentine Oil of *Pinus longifolia* (Roxb.) & Δ^3 -Carene", page 100, Table I, column 5, "Volume of reaction mixture M", last line: for 7.5, read 17.5.

1951, 10A, No. 4, April 1951, article entitled "Possibilities of Iron & Steel Making in India without Coking Coal", page 161, L.H. column, line 29, for were used for direct steel production, read were used as feeders for direct steel production. R.H. column, line 15, for A slag quantity of 1,690-1,800 lb., read A slag quantity of 1,600-1,800 lb. Page 163, Fig. 4, inside captions, top, for slag volume per ton of lumps about 2866 lb. ton of lumps, read slag volume per ton of lumps about 2,866 lb., bottom, for slag volume per ton of lumps about 4189 lb. ton of lumps, read slag volume per ton of lumps about 4,189 lb. Page 164, L.H. column, line 3, for is attractive, read are attractive. Page 165, References: No. 15, for Fechn. read Techn.; No. 20, for 63, read 163; No. 22, delete III, Np; No. 23, for 114, read 21.

Progress Reports

RADIO RESEARCH COMMITTEE, COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH

THE RADIO RESEARCH COMMITTEE WAS CONSTITUTED IN 1942 BY THE COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH WITH THE FOLLOWING OBJECTS:

(1) To discuss and formulate plans of research as under:

- (a) Investigation of problems of immediate practical importance for development of radio industry in India on a sound basis.
 - (b) Synoptic studies of atmospheric phenomena as affecting radio wave propagation, e.g. atmospherics, ionosphere, etc.
 - (c) Investigations of a fundamental nature as may have long-range application to radio development.
- (2) Maintain a list of institutions in India where radio researches are being carried out and to keep record of their activities and available facilities.

(3) Distribute the problems decided upon [as in (1)] to such institutions as are capable of and are willing to co-operate with the work of the Committee and to generally see that there is no unnecessary duplication of work.

(4) To arrange for testing and standardization of radio products.

A brief account of its activities is given below:

1. *Carbon Microphones*: Prof. S. K. Mitra & Dr. H. Rakshit — Investigations have been carried out on the production of suitable carbon granules from anthracite, Jharia coke and petroleum coke; the last was found to be the best. Granules selected to pass 60-80 mesh were heated to a high temperature for 3 hr. in a vacuum furnace. The compressibility, specific resistance and temperature coefficient were studied. Microphones constructed from the granules prepared in the laboratory were found to be satisfactory, except that the background noise was high.

2. *Loudspeakers—energized type*—Investigations were carried out on the manufacture of cones from locally available paper. Mild steel was found satisfactory for electromagnetic cones, and the loudspeakers constructed were found to possess an average response of 5 db. over 40 to 5,000 cycles. The performance of cones made from bamboo paper pulp cast in a zinc former, dried and stiffened with varnish coating was found to be satisfactory.

For the production of permanent magnet loudspeakers, the main limiting factor was the availability of magnet steels.

3. *Insulating Materials & High Frequency Dielectrics*: Prof. S. K. Mitra & Dr. H. Rakshit — Studies were made on the suitability of porcelain, bakelite, shellac-moulded boards and paper, supplied by the Council of Scientific & Industrial Research, as high frequency dielectrics (up to a frequency of 10 mc./s.). The results of these investigations have been published in the *Journal of Scientific & Industrial Research*.

4. *Radio Valves*: Prof. S. K. Mitra — Radio valves of the type 80 have been made and tested. Details have been described in the *Journal of*

Scientific & Industrial Research. Processes for the production of triodes and pentodes are under test. It is proposed to undertake repairs to transmitting valves.

5. *Capacitors & Resistors*: Prof. K. Sreenivasan — *Paper Capacitors* — Kraft paper, tin foils and impregnating wax used in the experiments were imported from abroad. A winding machine has been designed and capacitors wound and impregnated under vacuum with paraffin wax. The capacitors were encased in paper tubes and ends sealed with a compound made from kaolin, bees-wax and resin.

6. *Mica Capacitors*: Prof. K. Sreenivasan — The raw materials used in the manufacture of capacitors were indigenous. Ruby muscovite mica from Bihar has been found suitable. Copper foils of thickness ranging from 0.001" to 0.002" were used as electrodes. The capacitors were impregnated with wax, pressed in a screw press while hot, and kept in a vacuum chamber at 220°F. They were allowed to cool and packed in a porcelain container with a compound of the following composition: hard pitch 30; resin 15; bees-wax 10; and kaolin 45 per cent.

The capacitors were satisfactory under some conditions and were supplied in quantities to the Air Force. The scheme was terminated in February 1943.

7. *Carbon Resistors*: Prof. K. Sreenivasan — Composition resistances were manufactured with the following ingredients: silica of 200 mesh; plumbago; bleached shellac; urea. The mixture was extruded through hard steel moulds using ethyl alcohol as plasticizer. The moulded mixture was heat treated in an oven at 250°C., cut to size, ends sprayed with molten copper and copper leads soldered to sprayed ends. The resistances had good overload characteristics, but their shelf life was not very satisfactory.

8. *Vitreous Enamel Resistors*: Prof. K. Sreenivasan — The resistors were wound with fully oxidized nichrome wire on porcelain formers which were specially manufactured to stand repeated thermal shocks. The enamel frit used to coat the resistances had the following composition: red lead 45; boric acid 26; flint 11; sodium carbonate 4; cryolite 6; tin oxide 2; manganese dioxide 0.5; cobalt dioxide 1; ferric oxide 3; zinc oxide 1.5 per cent. The resistors were fired in a high temperature furnace at 950°C. The resistors also had good overload characteristics and were extensively used during the war years by Armed Services, specially the Air Force.

9. *Volume Controls*: Dr. G. R. Toshniwal — Volume control elements were made by spraying colloidal graphite on unglazed brown paper 7 mils. thick. The paper was washed with a solution of neutral soap and dried at 60°C. Aquadag was sprayed upon the paper thus treated, and the paper dipped in a weak solution of ammonium sulphate for a few minutes and dried at 60°C. Volume controls of values from 0.5 to 2 megohms

were made. They had excellent electrical stability and mechanical resistance.

10. *Lead Acid Batteries* : Mr. V. V. L. Rao — The manufacture of lead acid batteries was investigated by Mr. H. Joga Rao of the Provincial Broadcasting Services. Experimental cells were made from a variety of designs and have given satisfactory results.

11. *Electrolytic Capacitors* : Mr. V. V. L. Rao — The work was started first with the object of salvaging defective capacitors but it was found to be uneconomic. Attempts were made to study the possibilities of manufacture, but as high purity foils were not available, high voltage capacitors were not attempted. The process for anodization of pure foils for low voltage capacitors was evolved and details on the work published in the *Journal of Scientific & Industrial Research*.

12. *Cheap Radio Sets* : Dr. G. R. Toshniwal — Three sample superheterodyne sets were constructed, one for local reception, another to cover medium wave band, and the third, a 3-band all-wave set. The sensitivity was 40 to 80 milliwatts output. The medium wave sets could be manufactured at Rs. 55 each on the basis of pre-war prices. Components like slow motion drive, tuning coils, i.f. transformers, chokes, mica capacitors and volume controls were designed and constructed locally. Distortion factor meter and Q-meter were also built to aid the design of the components and sets.

13. *Cutting & Polishing of Quartz* : Dr. D. M. Bose — A method of cutting, polishing and cleaning quartz crystals for use in master oscillators of radio transmitters has been developed. Oscillators made with the crystals had good performance characteristics.

14. *Radio Industry* — In 1948, the Ministry of Industry and Supply set up a Committee for considering the establishment of a radio factory in India with the Chairman of the Radio Research Committee as a member. An expert sub-committee, headed by the Chairman, Radio Research Committee, examined the project reports from reputed foreign manufacturers and recommended a French firm, called C.S.F., for entering into technical arrangements. The recommendations are under the consideration of the Ministries of Defence and of Commerce and Industry.

Synoptic Studies

1. *Ionospheric Investigations* — The Radio Research Committee has participated in the world programme of ionospheric studies since 1943. The data collected at Calcutta have been found useful, and a regular 24-hour observation is being maintained. The data collected every month, and periodical summaries of results are being published in the *Journal of Scientific & Industrial Research*.

An ionospheric research station has since been established at Haringhata, 24 miles away from Calcutta. The Australian Council of Scientific & Industrial Research has supplied an automatic recorder on permanent loan for installation at Haringhata.

2. *Studies on Atmospherics* — A programme of research on the direction of arrival of atmospherics was prepared in 1944, in collaboration with the Indian Meteorological Department, and five d.f. sets were installed at Bangalore, Dacca, Waltair, Poona and Delhi. It was soon found that for

obtaining accurate data, the d.f. sets had to be redesigned to operate at lower frequencies. As such sets were readily available from abroad, it was decided to import these. The Indian Meteorological Department has agreed to bear the cost of the equipment.

3. *Nature of Atmospherics* : Dr. S. R. Khastgir — Work on the nature of atmospherics was initiated in July 1950, and apparatus and equipment required is being constructed. Systematic investigations are expected to be taken up shortly.

4. *Radio Noise* : Dr. M. B. Sarwate — A scheme submitted in 1948 to measure the overall noise value on the low frequency band, viz. 100-500 kc./s., is under consideration.

5. *Short-wave Radio Signal Fading* : Dr. S. S. Banerjee — This work is being carried out at the Banaras Hindu University. A pulse transmitting-receiving system and an automatic pen recorder have been constructed. It is proposed to take out a patent for these. Observations of fading at vertical and oblique incidence are being made.

6. *Polarization of Down-coming Waves* : Dr. S. R. Khastgir — The polarization of radio waves reflected from the ionosphere is being started at the Banaras Hindu University. Equipment consisting of crossed loop aerials, ground wave suppression system, high gain amplifiers and shielded aerial tuning arrangement has been completed and studies on polarization of medium waves have been made.

Fundamental Research

1. *Upper Atmosphere* : Prof. M. N. Saha — A wave theory for the study of propagation of electromagnetic waves, as opposed to the ray theory of Appleton and others, has been developed. Expressions for steady current conductivity of the ionosphere, electrical polarization, complex conductivity, medium refractive index of ordinary and extraordinary rays and absorption of radio waves have been derived.

The problem of ionospheric triple splitting has been investigated. A physical theory of solar corona and the origin and condition of escape of microwaves from the sun has been developed. It is suggested that the origin of sunspot noise can be explained in terms of the transition of nuclear moments in the intense magnetic field of the sunspot. These results have been published in a series of 10 papers.

2. *Investigations on the Ionosphere* : Prof. S. K. Mitra — The results obtained during 1944-49 showed that the annual average mid-day intensity variation responsible for the region E of the ionosphere increased by 150 per cent from 1945 (low solar activity) to 1947 (high solar activity); but that responsible for region F₂ increased by 230 per cent in the same period. It was also found that the rate of ion production of region E over Calcutta increased from 30 per c.c. per sec. in 1945 to 50 c.c. per sec. in 1947. For region F₂ this increased from 50 to 400 per c.c. per sec. During the period 1945-47, the noon-time temperature at E region heights increased from 300° to 400°. At the levels of region F₂, however, the increase was from 700° to 1,300°. An analysis of the value of earth's magnetic field was made and the presence

(Continued on page 268)

INDIAN PATENTS

[A few of the Patent Applications notified as accepted in the *Gazette of India*, Part III, Section II, April 1951, are listed below.]

Inorganic Chemicals

42281. Recovery of iron and sulphate constituents of spent iron pickling liquors: *Recovering iron and sulphate from iron pickling liquor by reacting with chemical compounds adapted to form metallic sulphates other than ferrous sulphate and iron oxides* — VIJNAHA PARISHAT
42341. Production of calcium chromate: *Producing calcium chromate by utilizing reactions of ammonia soda process, modified by the substitution of sodium chromate for sodium chloride, in conjunction with a sodium chromate production process* — UDY
43880. Manufacture of pigmentary titanium dioxide: *Feeding a mixture of titanium tetrachloride, oxygen-containing gas and 0.01 to 10 per cent of a volatile silicon compound into a combustion zone and igniting the mixture* — SAUREFABRIK SCHWEIZERHALL

Fuels & Lubricants

42167. Process for manufacturing improved quality coke: *Disintegrated coal and separate concentrate of various constituents of the coal agglomerate, which are given suitable size distribution and coked separately or in the form of a blend* — BURSTLEIN & SOCIETE DES ACIERIES DE LONGWY (SOCIETE ANONYME)

Metals & Metal Products

43002. Production of precipitated copper metal: *Precipitating copper metal from a solution containing copper by subjecting a saturated solution at a temperature above 100°C. to increased pressure in an atmosphere of carbon monoxide* — CHEMICAL CONSTRUCTION CORP.
44545. Improvements in mining machines: *Cutter head pivotally mounted on machine frame so as to be turnable sidewise and connected to the frame through a double-acting pressure-fluid cylinder and piston steering unit* — MAVOR & COULSON LTD.
44275. Concentration or cleaning of minerals by froth flotation: *Comprising a cell having a bottom composed of a porous medium consisting of powdered metal or glass or other material rendered coherent by sintering* — NATIONAL COAL BOARD

Rubber & Rubber Products

42233. Alumina-base fillers for rubber compositions: *Natural alumina monohydrate ground to 1 micron size or obtained by heating hydrated alumina in an autoclave in an aqueous medium above 160°C.* — COMPAGNIE DE PRODUITS

CHIMIQUES ET ELECTROMETALLURGIQUES ALAIS, FROGES ET COMARGUE

Stone, Clay & Glass Products

42530. Baking or calcining soils *in situ*: *Calcining soil stabilized as slabs in situ by heating simultaneously internally with fuel cartridges and on the surface in a furnace* — SAHNEV
42057. Improvements in building structure and building elements: *Building element consists of two side plates and one centre plate joined to said side plates by two oblique web plates and side plates being staggered by their own height with respect to the centre plates, said side plates and centre plate being parallel to one another* — LIVING-STONE ESTABLISHMENT
43841. Bricks and other building blocks: *Having longitudinally extending tongue and groove on its bearing faces* — BEANLAND
43969. Method for making corrugated slabs: *Having greater thickness at the tops and bottoms by sprinkling additional material on an unset slab* — ETERNIT

Miscellaneous

43424. Preliminary treatment of tea leaf: *Tea leaf is subjected to pressure between surfaces, at least one of which is of resilient material* — SAYAMA TEA ESTATES LTD. & WORTHINGTON
44380. Multi-colour printing: *Wherein materials, which render the printed colours waterproof, are incorporated in the composition containing dyes to be printed* — SARK
44464. Production of cellulose acetate threads: *In the continuous extension method, a part of the coagulant liquid is withdrawn and subjected to a high temperature so as to separate the potassium acetate which is recycled into the coagulant bath for maintaining its composition almost constant* — COURTAULDS LTD.
44525. Improvement in static ringing converters: *Self-biased thyatron oscillator driven by means of a condenser rectifier system* — THE DIRECTOR, INDIAN INSTITUTE OF SCIENCE, BANGALORE
44679. Electrical rectifying systems: *Comprises a main rectifier and an auxiliary rectifier, load connected to main rectifier while parallel combination of at least one counter cell and switch connected to auxiliary rectifier* — N. V. PHILIPS' GLOEILAMPENFABRIEKEN
42663. Lining drug containers or tanks with acid, alkali, petrol, oil or other resistant protective linings: *Treating the inner surfaces with an adhesive solution and applying a protective sheet material thereon* — GEORGE SPENCER MOULTON & CO. (INDIA) LTD.

PATENTED INVENTIONS OF THE C.S.I.R.

28306. A plastic composition : Rubber is heated at 60°-110°C., adding to the heated rubber bamboo strainer waste or jute waste and a powdered mixture of sulphur, zinc oxide and accelerator M. The mass is moulded and baked at 120°-50°C. The proportions (by weight) of the ingredients, on the basis of strainer waste or jute waste as 100, are : rubber, 20-75 ; sulphur, 15-40 ; zinc oxide, 0.5-1.0 ; and accelerator M, 0.3-1.0. Articles such as bobbins or pickers made of the plastic composition are hard as wood, light, and unbreakable for all practical purposes — S. S. BHATNAGAR & A. AHMED
28307. Rubber composition for manufacturing artificial cork, stoppers, refrigerator pads, insulating materials, and like substances : Rubber is heated at 50°-80°C., mixed with cotton waste, bamboo strainer waste or jute waste, and a mixture of sulphur, zinc oxide, a moderate accelerator (such as accelerator M) and sodium bicarbonate ; the temperature of the mass is brought to below 50°C. ; solid stearic acid is sprinkled over the mass, which is then baked in an oven at 110°C. for about 2 hr. and thereafter at 140°C. for about 1 hr. If a small quantity of casein is added to the rubber and the strainer waste content is reduced, the final product will be spongy. The proportions (by weight) of the ingredients, on the basis of bamboo strainer waste or jute waste as 100, are : rubber, 20-75 ; sulphur, 15-40 ; zinc oxide, 0.5-1.0 ; accelerator M, 0.5-1.0 ; cotton waste, 2-7 ; sodium bicarbonate, 2-7 ; stearic acid, 4-14 — S. S. BHATNAGAR & A. AHMED
28376. Degradation of proteinous materials for use in foam-generating substances or the like : The invention is characterized in that in hydrolysing proteinous material with an alkali metal hydroxide, or an alkali salt showing alkaline reaction, the hydroxide required for hydrolysis is produced in the mixture itself by cataphoresis of a mixture of the proteinous material and a solution of sodium or potassium chloride. The solution is then neutralized with hydrochloric or sulphuric acid and filtered free from insoluble material, and the filtrate is concentrated to a density of 1.1-1.2 — A. RAM, S. S. BHATNAGAR & KARIMULLAH
- 28427 : Non-breakable and leak-proof containers : In preparing sheets or blanks by pressing under heat one or more layers of a fibrous substance treated with an impregnating agent, an unpressed margin is left along the edges, and portions of the margin are subsequently pressed, alone or over one another, in presence of heat to form leak-proof joints or stiff edges. The manufacture of various types of non-breakable containers by bending the sheets and pressing the unpressed margins is described and illustrated with drawings. The method is also applied to making plugs, screw caps, lever tops or sliding lids to close containers — S. S. BHATNAGAR, P. PRAKASH & L. C. VERMAN

PROGRESS REPORTS — Continued from page 266

of a seasonal variation at the height of region F₂ was detected. Analysis of the value of coefficient of recombination for regions E and F₂ showed that the values for both these regions undergo similar diurnal and seasonal variations, the amplitude of variation for region F₂ being much larger.

Apart from the work on geomagnetic control of F₂ layer ionization, investigations on the effect of solar eclipse on the ionospheric ionization and ionospheric tide deserve special mention. The results of these investigations have been published in a series of 8 papers.

The following schemes have been recommended for investigations at the National Physical Laboratory : (1) electronic frequency analyser — Dr. N. B. Bhatt ; (2) studies of microwaves emitted by extra-terrestrial sources — Dr. H. Rakshit ; (3) study of signal/noise ratio and the effect of ignition type of noise on ultra-short waves — Prof. S. P. Chakravarti ; (4) studies on reflection coefficient of different types of terrains for ultra-short microwaves — Dr. S. S. Banerjee.

General

The Committee has surveyed training and research facilities in different institutions. The Ministry of Education have invited a member of

this committee to serve on the Ministry's Syllabus Committee for telecommunication engineering.

Practical Training Course in Radar — A short course of training in radar was organized by the Radio Research Committee in collaboration with the Ministry of Defence. The training is to be extended to fresh batches of scholars.

Research Equipment — The Committee has, from time to time, brought to the notice of research workers in electronics, the availability of equipment for electronics research and have helped them to secure the equipment.

Symposium on Microwaves — A Panel on Ultra-short and Microwaves was set up under the Committee in 1945. Thirteen study groups were formed and 27 survey reports were prepared which were discussed at a symposium held in New Delhi in December 1949.

Standardization — A survey of facilities for testing and standardization of radio equipment and components was carried out by the Committee in 1945 and, based on this survey, the Committee recommended the establishment of a Central Radio Research Laboratory. A sub-committee, with Dr. D. S. Kothari as convener, has been set up to prepare plan for the establishment of a Central Radio Research Laboratory.

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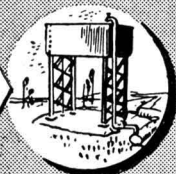
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The Ionospheric Polarization of Low Frequency Radio Waves

JOHN M. KELSO

Ionosphere Research Laboratory, The Pennsylvania State College, State College, Pa., U.S.A.

A discussion is given of some of the basic principles of elliptic polarization in general, and also as specifically applied to magneto-ionic theory. Several new procedures, which facilitate the numerical treatment of these problems, are presented. These results are applied to the vertical propagation of 150 kc. signals at State College, Pennsylvania, U.S.A. The relation of these specific results to those obtained under other conditions is discussed.

AT short wavelengths and in middle latitudes a radio signal directed vertically is reflected from the ionosphere (if at all) with almost circular polarization. Perhaps because of this fact there has not been as much emphasis on the study of polarization as there has been of other phenomena. However, as a consequence of the recent interest in the propagation of radio waves of low frequency, there has been a renewal of interest in the polarization of such signals. For these long waves the polarization departs considerably from circularity and since the waves are reflected from very low regions of the ionosphere, the effects of collisions are much more significant.

Most of the papers in the literature which find it necessary to deal with polarization appear to assume that the basic principles of polarization are too well known to need discussion. Indeed, this attitude is so prevalent that it is quite difficult to obtain any source of very complete information on this subject. That difficulties do arise is clearly shown by the fact that two well-known workers, Taylor¹ and Martyn², and a number of later writers have made the incorrect statement that the polarization ellipses of

the two magneto-ionic components are *always* oriented so that their major axes are perpendicular. This error has been pointed out by Aden, de Bettencourt and Waterman³ and, independently, by Benner, Grace and Kelso⁴.

For the above reasons the present paper has two principal purposes: (1) to present certain of the "well-known" features of the general theory of radio wave polarization, as well as some new methods for presenting the results and for shortening the computations; (2) to exhibit some numerical results for vertical incidence propagation of 150 kc. (2 km. wavelength) signals. The theory used for the numerical computations is based on the simple magneto-ionic theory as ordinarily used in ionospheric work at higher frequencies, and does not attempt to consider any problems which involve "wave theory" in any manner other than those included implicitly in the Appleton-Hartree equation.

General Elliptical Polarizations

We assume that the wave can be represented by two simple harmonic vibrations acting along lines at right angles in space. Thus the material in the present section applies to any simple harmonic motions in quadrature — mechanical or electrical.

(1) *Analytic Determination of Angle of Tilt & Ratio of Axes* — The resultant of two simple harmonic motions of the same frequency and acting at right angles in space is always a vector, rotating with the given frequency, which traces out an elliptical path. (Linear and circular polarizations can be considered as special cases of elliptical polarization.) The orientation and shape of this

resultant ellipse depend upon the ratio of the amplitudes and the relative phases of the original motions. There is also a question of the absolute amplitudes and absolute phases, but these do not usually enter into ionosphere problems.

In the present section we wish to start with a given pair of simple harmonic motions and determine the shape and orientation of the resultant ellipse. This is a problem in analytic geometry which is simply stated, but since the work involved is complicated, although not theoretically difficult, it seems well worth while to sketch the derivation of the results and to note that the complete derivation, as followed here, can be found in Born's *Optik*⁵. The notation of co-ordinate axes has been changed here to conform to the usual ionospheric axes used with the magneto-ionic theory.

We consider two cosine motions with different amplitudes and phases acting along the Y and Z directions respectively. (When the magneto-ionic theory is introduced, the Z direction will be the direction of the transverse component of the earth's magnetic field, and the X direction, the direction of propagation of the wave.)

$$(1) \quad \begin{cases} H_y = a_1 \cos(pt + \phi_1) \\ H_z = a_2 \cos(pt + \phi_2) \end{cases}$$

The cosines can be written as the real parts of exponentials:

$$(2) \quad \begin{cases} H_y = \text{Re}[a_1 e^{j(pt + \phi_1)}] \\ H_z = \text{Re}[a_2 e^{j(pt + \phi_2)}] \end{cases}$$

From this complex representation we can define a unique complex polarization vector, R:

$$(3) \quad R = \frac{H_z}{H_y} = \frac{a_2}{a_1} e^{j(\phi_2 - \phi_1)} = p e^{j\phi}$$

where

$$(4) \quad \begin{cases} p = a_2/a_1 \\ \phi = \phi_2 - \phi_1 \end{cases}$$

Hence, the complex polarization vector depends only upon the amplitude ratio and the phase difference, and not upon the absolute magnitudes of either amplitudes or phases. Thus, for a given pair of equations (1) or (2), there is a unique value of the polarization, R; but the converse is not true. For present purposes, except when considering the sum of two elliptically polarized waves, it will be sufficient to consider that two elliptically polarized waves are the same if they have the same polarization, R.

Since each component in equation (1) involves the cosine of the sum of two angles, it is easy to expand this cosine using the common trigonometric identity, and to eliminate $\sin pt$ and $\cos pt$, obtaining,

$$(5) \quad \frac{H_y^2}{a_1^2} + \frac{H_z^2}{a_2^2} - 2 \frac{H_y H_z}{a_1 a_2} \cos \phi = \sin^2 \phi.$$

It is well known that equation (5) is the equation of an ellipse whose axes do not, in general, coincide with the Y and Z axes. Further, it can be seen from equations (1) that the ellipse is inscribed in a rectangle of side $2a_1$ along Y, and side $2a_2$ along Z. Such an ellipse is shown in Fig. 1.

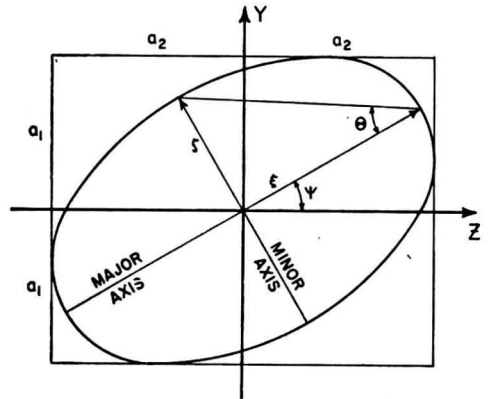


FIG. 1 — POLARIZATION ELLIPSE SHOWING CO-ORDINATE SYSTEMS AND AXES.

In Fig. 1, let ψ be the angle between the major axis of the ellipse and the Z axis, and let $\tan \theta$ be the ratio of minor to major axes. We wish now to define a new co-ordinate system with reference to the major and minor axes of the ellipse. Let the displacement along the major axis be ξ and that along the minor axis be ζ . Then, for same a, b and ϕ_0 , we may write the ellipse as,

$$(6) \quad \begin{cases} H_\xi = a \cos(pt + \phi_0) \\ H_\zeta = \pm b \sin(pt + \phi_0) \end{cases}$$

where the (\pm) sign appears because of the two possible senses of rotation of the resultant vector, with the $(+)$ sign giving a left-handed sense of rotation (counter clockwise, in Fig. 1).

The angles ψ and θ , mentioned above, are easily measured experimentally, and thus are very suitable quantities to use in specifying the ellipse. Since θ , as defined above, is

inherently positive, we may affix to it an algebraic sign which can indicate the sense of rotation of the resultant vector. We would now like to relate the angles Ψ and θ to the polarization, R , defined in equation (3).

The usual expressions for transforming from the YZ system to the $\xi\zeta$ system are given by,

$$(7) \quad \begin{cases} H_{\xi} = H_y \sin \Psi + H_z \cos \Psi \\ H_{\zeta} = H_y \cos \Psi - H_z \sin \Psi \end{cases}$$

Expanding the cosines of equations (1) as mentioned above, one can now substitute for H_y and H_z in equations (7). We also can expand the cosine terms in equations (6). We then have two expressions for each of H_{ξ} and H_{ζ} from which we can easily eliminate $\cos pt$ and $\sin pt$ to obtain,

$$(8) \quad \begin{cases} (a) \ a \cos \phi_o = a_1 \cos \phi_1 \sin \Psi + a_2 \cos \phi_2 \cos \Psi \\ (b) \ a \sin \phi_o = a_1 \sin \phi_1 \sin \Psi + a_2 \sin \phi_2 \cos \Psi \end{cases}$$

$$(9) \quad \begin{cases} (a) \ \pm b \cos \phi_o = -a_1 \sin \phi_1 \cos \Psi + a_2 \sin \phi_2 \sin \Psi \\ (b) \ \pm b \sin \phi_o = a_1 \cos \phi_1 \cos \Psi - a_2 \cos \phi_2 \sin \Psi \end{cases}$$

Squaring equations (8) and adding, and squaring equations (9) and adding; and adding the results, we obtain,

$$(10) \quad a^2 + b^2 = a_1^2 + a_2^2.$$

Multiplying (8a) by (9a), and multiplying (8b) by (9b) and adding the results, we obtain;

$$(11) \quad \pm ab = a_1 a_2 \sin \phi.$$

Dividing (8a) by (9a), and dividing (8b) by (9b), equating, cross multiplying, and collecting terms,

$$(12) \quad \tan 2\Psi = \frac{-2a_1 a_2}{a_1^2 - a_2^2} \cos \phi.$$

Defining,

$$(13) \quad \tan \alpha = \rho = \frac{a_2}{a_1}.$$

Then,

$$(14) \quad \tan 2\Psi = -\tan 2\alpha \cos \phi.$$

Since $\tan \theta = b/a$, we can substitute for $\sin \theta$ and $\cos \theta$ in the identity,

$$\sin 2\theta = 2 \sin \theta \cos \theta,$$

to obtain

$$\sin 2\theta = 2ab / (a^2 + b^2).$$

Introducing equations (10), (11) and (13), we obtain,

$$(15) \quad \sin 2\theta = \pm \sin 2\alpha \sin \phi.$$

Thus, for a given pair of equations of the form of equation (1), we can determine the angle of tilt, the ratio of the axes, and the sense of rotation of the resultant ellipse by using equations (14) and (15). There is a certain degree of ambiguity about these latter two equations, but this can be removed by other considerations to follow.

(2) *Graphical Determination of Angle of Tilt & Ratio of Axes*—The results of the preceding section offer a procedure for the determination of the configuration and orientation of the resultant ellipse for a given pair of equations of the form of equations (1). It is the purpose of the present section to offer a rapid graphical method for obtaining the same information.

As noted above, we are not concerned with the absolute magnitudes of either the amplitudes or of the phases, so that we can introduce the abbreviations from equation (4) into equation (1), to obtain a pair of equations which, for our purposes, are equivalent to the equations (1):

$$(16) \quad \begin{cases} H_z = \rho \cos (pt + \phi) \\ H_y = \cos pt \end{cases}$$

By examining qualitatively the behaviour of the resultant ellipse as pt increases from zero, one can determine the general characteristics of the resultant when the quantities ρ and ϕ have values in certain ranges. For example, if $\rho < 1$, and $0 < \phi < \pi/2$, we see that at $t = 0$, $H_z = \rho \cos \phi < 1$, and $H_y = 1$; as pt increases, both H_z and H_y decrease at first, so that we can determine several facts about the resultant ellipse: (1) the rotation is left-handed (counter clockwise) in Fig. 1; (2) the ellipse lies in a rectangle with its long side along the Y direction; (3) the major axis of the ellipse is oriented as shown in Fig. 1.

Applying similar reasoning to a complete range of variations of ρ and ϕ , we can plot a diagram, Fig. 2, which has been adapted from one given by Booker⁶. This figure shows the resultant ellipse for $\rho \leq 1$, and ϕ in all four quadrants, and indicates: (1) the quadrants containing the major axis; (2) whether the major axis inclines more nearly toward the Y or the Z direction; (3) the sense of rotation of the ellipse; (4) the two points of circular polarization ($\rho = 1$, $\phi = \pm \pi/2$), the line ($\phi = 0, \pi$) of linear polarization, and the point (infinity) of linear

LEFT-HANDED

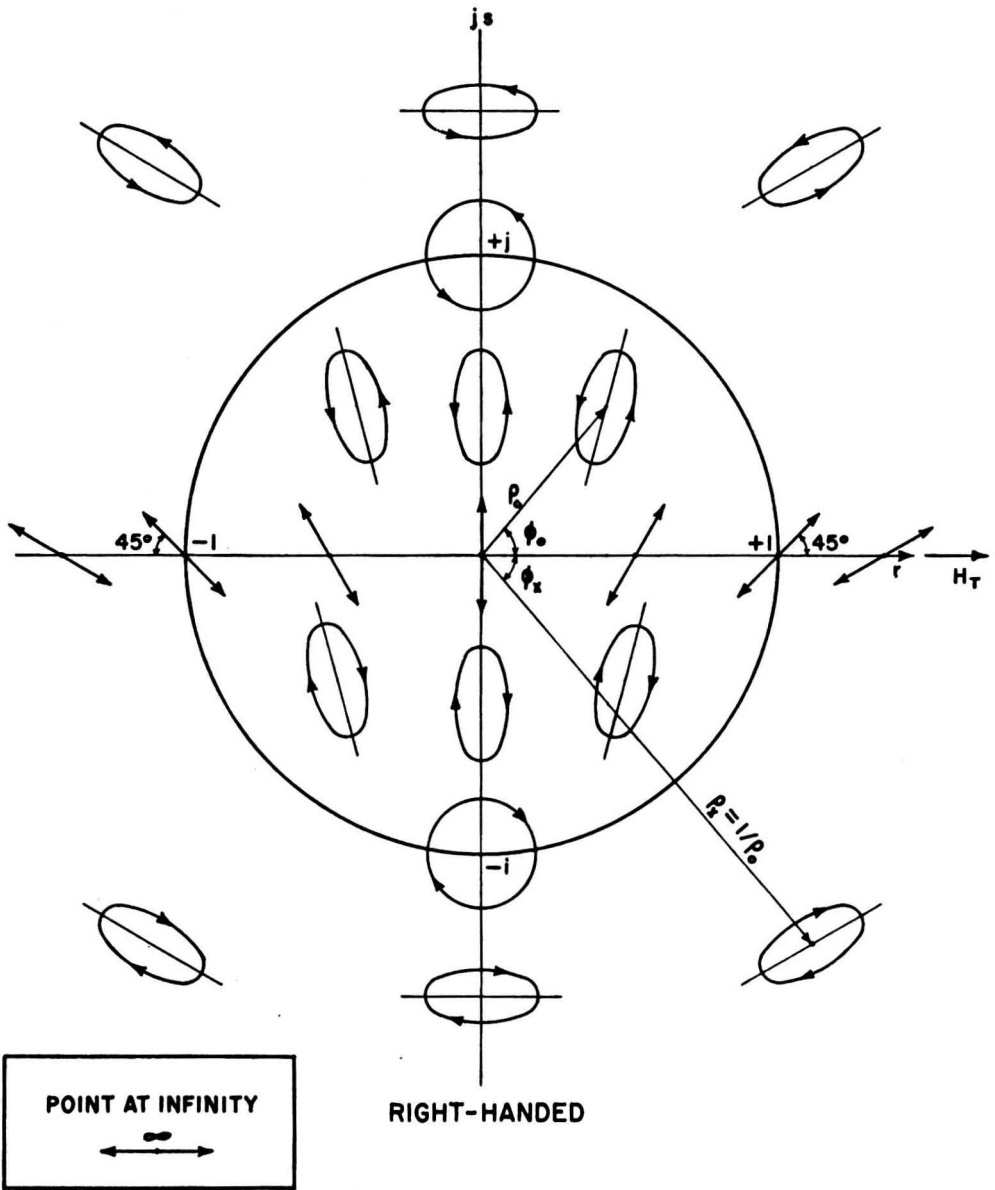


FIG. 2 — SCHEMATIC REPRESENTATION OF POLARIZATION IN THE COMPLEX PLANE.

polarization — all other regions give ellipses. The ellipses have been oriented so that the axis $\phi = 0$ is in the direction of the Z axis as used above, i.e. in the direction of the

transverse component of the earth's magnetic field as it will be introduced below.

From the Appleton-Hartree equation, it is easy to show that the two magneto-ionic

components are related so that the product of their polarizations is unity. Thus, if the subscript "o" stands for the ordinary, and "x" for the extraordinary component,

$$(17) \quad \rho_o \rho_x = 1, \quad \phi_o = -\phi_x$$

One such pair of ellipses are indicated on Fig. 2, and it is readily seen, either from general considerations, or from equations (14) and (15), that the two ellipses have opposite senses of rotation, but similar shapes, and that they are tilted equally from the line at 45° between the positive Y and Z directions. That is,

$$(18) \quad \begin{cases} \psi_o + \psi_x = 90^\circ \\ \theta_o = -\theta_x \end{cases}$$

The use of Fig. 2 and the results in equation (18) eliminate the ambiguities mentioned in connection with equations (14) and (15).

We wish now to obtain a chart which will give, in the complex polarization plane (the R plane), the lines of constant angle of tilt and constant arc tangent of the axial ratio. We note first that the left half-plane of Fig. 2 is the same as the right half-plane, but with the major axis in the second and fourth quadrants, instead of the first and third. Also, the lower half-plane is the same as the upper half-plane, except that the rotation is right-handed instead of left-handed. Thus, our chart need only include the first quadrant, since the polarizations corresponding to points in the other three quadrants are simply related to those in the first quadrant. Further, a point at some angle ϕ which has a magnitude ρ is related to the point at the same angle ϕ but at a distance $1/\rho$ from the origin. The two ellipses have the same shape and rotation senses, but are tilted equally on opposite sides of the 45° diagonal mentioned above. That is, the one ellipse has its major axis tilted at the same angle from the Y direction as the other is tilted from the Z direction. Hence, results for all values of ρ and ϕ can be obtained in a simple manner from those within the first quadrant of a circle at a unit distance from the origin.

Let us eliminate α from equations (14) and (15), obtaining

$$(19) \quad \begin{cases} -\rho^2 \tan 2\psi + 2\rho \cos \phi + \tan 2\psi = 0 \\ \mp \rho^2 \sin 2\theta + 2\rho \sin \phi \mp \sin 2\theta = 0 \end{cases}$$

If $r = \rho \cos \phi$ and $s = \rho \sin \phi$ are the real and imaginary parts, respectively, of the polarization, i.e. $R = r + js$, then the equations (19) become:

$$(20) \quad \begin{cases} (r^2 + s^2) - \frac{2r}{\tan 2\psi} = 1 \\ (r^2 + s^2) \mp \frac{2s}{\sin 2\theta} = -1 \end{cases}$$

Rearranging these equations, we obtain from the first the equation for the lines of constant angle of tilt, ψ ,

$$(21) \quad \left[r - \frac{1}{\tan 2\psi} \right]^2 + s^2 = \frac{1}{\sin^2 2\psi},$$

which are circles with centres at $(1/\tan 2\psi, 0)$ and with radii $1/\sin 2\psi$. Similarly, the second of equations (20) leads to an equation for the lines of constant θ ,

$$(22) \quad r^2 + \left[s \mp \frac{1}{\sin 2\theta} \right]^2 = \frac{1}{\tan^2 2\theta},$$

which is the equation for a family of circles with centres at $\left(0, \frac{\pm 1}{\sin 2\theta}\right)$ and radii $1/\tan 2\theta$.

Fig. 3 shows these lines of constant ψ and θ drawn within the unit circle of the R plane. The box in the upper right of the figure shows the ranges of ψ and θ for the other ranges of the polarization shown in Fig. 2.

As an example, we note that, if $R = 0.3 + j 0.5$, then $\psi = 69^\circ$, and $\theta = 24^\circ$. The polarization is left-handed, since R is in the upper half-plane (and θ is positive). Considering corresponding points in all four quadrants, we get the following table:

- (1) $R = 0.3 + j 0.5$, $\psi = 69^\circ$,
 $\theta = 24^\circ$, left-handed;
- (2) $R = -0.3 + j 0.5$, $\psi = -69^\circ$,
 $\theta = 24^\circ$, left-handed;
- (3) $R = -0.3 - j 0.5$, $\psi = -69^\circ$,
 $\theta = -24^\circ$, right-handed;
- (4) $R = 0.3 - j 0.5$, $\psi = 69^\circ$,
 $\theta = -24^\circ$, right-handed.

Now, it will be noted that the value of ρ corresponding to the value $R = 0.3 + j 0.5$ is $\rho = 0.5831$. The reciprocal of this value is $1/\rho = 1.7150$. For this inverse point $\psi = 21^\circ$, $\theta = 24^\circ$. Similar results can be obtained for each of the four examples above.

(3) *The Sum of Two Elliptically Polarized Waves* — As is well known, the sum of two elliptically polarized waves is another elliptically polarized wave. In the present section we consider the problem of obtaining this sum, but the work is restricted to adding two ellipses as the two magneto-ionic

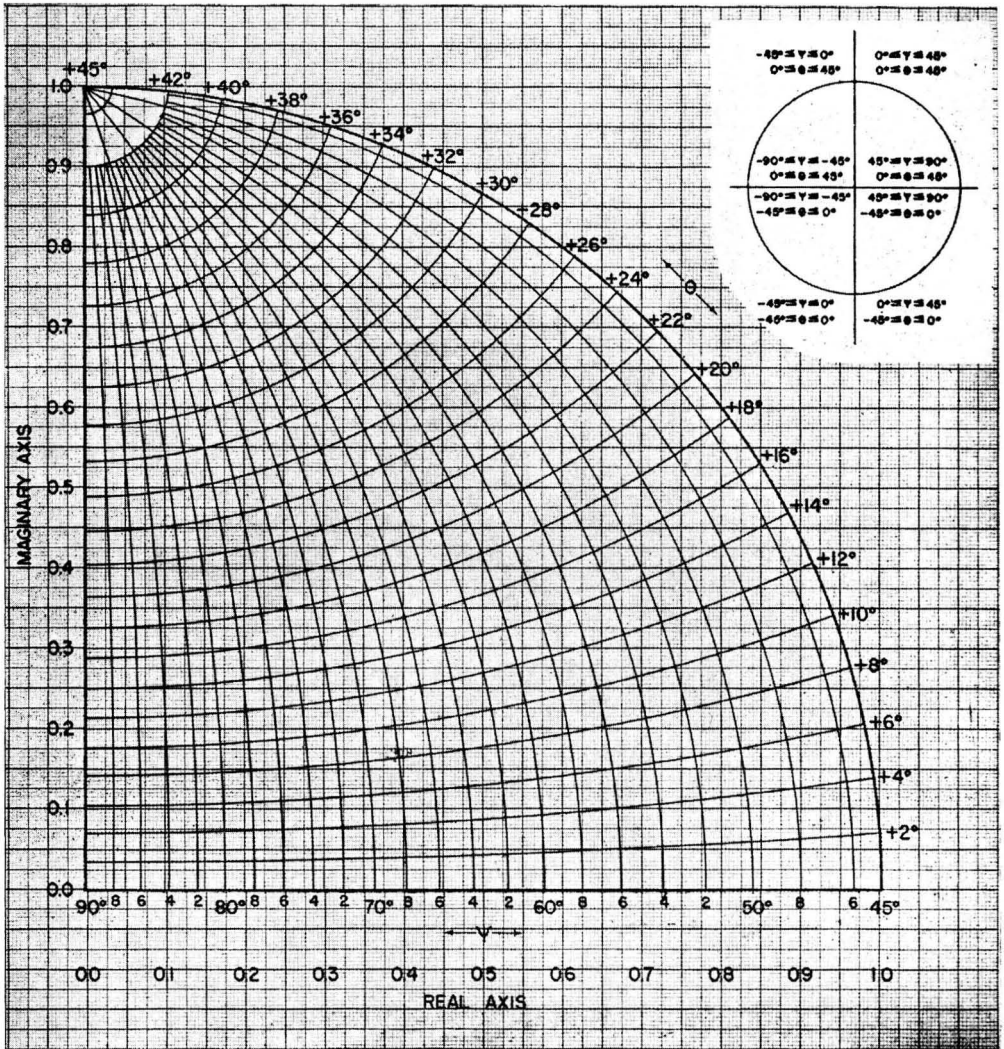


FIG. 3 — LINES OF CONSTANT Ψ AND CONSTANT θ INSIDE UNIT CIRCLE BOX AT UPPER RIGHT GIVES RANGES OF Ψ AND θ IN ENTIRE PLANE.

components are related, i.e. the product of their polarizations is unity. This restriction is not necessary, but it simplifies matters somewhat and, since the purpose of the present work is the study of polarization as related to the magneto-ionic theory, the restricted results will suffice.

We use the superscripts "o" and "x" to denote the two magneto-ionic components. Then the two waves to be added are given by,

$$(23) \quad \left\{ \begin{array}{l} H_z^o = \rho \cos (pt + \phi) \\ H_y^o = \cos pt \end{array} \right\} R_o = \rho e^{j\phi}$$

$$(24) \quad \left\{ \begin{array}{l} H_z^x = A \cos (pt - \phi + \alpha) \\ H_y^x = A \rho \cos (pt + \alpha) \end{array} \right\} R_x = \frac{1}{\rho} e^{-j\phi}$$

where the quantities A and α in equation (24) permit a constant difference in amplitude and phase between the two ellipses.

We now add the Y components and the Z components separately, thus obtaining a pair of equations of the form of equation (1) for the resultant ellipse. If ρ_r and ϕ_r are the corresponding quantities defined in equation (4), then,

$$(25) \quad \rho_r = \frac{\sqrt{\rho^2 + 2A\rho \cos(2\phi - \alpha) + A^2}}{\sqrt{1 + 2A\rho \cos \alpha + A^2\rho^2}}$$

$$(26) \quad \phi_r = \tan^{-1} \left[\frac{\rho \sin \phi + A \sin(\alpha - \phi)}{\rho \cos \phi + A \cos(\alpha - \phi)} \right] - \tan^{-1} \left[\frac{A\rho \sin \alpha}{1 + A\rho \cos \alpha} \right]$$

By inspection of equations (25) and (26), it is a fairly straightforward matter to develop a graphical procedure by which the polarization of the resultant can be determined as a function of either A or α .

An example using the above procedure has been worked out for the sum of a pair of

ellipses whose polarizations are given by $R_o = 0.7306e^{j(74^\circ 10')}$ and $R_x = \frac{1}{0.7306} e^{-j(74^\circ 10')}$.

(These values represent reasonably well the form of the ellipses measured at this laboratory at a frequency of 150 kc./s. Only one rotation sense is usually seen, however.) In Fig. 4, the angles Ψ and θ are shown as functions of the relative phase α for four different values of the relative amplitude A. This figure shows the great changes in polarization which can result from adding a very small amount of extraordinary wave to the ordinary wave, if the phase difference between the two waves changes very greatly.

In using the graphical method mentioned above, one makes use of the chart in Fig. 3. Fig. 5 shows two curves on this chart obtained from the graphical procedure as applied to the above choice of waves for two different choices of the relative amplitude. The curve for $A = 0.15$ corresponds to one pair of the curves shown in Fig. 4. It can be

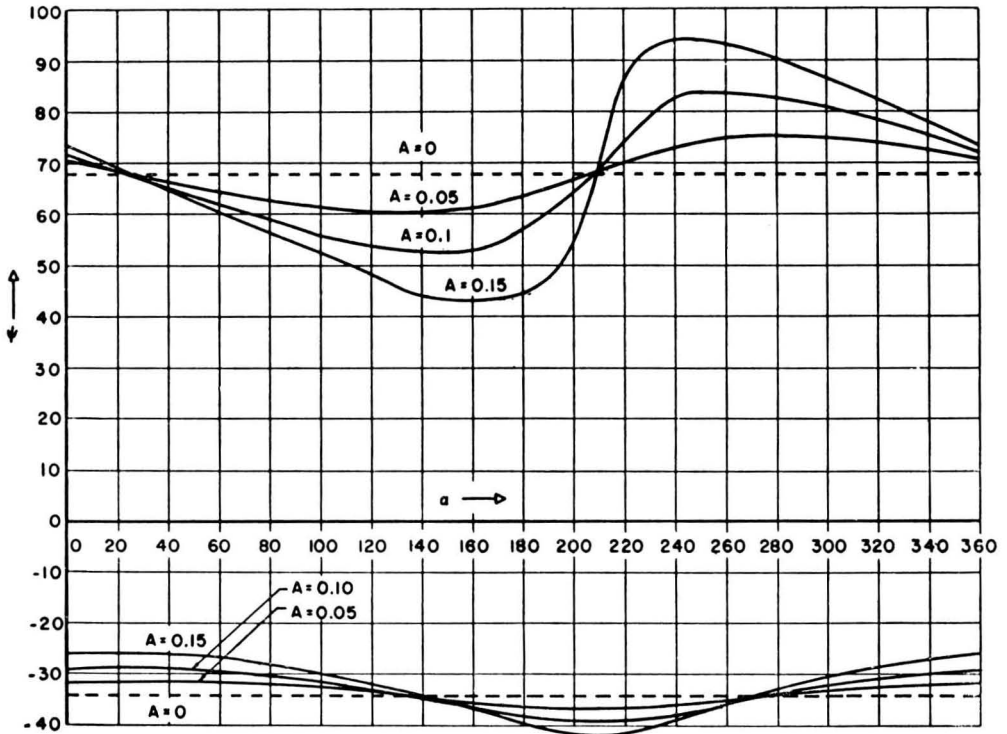


FIG. 4 — θ AND Ψ AS FUNCTIONS OF α FOR $A = 0, 0.05, 0.10, 0.15$.

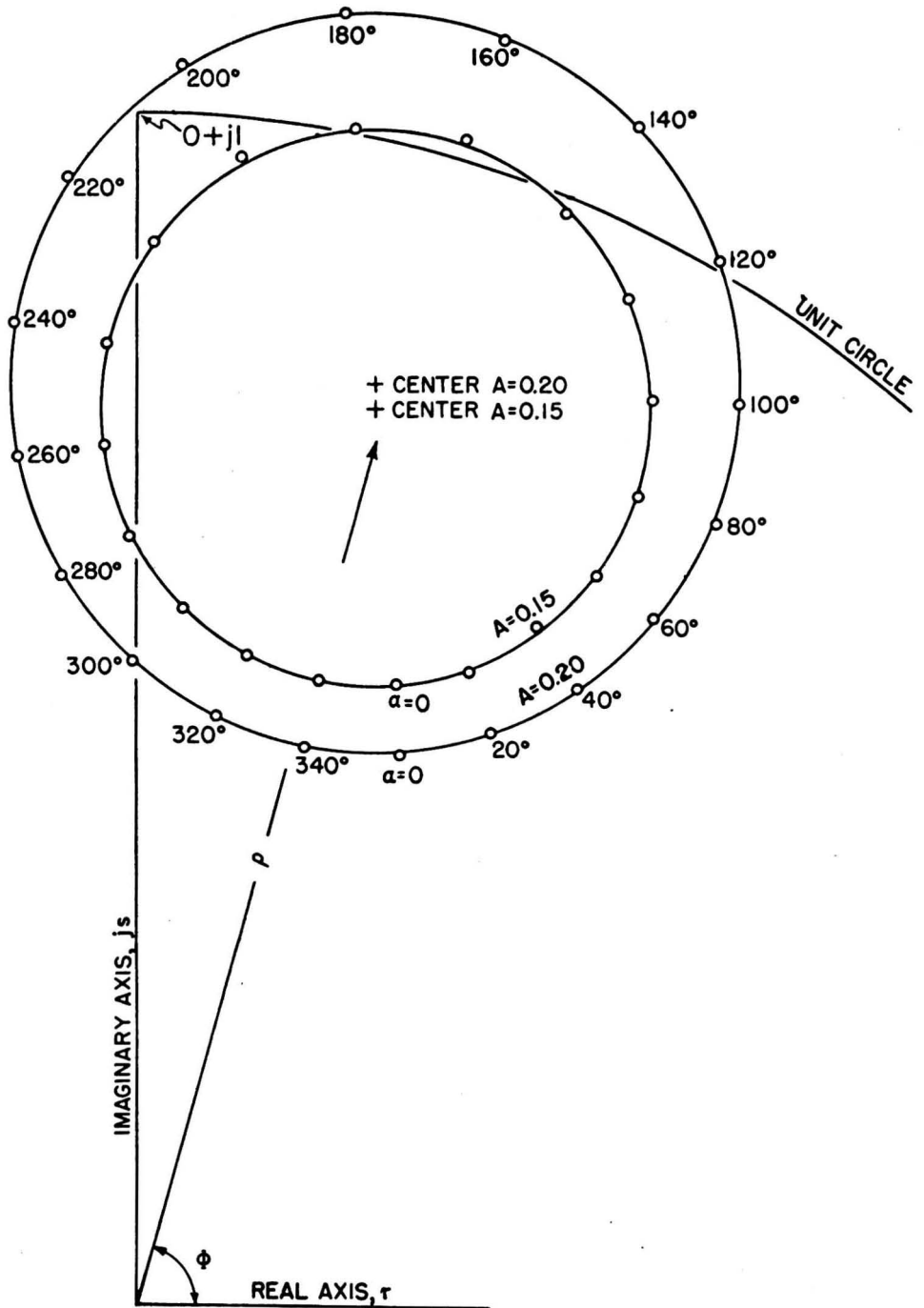


FIG. 5 — LOCUS OF COMPLEX POLARIZATION VECTOR AS FUNCTION OF α FOR $A=0.15$ AND $A=0.20$.

shown analytically that the curves of constant amplitude ratio, when plotted on Fig. 3, are circles, and the centres and radii of these circles can be obtained numerically. (The general algebraic solution is too inconvenient to be of much use.) It should be noted that the circle for $A = 0.20$ contains the point $0 + j1$. Considering this fact in the light of Fig. 2, one sees that the major axis of the resultant turns through 180° as the phase α goes through 360° .

Appleton-Hartree Equation — Magneto-ionic Theory

The notation used here is that of Appleton⁷. We consider a right-handed co-ordinate system, XYZ, with a plane wave propagated in the X direction. The earth's magnetic field, H, lies in the XZ plane at an angle θ_p from the X axis, and has components H_x and H_z along the X and Z directions respectively.

Appleton has shown that the complex index of refraction, q, is given by equation (27) below; and, if H_x and H_y are the components of the magnetic field of the wave along the Z and Y directions, then the polarization, R, of the wave is given by equation (28) below.

$$(27) \quad q^2 = \left(\mu - j \frac{ck}{p} \right)^2 = 1 + \frac{Z}{2(\alpha + j\beta) - \frac{\gamma_z^2}{(1 + \alpha + j\beta)} \sqrt{1 + \frac{\gamma_z^4}{(1 + \alpha + j\beta)^2} + 4\gamma_z^2}}$$

$$(28) \quad R = \frac{H_x}{H_y} = \frac{-j}{\gamma_z} \left[\frac{1}{q^2 - 1} - (\alpha + j\beta) \right]$$

where μ = refractive index; k = index of attenuation; c = velocity of electromagnetic waves in free space; N = electron density; p = angular frequency; ν = collisional frequency; $\alpha = p^2/p_o^2$; $\beta = p\nu/p_o^2$; $\gamma = pp_H/p_o^2$; $\gamma_{L,T} = pp_{L,T}/p_o^2$; $p_o^2 = 4\pi Ne^2/m$; $p_H = He/mc$; m, e = mass and charge of an electron.

Because of the (\pm) sign of equation (27) it is seen that, for a given point in an ionized region, there are two values for the complex index of refraction, and, hence, for the polarization. One of these values corresponds to the "ordinary" component, the other to the "extraordinary" component. For definitions of these components and further details, see Mitra⁸.

Substituting equation (27) into (28), multiplying the corresponding result using

the (+) sign by that using the (-) sign, and collecting terms, it is seen that the product of the polarizations for the ordinary and the extraordinary components is unity, as mentioned in the preceding section.

Numerical computations from equations (27) and (28) in their present form are rather tedious. The scheme used here is a slight modification of that given by Bailey⁹. For the derivation of the following equations, the reader is referred to the original work.

Using the notation given above, we evaluate the following sequence of equations :

$$(29) \quad \left\{ \begin{aligned} \sigma &= 2 \cos \theta_p / \sin^2 \theta_p \\ x &= \frac{\sigma \nu}{p_H}, \quad y = \frac{\sigma p}{p_H} \left(1 - \frac{p_o^2}{p^2} \right) \\ \rho^2 &= x^2 + y^2 \\ \xi &= \frac{x}{\rho^2}, \quad \eta = \frac{-y}{\rho^2} \\ A &= \xi^2 - \eta^2 - 1, \quad B = 2\xi\eta \\ C &= \sqrt{A^2 + B^2} \\ F &= + \frac{\sqrt{\frac{1}{2}(C+A)}}{\xi} \\ r &= \xi (1 \pm F) \\ s &= \eta \left(1 \pm \frac{1}{F} \right) \end{aligned} \right.$$

The quantities r and s above are the real and imaginary parts, respectively, of the polarization. When these quantities have been obtained, the angle of tilt, the ratio of the axes and the sense of rotation of the resultant ellipse can be determined either graphically or numerically according to the methods given previously.

When $B^2 \ll A^2$ in equation (29), the numerator of the quantity F lacks sufficient significant figures to give a useful result. Using the first two terms of a power series, one can obtain the alternative (approximate) expression,

$$F = \frac{1}{\xi} \left[\frac{B^2}{4|A|} \right]^{\frac{1}{2}}$$

The expressions for r and s in equations (42) contain a (\pm) sign. The upper signs belong to one component, and the lower signs to the other. However, because of the nature of the derivation of these equations, the relation of this (\pm) sign to that

in equation (27) is not immediately evident. In particular, there is a possibility of a change of signs for N greater than or less than the value for which $p^2 = p_c^2$ (the condition for reflection of a vertical signal in the absence of the magnetic field and collisions); and also the signs may change when the value of ν crosses the value $\nu_c = p_c^2/2p_L$, the critical collisional frequency. (For further details on the significance of these points, we again refer the reader to Mitra⁸.) Using a limiting analysis—allowing N and/or ν to approach either zero or one of the critical values—the following table was established, where N_c is the value of N for which $p^2 = p_c^2$. Some additional information on this subject will be offered below.

TABLE I

	$\nu < \nu_c$		$\nu > \nu_c$	
	$N < N_c$	$N > N_c$	$N < N_c$	$N > N_c$
Ordinary	—	—	—	—
Extraordinary	+	+	+	+

Using this procedure, numerical calculations have been made for the polarization for various values of N and ν . These calculations were made for signals incident vertically at State College, Pennsylvania, U.S.A. (40°49' North, 77°52' West), where, at an altitude of 100 km., the magnetic field is computed to give $p_H = 9.406 + 10^6$, $\theta_p = 19^\circ 9'$, and $\nu_c = 5.348 + 10^6$. All calculations are for an operating frequency of 150 kc. per second.

After r and s were obtained for various values of N and ν , it was then possible to refer to Fig. 3 in order to determine the angle of tilt, Ψ , and the arc tangent of the axial ratio, θ , corresponding to these values of r and s . A complete picture of these final results is given in Fig. 6, where the lines of constant N and ν are plotted in the $\theta\Psi$ plane. The upper half of this figure, where θ is positive, corresponds to left-handed polarizations, while the lower half of the figure, where θ is negative, corresponds to right-handed polarizations. The axis $\theta = 0$ and the vertical line $\Psi = 45^\circ$ correspond to the classical reflection condition, $p^2 = p_c^2$. The two diagonal straight lines are the lines $\nu = \nu_c$.

Using this chart, the polarization characteristics can be determined for a wave as it

passes through a medium where the parameters N and ν are changing. For each value of N and ν there are two points on this chart, located in positions which are symmetrical about the centre of the chart. As the wave emerges from the layer, the points on this chart denoting the wave polarization move out of the chart from the upper right corner, and from the lower left corner. Waves whose limiting polarizations correspond to values in the upper right corner of this chart are usually called "ordinary", while those waves having polarizations given by the lower left corner are called "extraordinary". However, it should be noted that if the polarization of the wave is not to suffer discontinuities as the medium varies, it is not possible to restrict any portion of this chart to a single one of the two characteristic waves. Thus, the terms "ordinary" and "extraordinary" are indicated on this figure only outside of the chart itself, and they are intended to apply to emerging waves only.

Because of the choice of propagation angle, θ_p , the present chart represents downcoming waves at State College. For upgoing waves, the values of θ and Ψ have the opposite algebraic signs from those quantities for downcoming waves, i.e. the points corresponding to downcoming and upgoing waves are symmetrical about the centre of the chart.

Although the present chart was prepared for restricted propagation conditions, the general form is universal. In particular, the lines for $p^2 = p_c^2$ and the lines for $\nu = \nu_c$ are the same whatever the conditions of frequency, magnetic field, or propagation angle. This set of lines divide the chart into eight regions, the general properties of which are the same under all conditions, except for the definitions of the terms "ordinary" and "extraordinary". This latter point can be checked by considering the polarization for $N = 0, \nu = 0$.

Acknowledgements

The author would like to express his indebtedness to Dr. A. H. Waynick, under whose supervision the present work was done. Mr. H. J. Nearhoof, who has applied the present procedures to the analysis of experimental data, has been responsible for the detection of several errors and inconsistencies which might otherwise have found their way into this paper.

Elimination of the Nitro Group in the Process of Diazotization of 3, 4-Dinitraniline & 2, 5-Dinitro-*P*-Toluidine in Hydrochloric Acid—Part I

B. B. DEY, R. KRISHNA MALLER & B. R. PAI
Presidency College, Madras

During diazotization in hydrochloric acid, chlorine replaces the nitro group in position -4 of 3, 4-dinitraniline and in position -5 of 2, 5-dinitro-*p*-toluidine. These observations have extended Meldola's principles governing such displacements. The reaction has been explained in terms of electronic concepts and its analogy to the replacement reactions characteristic of *o*- and *p*-dinitrobenzenes has been brought out.

THE elimination of a nitro group and its replacement by chlorine in the course of diazotization of a dinitroaniline in hydrochloric acid was first observed by Meldola and Eyre¹ in the case of 2, 3-dinitro-4-methoxyaniline. On diazotization and subsequent treatment of the diazonium salt with alcohol, they had in this case obtained 2, nitro-3-chloroanisole instead of the 2, 3-dinitroanisole, which would be expected if the reaction had proceeded normally. Further, on coupling the diazonium salt with alkaline β -naphthol and analysing the resulting phenyl-azo- β -naphthol for nitrogen, they were able to account for the presence of only one nitro group in the dye. These observations led them to the conclusion that during the process of diazotization, one of the nitro groups had been eliminated and its place taken by chlorine. A similar abnormal behaviour was also noticed by Freyss¹ at about the same time in the case of 4, 5-dinitro-*o*-toluidine which, on diazotization, was found to have lost a nitro group and yielded 4, nitro-*m*-cresol.

Following upon their original observation, Meldola and his co-workers^{2,3} later made an extensive study of similar behaviour in the case of other isomeric dinitroanisidines and a few polynitroanilines, and the results of their researches led them to formulate

certain general conditions governing such eliminations, viz. (a) the nitro group should be either in the *ortho* or *para* position to the diazo group, and (b) there should be a second nitro group adjacent to the one which is displaced.

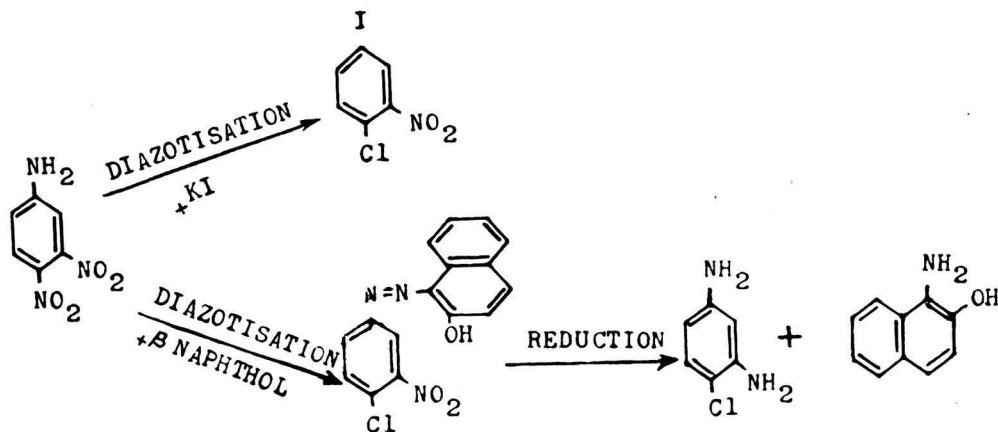
This easy replaceability of a nitro group by halogen during a diazo reaction need not be considered to be confined exclusively to compounds of the benzene series since a rearrangement somewhat on the lines of Meldola's observations has been reported by Morgan⁴ and others⁵ in the case of 1-nitro-2-amino-naphthalene where, in the presence of hydrochloric acid, the diazonium salt of the nitro base becomes transformed into the corresponding derivative of the chloro base. Similar replacements of substituent radicles by hydroxyl in diazo derivatives of the naphthalene series bearing a close analogy to Morgan's observation have been the subjects of study by Gaess and Ammelburg⁶ and also by Meldola and Streatfield.⁷

In so far as the study of diazotization in hydrochloric acid of dinitroanilines is concerned, it may be pointed out that Meldola and his co-workers had confined their investigations mainly to the eliminations that occur, during the process of diazotization, in heavily substituted anilines, thereby leaving room for the possibility of steric influences operating to help such displacements to take place. Moreover, neither Meldola nor the other subsequent workers had investigated the possibility of such displacements occurring in the case of the simplest dinitroanilines, conforming in their configuration to the conditions laid down by Meldola *et al.* It was, therefore, considered desirable to investigate from this point of view the behaviour of the three simple

isomeric dinitroanilines (2 : 3, 3 : 4 and 2 : 5) when subjected to diazo reaction.

It will be observed that of these three dinitroanilines, only two isomers, viz. 2, 3 and 3, 4-dinitroanilines, comply in full with the conditions prescribed by Meldola for

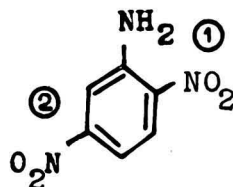
ponents of the reduced dye being found to be 4-chlor-*m*-phenylene diamine. This could be explained only on the assumption that the 4-nitro group had been replaced by chlorine in the course of the diazotization, thus :



the successful elimination of a nitro group, since, in the third isomer, viz. 2, 5-dinitroaniline, the nitro groups do not occur contiguously. Ginneken, quoted by de Mooy⁸, appears to have first made the observation that when 2, 3-dinitroaniline was diazotized and decomposed in a chloride solution, not only was the amino group but also the adjacent nitro group replaced by chlorine, yielding 3-nitro-1, 2-dichlorobenzene. This should obviously have followed from Meldola's postulate, but the other workers (Ginneken and de Mooy) did not apparently correlate their observation with the behaviour noted by Meldola of the similarly constituted dinitroanisidine nor did they proceed to investigate the same reaction with respect to the other isomer, viz. 3 : 4-dinitroaniline. This has now been done in detail and it has been found that, in conformity with Meldola's generalizations, a displacement of the nitro group in *para* position to the diazo group does take place readily and with ease. When a solution of diazonium chloride prepared from 3, 4-dinitroaniline was treated with potassium iodide in the usual manner, there resulted, instead of 3 : 4-dinitroiodobenzene, 3-nitro-4-chloro-1-iodobenzene. Further proof was obtained from the reduction of its

azo- β -naphthol derivative, one of the com-

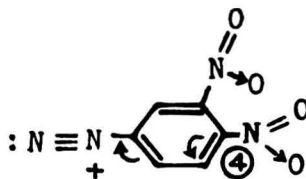
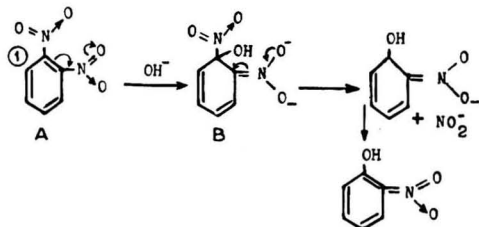
In the light of the foregoing observations and the generalization made by Meldola, the possible behaviour of 2, 5-dinitroaniline, when subjected to a similar diazo reaction, assumes special interest. If Meldola's conditions be accepted, the position of the second nitro group marked (2) in the diagram would not be propitious for a successful elimination of the nitro group marked (1). Attempts to prepare 2, 5-dinitroaniline in quantity by the separation of the mixed isomer resulting from the nitration of *meta*-nitroacetanilide were not very successful and so the similarly constituted toluidine derivative, viz. 2 : 5-dinitro-*p*-toluidine, was taken for investigation instead. The methyl group in 2 : 5 dinitro-*p*-toluidine, in so far as these displacements are concerned, may be considered to be without effect, since 4 : 5-dinitro-*o*-toluidine (cf. 3 : 4-dinitroaniline), when diazotized,



undergoes the normal elimination (Freyss, loc. cit.).

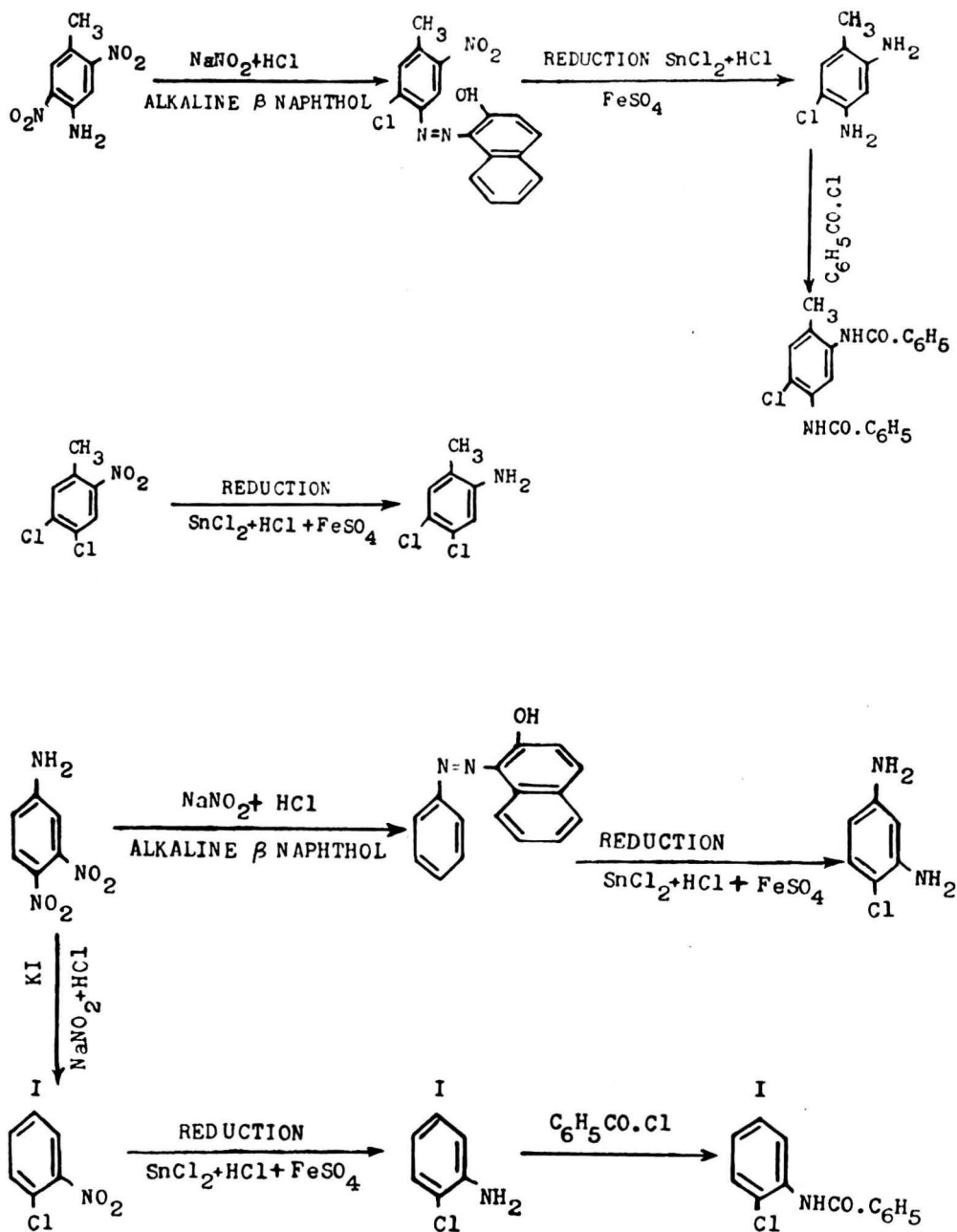
On diazotizing 2:5-dinitro-*p*-toluidine in hydrochloric acid, a replacement of the 5-nitro group by chlorine was found to occur, the product of Sandmeyer reaction being 2-nitro-4:5-dichlorotoluene. Further, on coupling the diazo body with alkaline β -naphthol and reducing the resulting dye, 5-chloro-*m*-toluylene diamine was obtained and identified by its benzoyl derivative. The conclusion is thus inevitable that elimination of the nitro group from a dinitroaniline can take place not only if the second nitro group is in the *ortho* position to the one suffering displacement but also when it is in the *para* position. This possibility does not appear to have been considered or investigated by Meldola and his co-workers. Meldola's postulate should, therefore, be modified as follows: In a benzenoid dinitroamine where the nitro groups occur either in the *ortho* or in the *para* positions to each other, one of them suffers elimination on diazotization in hydrochloric acid, the eliminated group being either in the *ortho* or in the *para* position to the diazo group.

In the aromatic compounds the phenomenon of displacement of a nitro group in the *ortho* or *para* position to another nitro group through the agency of nucleophilic reagents is now well established. The conversion of *ortho*-dinitrobenzene to *ortho*-nitrophenol by reaction with sodium hydroxide is explained on the basis of the electronic theory, as the result of the nucleophilic attack at carbon atom marked (1) in (A) (see diagrammatic representation below) being facilitated by the -M and -E effects of the nitro group in the *ortho* position. Restoration of aromaticity in the transition complex (B) leads to *ortho*-nitrophenol with ejection of the nitro group as the NO_2^- ion.



Extending these principles to *ortho*- or *para*-dinitroanilines, the nucleophilic displacement of the one nitro group is facilitated not only by the -M and -E effects of the other nitro group in the *ortho* or *para* position, but also by the tautomeric shift initiated by the positively charged diazonium pole, in the *ortho* or *para* position. Thus in 3,4-dinitrobenzene diazonium chloride, the structure resulting from the tautomeric shift as pictured in conjunction with the -M and -E effects of the nitro group at position (3) should facilitate the nucleophilic displacement of nitro group at position (4). In 2,5-dinitrobenzene diazonium chloride, since it is the (2) nitro group that is displaced by the action of nucleophilic reagents, it follows that the positive diazonium pole plays a definite rôle in increasing the susceptibility of the molecule to nucleophilic attack.

As regards the experimental technique involved in these diazotizations and the later isolation and identification of the resulting products, satisfactory methods of procedure have been worked out. In each case the diazotized amine was coupled with β -naphthol in alkaline solution and the azo dye obtained purified and then reduced with tin and hydrochloric acid to yield the component parts which were separated and identified by means of suitable derivatives. Further, the diazo compounds have been converted almost quantitatively to the chloro or iodo derivatives by employment of cuprous chloride and potassium iodide respectively, thus affording further confirmation of the conclusions reached. The reactions taking place are diagrammatically represented below. The methods worked out for the preparation of 3,4-dinitroaniline and 2,5-dinitro-*p*-toluidine are also described being variations of published procedures^{9,10} which were either scanty in detail or inconvenient to reproduce. In regard to the preparation of 2,5-dinitro-*p*-toluidine in particular, it may be mentioned that it was discussed in our earlier publication¹¹.



DIAGRAMMATIC REPRESENTATION OF REACTIONS.

Experimental Procedure

Preparation of 3:4-dinitroaniline — Nitration of *m*-nitroacetanilide: 10 gm. of alcohol crystallized sample of *m*-nitroacetanilide (m.p. 155°C.) dissolved in 40 c.c. of ice-cold concentrated sulphuric acid was treated in the course of 10 min. with a mixture of 10 gm. of potassium nitrate in 20 c.c. concentrated sulphuric acid and the mass kept stirred for nearly 3 hr. till room temperature was attained. The nitration product obtained after pouring the mixture into crushed ice was allowed to stand in contact with cold water overnight and the resulting yellowish red mass filtered, washed several times with water and air dried. The crude product weighed 14.4 gm.

Isolation of 2:3-dinitroacetanilides — The crude product (14 gm.) was dissolved in 40 c.c. boiling alcohol (93 per cent) and allowed to cool. The crystals obtained were removed by filtration and weighed 3.7 gr. The product sintered at 120°C. and fused completely at 170°C. It was redissolved in the minimum quantity of boiling alcohol (35 c.c. of 93 per cent) and allowed to stand. The pure product (2.7 gm.) thus obtained melted sharply at 186°-87°C. (2:3-dinitroacetanilide, m.p. 187°C.); yield, 21.6 per cent of theory.

The total alcoholic mother liquors were poured into about 500 c.c. of cold water and mechanically agitated and the precipitated yellow solid collected, washed on filter and air dried (4.3 gm.). On crystallization from a benzene-alcohol mixture (25 c.c. of benzene and 5 c.c. of absolute alcohol), 2.6 gm. of 3:4-dinitroacetanilide was obtained, m.p. 145°-46°C. (yield, 20.8 per cent of theory). This was refluxed with a mixture of 12.3 c.c. of concentrated sulphuric acid and 38.3 c.c. of 50 per cent ethyl alcohol for 2 hr. On allowing to cool to room temperature crystals separated which were collected, washed with dilute alcohol and air dried; yield, 1.4 gm. of 3:4-dinitroaniline, m.p. 153°-54°C. The alcoholic sulphuric acid mother liquor, on pouring into a large excess of water (300 c.c.) and stirring, precipitated a further quantity of 3:4-dinitroaniline (0.5 gm.); total yield, 1.9 gm. (18.5 per cent of theory based on *m*-nitroacetanilide).

Preparation of 3-nitro-4-chlorobenzene-azo- β -naphthol — 2 gm. of 3:4-dinitroaniline were stirred into a mixture of 4 c.c. of concentrated hydrochloric and 24 c.c. of glacial

acetic acids at room temperature and then cooled below 5°C. and treated rapidly with 0.8 gm. of sodium nitrite in minimum amount of water. The reaction was allowed to proceed for 10 min. at the end of which the excess nitrous acid was destroyed by urea and the clear diazonium solution obtained. It was then added dropwise to a cold well-stirred solution of 1.6 gm. of β -naphthol in 100 c.c. of 30 per cent caustic soda (aq.) and kept stirred for an hour. It was diluted at the end and the precipitated deep red dye filtered at the pump and washed free from alkali. It was then removed, ground up with dilute hydrochloric acid, filtered, washed and dried in an air oven; yield, 1.3 gm. Crystallization from ethyl acetate provided the pure dye, m.p. 200°C. (decomp.). Found: nitrogen, 12.9 per cent; $C_{16}H_{10}N_2O_3Cl$ requires nitrogen, 12.8 per cent.

*Preparation of 4-chloro-*m*-phenylene diamine from the azo-dye* — 1 gm. of 3-nitro-4-chlorobenzene-azo- β -naphthol was reduced by boiling with a mixture of 1 gm. of tin, 6 gm. of stannous chloride and 1 gm. of ferrous sulphate contained in 2:1 dilute hydrochloric acid (30 c.c.). After reduction was complete, as shown by the liquid becoming colourless (1 hr.), the clear solution was filtered off from the excess tin, diluted and the dissolved tin removed as sulphide by treatment in the hot with hydrogen sulphide gas. It was then concentrated on the water bath, basified with 30 per cent caustic soda solution and extracted thrice with 25 c.c. portions of chloroform. The extract was dehydrated over anhydrous sodium sulphate and the chloroform distilled off. The residue left on crystallization from 50 per cent ethyl alcohol yielded needles of 4-chloro-*m*-phenylene diamine, m.p. 91°C.

Preparation of 1-chloro-2-nitro-4-iodobenzene — 1 gm. of 3:4-dinitroaniline was diazotized in the manner already described and the clear diazonium solution obtained was treated dropwise with a solution of 2.2 gm. of potassium iodide in 5 c.c. of cold water. After the addition, during which there was considerable effervescence, the mass was stirred for an hour without extraneous cooling and then heated slowly to 80°C. when an oil separated out. The flask was then removed, cooled to room temperature and the contents diluted with water and the precipitated solid filtered off. It was then

ground up with dilute alkali, filtered, washed again and dried; yield, 1.2 gm. On crystallization from 93 per cent ethyl alcohol, reddish-brown needles of 1-chloro-2-nitro-4-iodobenzene separated out, m.p. 75°-76°C. Found: nitrogen, 4.6 per cent; $C_6H_3NO_2ICl$ requires nitrogen, 4.9 per cent.

On reduction with tin and hydrochloric acid and basification, 2-chloro-5-iodoaniline was obtained which was characterized by its benzoyl derivative. The sample crystallized from alcohol melted sharply at 159°C.

Preparation of 2:5-dinitro-para-toluidine — 15 gm. of *o*-nitro-acet-*p*-toluidine in 60 c.c. of concentrated sulphuric acid were stirred and treated below 5°C. with 15 gm. of potassium nitrate in 30 c.c. concentrated sulphuric acid, a little at a time, and the mixture kept stirred for 3 hr. in the cold. At the end, the solution was poured into melting ice and the precipitated solid filtered off, washed with cold water and dried. The pale-yellow product was crystallized from 93 per cent ethyl alcohol and obtained as straw-coloured needles; yield, 14.4 gm.; m.p. 130°-35°C. The dinitro base obtained from it by boiling with a mixture of ten times its weight of concentrated sulphuric acid and fifteen times its weight of water for 1 hr., crystallized from 93 per cent ethyl alcohol in orange-red needles; yield, 3.7 gm. (25 per cent of theory); m.p. 189°C.

2-nitro-5-chloro-toluene-azo-β-naphthol — A solution of 2 gm. of 2:5-dinitro-*p*-toluidine in a mixture of 5 c.c. concentrated hydrochloric acid and 30 c.c. glacial acetic acid was diazotized in the usual manner using 1 gm. of sodium nitrite in minimum amount of water. The clear diazonium solution obtained after being rid of excess nitrous acid was coupled with β-naphthol (1.6 gm. in 100 c.c. of 30 per cent caustic soda solution) and the purple-red dye obtained as in the previous case; yield, 2.3 gm. It crystallized from ethyl acetate, m.p. 192°C. Found: nitrogen, 12.5 per cent; $C_{17}H_{12}N_3O_3Cl$ requires nitrogen, 12.3 per cent.

*Reduction to 5-chloro-*m*-toluylene diamine* — 1 gm. of 2-nitro-5-chloro-toluene-azo-β-naphthol was suspended in 2:1 dilute hydrochloric acid (30 c.c.) and reduced using 1 gm. of tin, 6 gm. of stannous chloride and 1 gm. of ferrous sulphate. After 1 hr. of boiling, the clear solution was rid of excess

tin, diluted and the dissolved tin salts removed by treatment with hydrogen sulphide. The clear solution was concentrated and after basification extracted thrice with 25 c.c. portions of benzene chloroform mixture (1:1) and the extract dried over anhydrous sodium sulphate, filtered and distilled. The residue, on crystallization from a mixture of benzene and ligroin, yielded the pure 5-chloro-*m*-toluylene diamine, m.p. 120°-21°C. Its benzoyl derivative crystallized from ethyl alcohol in leaflets, m.p. 206°C.

*4:5-dichloro-*o*-nitro-toluene* — 1.5 gm. of 2:5-dinitro-*p*-toluidine, diazotized in the manner already described, was dropped in small amounts into a well-cooled and stirred solution of cuprous chloride (3 gm.) in 10 c.c. concentrated hydrochloric acid and 5 c.c. of water. After addition was complete, the mixture was agitated for an hour without cooling and then warmed on a water bath to 80°C. It was then removed and distilled in steam, when a yellow solid came over in the distillate. After chilling the latter in an ice chest for a while, the solid was filtered off and dried; yield, 0.8 gm. On crystallization from 93 per cent ethyl alcohol, yellow rectangular plates of 4:5-dichloro-2-nitro-toluene separated out, m.p. 63°-64°C. Found: nitrogen, 6.98 per cent; $C_7H_5NO_2Cl_2$ requires nitrogen, 6.8 per cent. On reduction with tin and hydrochloric acid, 4:5-dichloro-*o*-toluidine resulted; m.p. 101°C.

Summary

On diazotizing 3:4-dinitroaniline and 2:5-dinitro-*para*-toluidine in hydrochloric acid, the nitro group in *para* and *ortho* position respectively to the diazo group was found to be replaced by chlorine. The observation relating to the behaviour of 2:5-dinitro-*p*-toluidine has made necessary a modification of the conditions laid down by Meldola *et al.* for the occurrence of similar eliminations from substituted dinitroanilines. In addition, a close analogy seems to exist between these replacement reactions and those that are observed in *o*- and *p*-dinitrobenzenes, which has been brought out clearly when explained in terms of electronic concepts.

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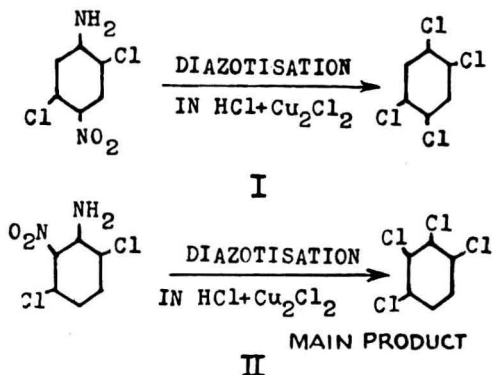
Elimination of the Nitro Group in the Process of Diazotization of 3-Chlor-4,6-Dinitroaniline in Hydrochloric Acid—Part II

B. B. DEY, R. KRISHNA MALLER & B. R. PAI
Presidency College, Madras

Replacement of both the nitro groups by chlorine takes place not only when 3-chlor-4,6-dinitroaniline is diazotized in hydrochloric acid but also on merely heating the compound with concentrated hydrochloric acid.

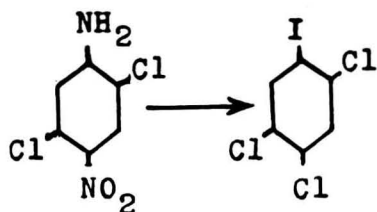
ALTHOUGH diazotizations of monochloronitranilines like 2 and 3-chlor-4-nitranilines in hydrochloric acid solution proceeds normally^{1,2}, the presence of a second chlorine atom in these nitranilines, occurring in the *para* position with respect to the first, has been reported to give abnormal products under the ordinary conditions of diazotization. Thus, in the case of 2,5-dichlor-4-nitroaniline, Holleman and Haeften³ observed that the diazotization of the amine in the usual way in hydrochloric acid solution in the presence of cuprous chloride, and decomposition of the diazo solution with Gattermann copper, led *not* to the expected 2,4,5-trichloronitrobenzene, but to a tetrachlorobenzene (1,2,4,5) instead (I). Similarly, on treating in the same way its *ortho*-nitro isomer, viz. 2,5-dichlor-6-nitraniline, they reported the formation mainly of 1,2,3,4-tetrachlorobenzene (II).

Later, Dey *et al.*⁴ made an analogous observation during the diazo replacement by iodine of the amino group in 2,5-dichloro-4-nitraniline. They noticed that when the



latter was diazotized in a hydrochloric acid solution and treated with potassium iodide, a product was obtained, free from nitrogen, which, on closer examination, proved to be identical with 2,4,5-trichlor-1-iodobenzene.

It will be observed from the foregoing changes that the nitro group suffering elimination and replacement by halogen has been either in *ortho* or *para* positions to the diazo group. These results constitute, therefore, a close parallel to the observations recorded by Meldola and his co-workers⁵ who, in connection with their studies on the elimination of the nitro group from diazotized dinitro-anisidines, had noticed that the dis-

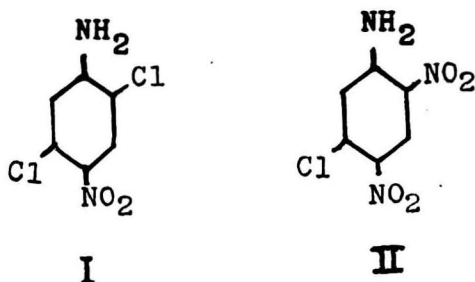


placed nitro group is either in the *ortho* or the *para* positions with respect to the diazo group. In addition, they had also postulated that there should be a second nitro group adjacent to the one which is displaced.

While Holleman and Haeften³ had failed to note the connection between their own observation and that of Meldola, Dey *et al.* (*loc. cit.*) first pointed out the close analogy existing between the two sets of reactions and also suggested that Meldola's general principle might be extended by postulating that the group adjacent to the nitro group displaced need not necessarily be a second nitro group but may even be a chlorine atom. Further, since normal diazotizations occur in the cases both of 2-chloro and 5-chloro-4-nitranilines even in the presence of hydrochloric acid^{1,2}, it is evident that the peculiar behaviour of 2,5-dichloro-4-nitraniline towards the diazo reaction can be attributed only to the combined influences of both the chlorine atoms occurring in *para* position to each other in the molecule. The suggestion was, therefore, natural that the presence of groups like methoxyl and ethoxyl might produce similar effects in substituted nitranilines. This led to a study of the literature on the subject which showed, however, that compounds like 2, methoxy-5-chloro⁶, 2-chloro-5-methoxy⁷ and 2,5-dimethoxy-4-nitranilines⁸ behaved normally on diazotization in hydrochloric acid.

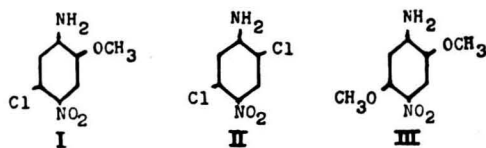
A study of the effect, if any, produced by the replacement of one of the chlorine atoms in 2,5-dichloro-4-nitraniline by a nitro group on its behaviour during diazotization, therefore, seemed to be of interest. Of the two such possible compounds, one, viz. 2-chloro-4:5-dinitraniline (I), should obviously

undergo elimination of the nitro group in the 4th position irrespective of the influence of the halogen atom in it, according to the postulates of Meldola and his co-workers (*loc. cit.*). Moreover, it has already been shown in part I of this series that 3,4-dinitraniline, when diazotized in hydrochloric acid, has its nitro group in position 4 replaced by halogen. There remains, therefore, only the other possible compound, viz. 3, chlor-4, 6-dinitraniline (II), to be investigated.

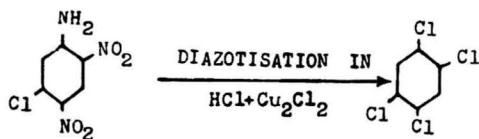


This compound has been described by Nietzki and Schedler⁹ and later by Fries and Roth¹⁰ who both obtained it by the same method, viz. the action of alcoholic ammonia on 4,6-dichloro-1,3-dinitrobenzene. Later, Nietzki and Zanker¹¹ claimed to have prepared it from 5-chloro-1,2,4-trinitrobenzene by the same method. Since these methods required the preparation of the intermediates themselves by the chlorination or nitration of suitable benzene derivatives, a more convenient and simple process appeared to be to start with *meta*-chloroacetanilide and dinitrate it in one step to the required compound. This has been accomplished by a modification of the process by Kehrman and Stanoyevitch¹², the modified procedure consisting in the employment of a mixture of nitric acid (*d*, 1.52) and oleum (12 per cent). Certain drawbacks of the Kehrman method are discussed in a previous publication¹³.

The diazotization of 3, chlor-4, 6-dinitraniline in a mixture of glacial acetic and hydrochloric acids and treatment of the diazonium solution with cuprous chloride (Sandmeyer reaction) resulted in a product which was found to be free from nitrogen and which was later identified to be 1,2,4,5-tetrachlorobenzene. This was surprising since it implied the simultaneous displace-



ment of both the nitro groups during diazotization. A similar formation in small quantities of tetrachlorobenzene during the Sandmeyer reaction on 3-chlor-4,6-dinitraniline had also been observed by Hodgson¹⁴, but the main product in his experiments was a trichloronitrobenzene. Further confirmation for the total elimination of the nitro groups from 3-chlor-4,6-dinitraniline was obtained when its diazonium chloride solution was on the one hand coupled with β -naphthol and on the other hand treated with potassium iodide. The former gave a dye which analysed correctly for trichlorobenzene-azo- β -naphthol, which on reduction gave 2,4,5-trichloraniline identified by its benzoyl derivative and also by analysis. The latter treatment yielded a product which proved to be 2,4,5-trichloro-1-iodobenzene, being identical with that obtained by Dey *et al.* (loc. cit.) as a result of the diazo displacement by iodine of the amino group in 2,5-dichlor-4-nitraniline.



Apart from its behaviour on diazotization 3-chlor-4,6-dinitraniline affords a unique example of a nitro compound which splits off its nitro groups on merely heating its solution in a mixture of glacial acetic and hydrochloric acids to 100°C. Nitrous fumes were evolved with effervescence and this was observed to continue even after the heating was discontinued. In the resulting solution the presence of both 1,2,4,5-tetrachlorobenzene and 2,4,5-trichloroaniline were detected. It is, therefore, seen that mere heating of the compound with

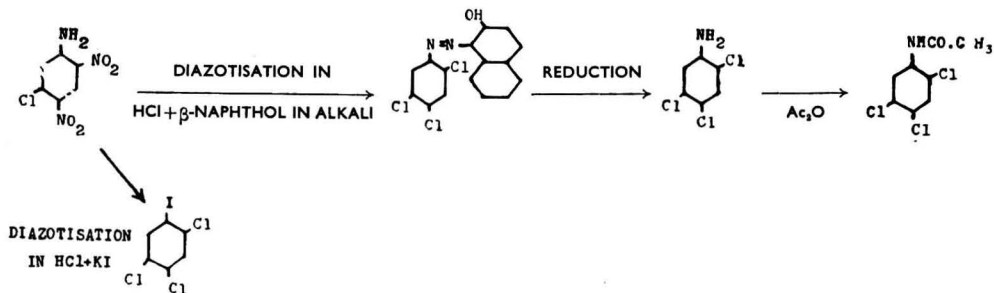
hydrochloric acid is enough to eliminate both the nitro groups and replace them by chlorine, thereby giving rise to 2,4,5-trichloraniline which in its turn is partly diazotized by the nitrous acid originating from the displaced nitro groups, the resulting diazonium group being replaced by chlorine to yield 1,2,4,5-tetrachlorobenzene. The new observations furnish an interesting and rare example in organic chemistry of consecutive reactions, the products of one serving to continue the other.

Experimental Procedure

Preparation of 3-chlor-4,6-dinitraniline — 25 gm. of *meta*-chloraniline hydrochloride, treated with a little over one mole of acetic anhydride and refluxed for 1½ hr., was poured into crushed ice and the acetamide compound separating removed and purified by washing with dilute sodium carbonate solution; yield of dry product, 19.7 gm. (76.3 per cent of theory); m.p. 78°-79°C.

10 gm. of pure, dry *m*-chloracetanilide were added, a little at a time, to a well-stirred mixture of 7 c.c. concentrated nitric acid (*d*, 1.52) and 17.5 c.c. of 12 per cent oleum kept at 0°-5°C. On completion of addition (1 hr.), the mixture was stirred for 1 hr. at ice-cold temperature and then poured in a thin stream into crushed ice (300 gm.). The mass was stirred for some time and the acid liquors decanted. The sticky solid left was washed with more water and finally treated with about 300 c.c. of cold water and mechanically agitated (1 hr.) till it had granulated. It was then filtered off, washed with a little cold water and allowed to dry in air.

The crude nitration product (14 gm.) was crystallized from alcohol (93 per cent). The crystals were filtered off and pressed free from mother liquor and then dried in a calcium chloride desiccator. The dark



brownish-yellow crystals thus obtained (6.4 gm.) were treated with a mixture containing 16 c.c. of concentrated sulphuric acid and 96 c.c. of 50 per cent alcohol and refluxed gently for 2 hr. It was then allowed to crystallize first at room temperature and then in the frigidaire overnight. The free chloro-dinitro base separating was filtered, pressed and allowed to dry in a calcium chloride desiccator (yield, 4.7 gm.). On crystallization from 93 per cent alcohol, pure 3-chloro-4, 6-dinitraniline separated out as brownish-yellow needles; yield, 3 gm. (23.5 per cent of theory); m.p. 174°C.

2, 4, 5-trichlorobenzene-azo- β -naphthol—1 gm. of 3-chloro-4, 6-dinitraniline suspended in a mixture of 10 c.c. concentrated hydrochloric and 10 c.c. of glacial acetic acids was heated to 100°C. when complete dissolution took place accompanied by effervescence and evolution of reddish fumes. It was then cooled to room temperature, filtered and the clear solution, kept agitated mechanically in an ice bath, was treated rapidly with 0.4 gm. of sodium nitrite in the minimum amount of cold water. Allowing 10 min. for completion of diazotization, the solution was treated with urea and the clear diazonium solution obtained by filtration. It was then added dropwise to an ice-cold solution of 0.8 gm. β -naphthol in 50 c.c. of 30 per cent caustic soda (aq.) and kept well stirred. After addition, the contents of the flask were kept stirred in the cold for an hour, then diluted and the precipitated red dye filtered off. It was washed free from alkali, then ground up with dilute hydrochloric acid, filtered and washed again. The air-dried dye, on crystallization from ethyl acetate, was obtained as dark-red sheaves of needles; yield, 0.75 gm.; m.p. 197°-98°C. Found: nitrogen, 7.6 per cent; $C_{16}H_9ON_2Cl_3$ requires nitrogen, 7.95 per cent.

Reduction of the Dye to 2, 4, 5-trichloraniline—0.5 gm. of 2, 4, 5-trichlorobenzene-azo- β -naphthol was reduced in the usual manner and after reduction basified and steamed. The distillate on cooling in the frigidaire gave 0.3 gm. of 2, 4, 5-trichloraniline. On crystallization from ligroin, it melted at 95°-96°C. and formed an acetyl derivative, m.p. 189°C. (crystallized from ethyl alcohol). Found: nitrogen, 6.0 per cent; requires nitrogen, 5.87 per cent.

Preparation of 1, 2, 4, 5-tetrachlorobenzene—1 gm. of 3 chlor-4, 6-dinitraniline was diazo-

tized in the manner previously described and the clear diazonium solution poured dropwise into a well-cooled and stirred solution of cuprous chloride (3 gm.) in 10 c.c. of concentrated hydrochloric acid and 5 c.c. of water. After the addition was complete, the mixture was stirred for 1 hr. at room temperature and then for a few minutes at 80°C. It was then diluted and distilled in steam. The distillate on cooling in frigidaire yielded a white solid (0.6 gm.). On crystallizing it from a mixture of ethyl alcohol (absolute) and benzene (1:1), 1, 2, 4, 5-tetrachlorobenzene, m.p. 140°C., separated out as needles.

Preparation of 2, 4, 5-trichloro-1-iodobenzene—1 gm. of 3-chlor-4, 6-dinitraniline was diazotized in the manner already described and the clear diazonium solution was treated dropwise with a solution of 0.75 gm. of potassium iodide in 2 c.c. of water. The mixture was stirred for 1 hr. at room temperature and then slowly heated to 80°C. After cooling, the solid was filtered off, ground up with dilute alkali, filtered again, washed and crystallized from alcohol. 0.5 gm. of the pure 2, 4, 5-trichloro-1-iodobenzene was obtained; mixed m.p. with an authentic sample, 106°C. (no depression).

Action of Hot Hydrochloric Acid (Concentrated) on 3-chlor-4, 6-dinitraniline—1 gm. of 3-chlor-4-6-dinitraniline was heated in a round-bottom flask (100 c.c.) with a mixture of 10 c.c. glacial acetic and 10 c.c. of concentrated hydrochloric acids. Effervescence was noticed to commence at 98°-100°C. when the flask was removed from the flame. Even after, the effervescence continued, evolving reddish-brown fumes, which turned a wet starch iodide paper blue. When the effervescence had ceased, the contents of the flask were steamed and the distillate collected and cooled in frigidaire when a white solid separated out (0.2 gm.). On boiling this solid with a little tin and hydrochloric acid for 1 hr., a portion went into solution. It was filtered off, washed with water and crystallized from ethyl alcohol-benzene (1:1) mixture; melting point with an authentic sample of 1, 2, 4, 5-tetrachlorobenzene 140°C. (no depression).

The filtrate was basified and steamed when 0.1 gm. of a steam volatile product was obtained which, on crystallization from ligroin, melted at 95°C. and did not depress

the mixed melting point with a sample of 2, 4, 5-trichloroaniline.

The original solution remaining after the removal of steam volatile constituents contained a little resinous matter which was filtered off. The filtrate, on diazotization and coupling with β -naphthol in the manner already described, yielded a dye (0.5 gm.) which on reduction gave a base which was identified to be 2, 4, 5-trichloroaniline (acetyl derivative, m.p. 190°C.).

Summary

3-chlor-4, 6-dinitraniline on diazotization in hydrochloric acid medium has been shown to suffer elimination of both the nitro groups and their replacement by chlorine. Mere heating the compound with hydrochloric acid has been found to produce the same result.

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of this investigation and for kind permission to publish the results.

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Separation of Argemone & Mustard Seeds by Air Elutriation

SURAJDEO PRASAD

Industrial Research Laboratory, Patna

A method based on the principle of air elutriation has been developed for separating mustard seed from commercial adulterated samples containing argemone. The conditions for efficient separation and for securing maximum yields have been worked out.

EPIDEMIC dropsy prevalent over wide areas in which mustard oil is consumed has been attributed to the presence in commercial mustard oil of argemone oil containing the alkaloids sanguinarine and dihydrosanguinarine^{1,2}. The presence of the toxic oil is due to the circumstance that mustard seeds (*Brassica juncea* Coss. and *B. campestris* Linn. Ver. *Sarson* Prain) used for the expression of oil are sometimes found admixed with argemone seeds (*Argemone mexicana*). Chemical methods have been suggested for the effective separation of the toxic alkaloids³ and so rendering the commercial oil harmless. A more rational and a simpler method would

be to eliminate the argemone seed from adulterated mustard seed before extracting the oil from the latter.

The air elutriation method worked out for the separation is based on the principle that when a mixture of the two seeds is confronted with an air current moving vertically upwards with a velocity intermediate between the settling velocities of the two, the seed with a lower settling velocity is carried upward, while that with a faster settling velocity comes down.

The theory of elutriation has been discussed by various authors^{4,5}. Under the conditions of eddying resistance, if a particle of density ρ_1 and diameter D settles down in a fluid of density ρ , then the velocity V of fall of the particle is given by the equation :

$$V = K\sqrt{\frac{gD}{\rho}(\rho_1 - \rho)} \dots \dots \dots (1)$$

where K is a constant and g is the acceleration due to gravity.

This relationship is true when the particles settle freely. If interfering particles are present, as in the present case, the settling is hindered. If ρ , representing the apparent density of solid-air mixture, is small in

comparison to ρ_1 , then equation (1) may be written as :

$$V \propto \sqrt{D\rho_1} \dots\dots\dots(2)$$

It will be apparent that when a mixture containing mustard and argemone seeds is subjected to the air elutriation, the percentage of mustard recovery depends upon the difference in the average values of $\sqrt{D\rho_1}$ for the two seeds.

Procedure

The elutriator (FIG. 1) was constructed by joining an inverted U-tube, 0.5" internal dia., to a tube 0.625" internal dia. The feed for the mixture was slightly widened to avoid choking. A water manometer (T) to measure the pressure drop was provided below the point where the air enters. The lower end of the elutriator was fitted with rubber tubings and pinch cocks (P_2 and P_3).

Air was blown in from an adjustable 1/4 h.p. blower fitted with a flow gauge. The mixture of argemone and mustard seeds was fed through a conical funnel continuously at a rate controlled by adjusting the pinch cock (P_1). A mild tapping of the hopper was sometimes necessary to prevent choking.

The blower was adjusted to give the optimum air velocity for separating mustard seed. The Reynold number of the air flow in the elutriator was kept above the viscous range. When a mixture of the two seeds is fed, the argemone seed collects in the range AB, the mustard seed in the range BC. Any mustard seed (except the undersized ones) which may be carried to

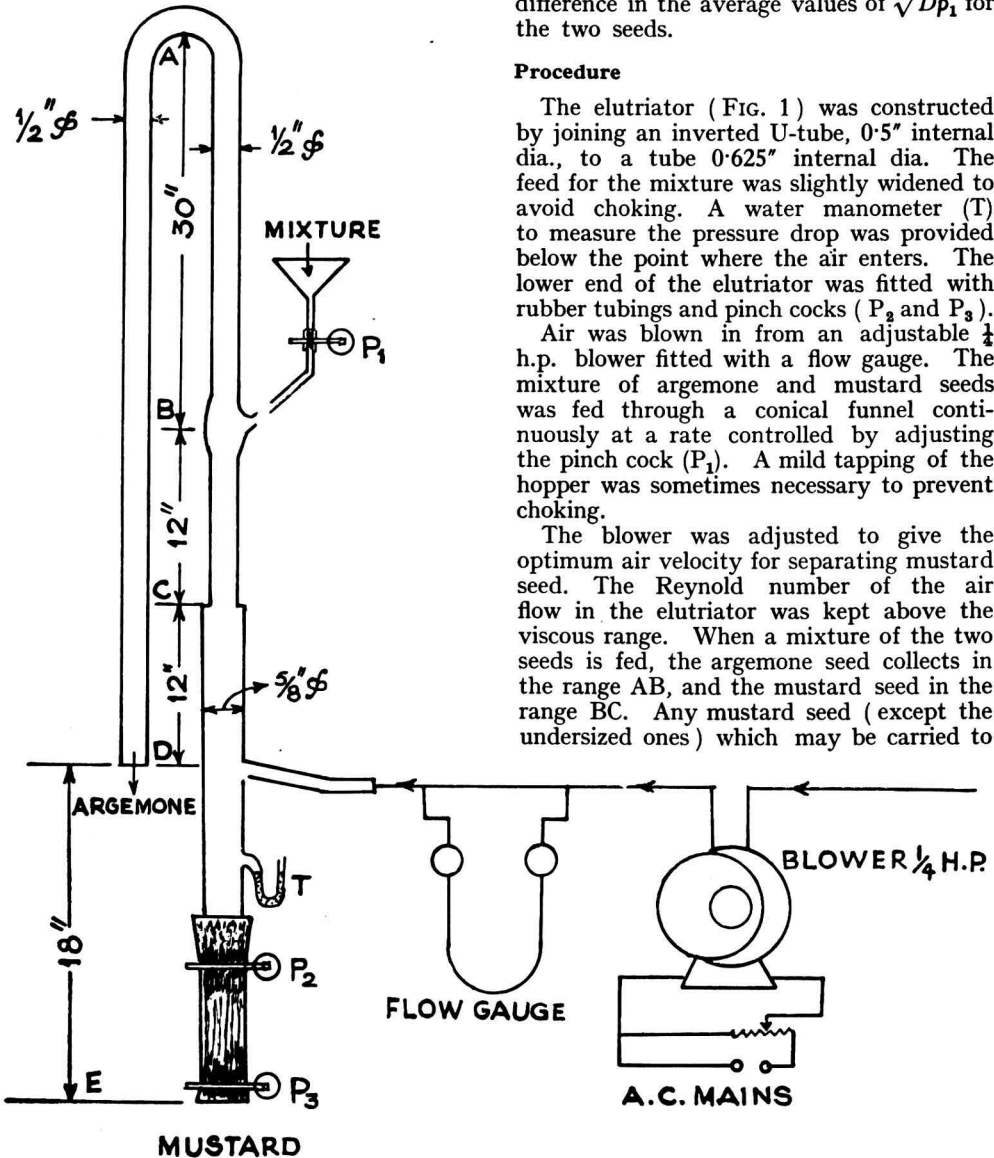


FIG. 1 — THE ELUTRIATOR.

the range AB gradually comes down. As soon as the mustard seed reaches C, its velocity of fall increases due to the lower air velocity in the range CD.

The elutriator can be operated continuously and the separated seeds drawn out by alternately releasing P₂ and P₃.

Results

The results obtained with black and yellow mustard seeds collected from different regions in U.P. and Bihar are given in Table I. The physical characteristics of the mustard seeds are given in Table II. Two varieties of argemone seeds obtained from north and south Bihar were used as adulterants. The average density, diameter and weight of the two samples of argemone are given in Table III.

There is a small but definite difference in the diameters and densities of mustard and argemone seeds. These differences are maintained even after partial drying of the seeds,

TABLE III—PHYSICAL CHARACTERISTICS OF ARGEMONE SEEDS

SOURCE	DENSITY	AV. DIA., cm.	AV. WT. OF EACH SEED, gm. × 10 ⁻³	√Dp ₁
North Bihar	0.949	0.152	1.789	0.382
South Bihar	0.907	0.159	1.896	0.380
<i>Freshly Harvested</i>				
Bihar	1.305	0.143	2.183	0.432

thus making possible the separation of the seeds.

The percentage of mustard seeds recovered by separation is given in Table I. The loss is usually due to undersize seeds and dirt. Fig. 2 gives the percentage of mustard seed recovered in relation to the average value of √Dp₁. It will be seen that the recovery is a maximum when the difference between √Dp₁ values for mustard and argemone samples is a maximum.

A pilot plant has been designed on the basis of data obtained in this investigation. The elutriator described here can be employed

TABLE I—MUSTARD SEED RECOVERED FROM ADULTERATED SAMPLES

Air velocity varied according to sample from 225 to 372 cm./sec. ; Reynold number 2165 to 3350

MUSTARD SEED	SOURCE	OIL CONTENT, %	ARGEMONE SEED IN ADULTERATED SAMPLES, %	MUSTARD SEED RECOVERED, %
<i>Partially Dry</i>				
Black and yellow mixed	Bahjoi, U.P.	44	8.7	99.02
Black (<i>Rai</i>)	Khagaria, Bihar	...	10.0	78.5
Yellow	Saran, Bihar	...	8.6	94.5
Black (<i>Lahi</i>)	Bhartua, U.P.	38	31.3	96.5
Yellow	Chandausi, U.P.	47	11.7	99.5
Black (<i>Lahi</i>)	Safidone Mondi, U.P.	32	14.5	96.8
Black (<i>Rai</i>)	Mangra Badshahpur, U.P.	38	8.6	92.9
Yellow	Chandausi, U.P.	44	10.8	97.3
Yellow	17.0	92.0
Black (<i>Rai</i>)	Mirjanhat, Bhagalpur	36	9.4	71.9
<i>Freshly Harvested</i>				
Yellow	Bihar	...	47.2	99.0
Black	Bihar	...	45.0	98.0

TABLE II—PHYSICAL CHARACTERISTICS OF MUSTARD SEED

MUSTARD SEED	SOURCE	DENSITY	AV. DIA., cm.	AV. WT. PER SEED, gm. × 10 ⁻³	√Dp ₁
<i>Partially Dry</i>					
Black and yellow mixed	Bahjoi, U.P.	1.070	0.210	5.417	0.482
Black (<i>Rai</i>)	Khagaria, Bihar	1.159	0.166	2.818	0.438
Yellow	Saran, Bihar	1.112	0.183	3.583	0.451
Black (<i>Lahi</i>)	Bhartua, U.P.	1.128	0.198	4.634	0.472
Yellow	Chandausi, U.P.	1.082	0.213	5.557	0.431
Black (<i>Lahi</i>)	Safidone Mondi, U.P.	1.116	0.191	4.118	0.483
Black (<i>Rai</i>)	Mangra Badshahpur, U.P.	1.142	0.182	3.683	0.455
Yellow	Chandausi, U.P.	1.010	0.216	5.350	0.487
Yellow	...	1.016	0.182	3.683	0.447
Black (<i>Rai</i>)	Mirjanhat, Bhagalpur	1.149	0.159	2.497	0.427
<i>Freshly Harvested</i>					
Yellow	Bihar	1.337	0.169	3.378	0.475
Black	Bihar	1.393	0.162	3.101	0.474

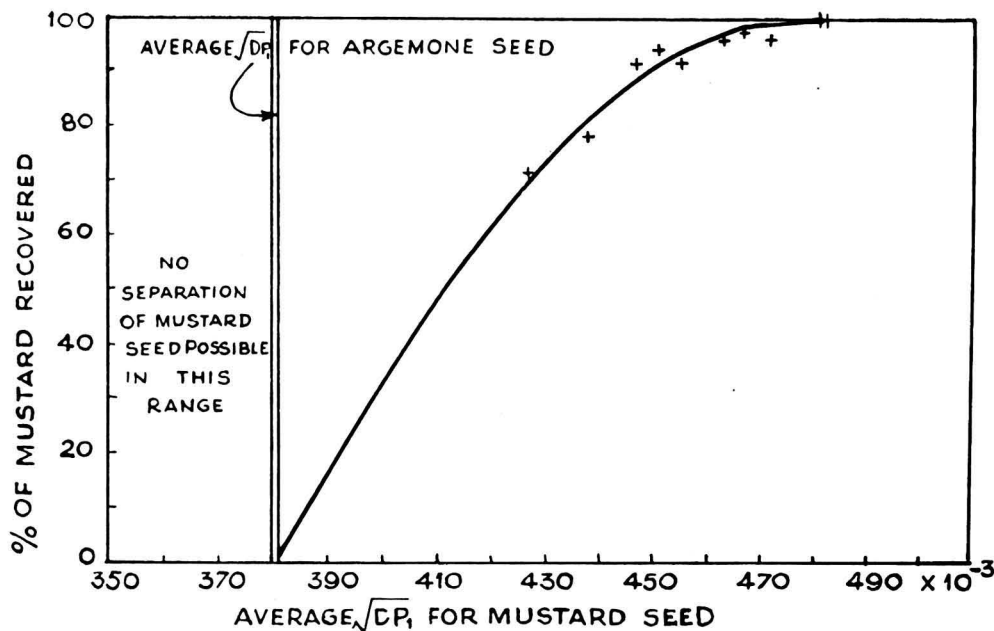


FIG. 2 — RECOVERY OF MUSTARD VARIES WITH $\sqrt{DP_1}$.

for determining the extent of adulteration in representative samples of commercial mustard seeds.

Acknowledgement

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Letters to the Editor

PERIODATE OXIDATION OF DYESTUFFS CONTAINING THE HYDROQUINONE GROUPING

WHILE ANALYSING DIAMINO ACID PHOSPHOTUNGSTATE solutions made up with dil. sod. hydroxide (alkaline to Alizarin Red S) for hydroxylysine by the periodate oxidation technique of Van Slyke¹, it was constantly observed that the indicator, instead of remaining purplish violet at the reaction employed, turned to a pale yellow-brown

on the addition of periodic acid solution. It was further noted that the property of the dyestuff as an indicator had been destroyed. Alizarin Red S has the formula 1,2-dihydroxy anthraquinone-3-sulphonate and acts as an indicator in the pH range 3.7 to 4.2.

It was initially suspected that the oxidation might be a case involving the scission of the ring between the two hydroxyl groups, as occurs, for example, with hexahydroxy-

cyclohexane (inositol)³. However, we were led to examine whether this oxidation may not be simpler and similar to that effected by alkaline ferricyanide and other mild oxidizing agents. For this the absorption characteristics of the periodate oxidized dyestuff were compared with those of the ferricyanide oxidized dyestuff in the visible range of the spectrum using the Coleman No. 14 spectrophotometer. There was a close similarity between the two (FIG. 1).

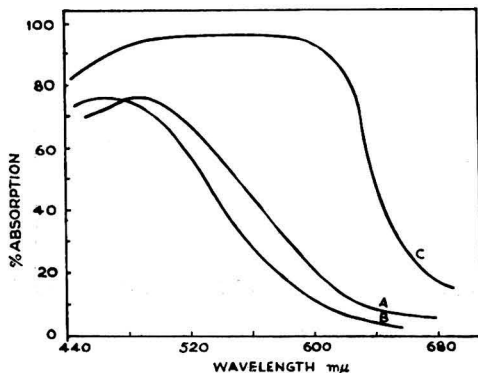
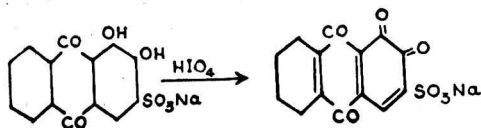


FIG. 1 — ABSORPTION CURVES: A, ALKALINE FERRICYANIDE OXIDIZED; B, PERIODATE OXIDIZED; C, ALIZARIN RED S.

For the comparison 0.5 c.c. of a 0.5 per cent soln. of the dyestuff oxidized with 1.2 c.c. of a 1.0 per cent soln. of ferricyanide and 0.5 c.c. of a 0.5M soln. of periodic acid were used. The total vol. was 20 c.c., the concentration of free alkali in each case being equivalent to 2.6 c.c. of 2N NaOH. Readings were taken, at this high alkaline pH, at 10mμ intervals against appropriate blanks.

Apparently, the oxidation proceeds to the quinone stage and no dissociable coloured salts are formed at the particular hydrogen ion concentration. Thus 1, 2-dihydroxy-anthraquinone-3-sulphonate gets oxidized to 1, 2, 9, 10-anthraquinone-3-sulphonate:



These experiments have been repeated with Alizarin Yellow, Alizarin Orange, Quinizarin, Gallein, Purpurin, etc. The close similarity between the absorption curves rule out the possibility of any blocking effect due to esterification of the OH-groups by *para*-periodic acid, etc., and obviously the anthraquinone part of the molecule is left intact as is the case with other mild oxidizing agents. Hence, the observed oxidation of Alizarin Red S is a case of oxidation of the *o*-catechol type of grouping to the *o*-quinonoid grouping; in other cases it is oxidation of the hydroquinone grouping to the quinonoid grouping. One mole of periodic acid makes available one atom of oxygen for this oxidation, which is instantaneous in the alkaline medium.

The above is in agreement with Criegee's surmise² that periodic acid can dehydrogenate hydroquinone, even though it is incapable of effecting additions, substitutions and dehydrogenations characteristic of lead tetra-acetate oxidations. However, while the periodic acid oxidation of compounds having the α -glycol, α -amino-alcohol structure, etc., is well known and made use of in diverse analytical techniques, the oxidation of the *o*-catechol type of grouping to the *o*-quinonoid, and of the hydroquinone structure to the quinonoid, has not so far been demonstrated.

Acknowledgement

Thanks are due to Dr. B. B. Dey for his kind interest in this investigation.

L. K. RAMACHANDRAN
P. S. SARMA

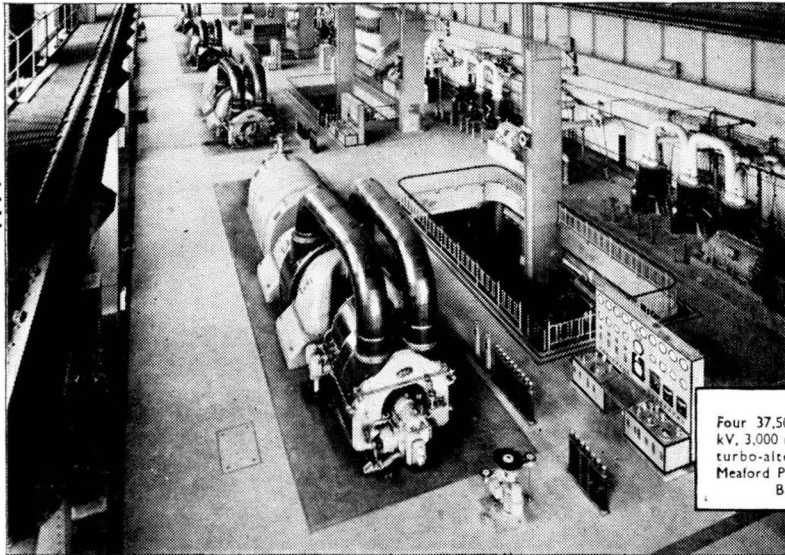
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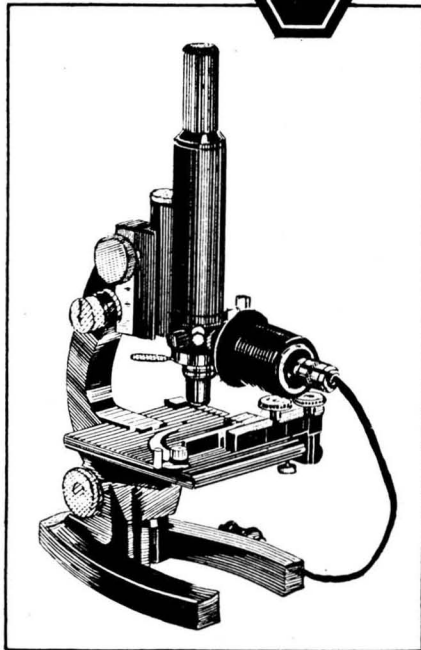


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