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CONTENTS

For Index to Advertisers, see page A17

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Current Topics

Collaboration between Research & Industry

THE first 'get-together' of scientists and representatives of industry, held in New Delhi during 20-21 December 1965, under the auspices of the Council of Scientific & Industrial Research, is of considerable significance for the future growth and expansion of India's economy. Ever since India embarked on a planned programme of economic development 15 years ago, there has been marked spurt in both industrial development and research effort. A peculiar but not wholesome feature of this phase of expansion has been that the growth in these two spheres has, by and large, tended to be unrelated. As a result, indigenous research contribution has not had the desired degree of impact on and participation in the progress of industry, and the industry has continued its reliance on foreign collaboration, based on turn-key contracts, in establishing industries, in preference to exploiting the results of indigenous research effort. This situation is perhaps partly due to the inherent differences in the organizational set-up in the two spheres. Research is mostly state-controlled and a substantial part of the industry is in the private sector. Also, the foreign collaborators are able to provide, in addition to fool-proof plants, design engineering and consultancy services, facilities not much developed in India. The lack of proper liaison between research and industry, and the absence of a two-way system whereby the results of indigenous research effort could be effectively fed to industry and conversely the problems of industry fed to the laboratories for solution, can lead to consequences detrimental to the healthy growth of both. The credit for the first positive step towards forging a link between research and industry in the country, so that they may jointly make the fullest possible contribution to the attainment of various economic and social objectives, goes to Shri M. C. Chagla, Union Minister for Education, for having mooted the idea of the get-together.

Convened at a time when the country is facing gigantic problems like persistent adverse balance of trade, food shortage and defence preparedness, the get-together was planned with specific objectives, viz. (1) development of substitutes for imported raw materials; (2) indigenous manufacture of essential components hitherto imported; (3) development of indigenous technological know-how at a sufficiently advanced level in respect of those articles on which foreign collaboration has been sought; and (4) measures by which the programmes of industrial research could be oriented to the needs and requirements of industry. The fields covered were grouped under 15 heads with a working group for each. Discussions at the working group meetings centred mainly round key papers prepared by conveners of the respective working groups on the basis of individual papers received from the participants in advance. After intensive discussion on the key papers, the working groups framed recommendations* in respect of both short- and long-range projects in their respective fields as well as on a variety of problems, of both specific and general nature, having a bearing on the collaboration between research and industry.

In the major task of identifying areas deserving priority of attention and spelling out problems needing to be tackled, the get-together undoubtedly achieved a high measure of success. With a surprisingly good response from the industry — more than 50 per cent of the participants as well as papers were from industry — well-coordinated and meticulous spadework at the planning stage, and the business-like manner in which the deliberations were conducted, the working groups were able to put forth pinpointed recommendations, not merely on the tasks to be tackled, but also, in most cases, allotting the tasks to institutions best suited and equipped for undertaking them. On account of the wide diversity of fields covered, there was considerable variation in the recommendations made. Thus, while some fields, particularly the engineering industries, by their very nature, permitted the formulation of specific time-targeted projects for the concerned research institutions, in some other areas the recommendations were necessarily of a general nature.

In the ultimate analysis, the get-together has a more profound and deeper significance in so far as it considered some of the basic problems, such as the mechanics of collaboration between research and industry, the shortcomings in the basic philosophy, structure and approach to various problems by research establishments and industry, and the problems of finance and personnel. A widely expressed view about which there can be no two opinions was the need for bringing about effective association of technical and managerial personnel from industry, representing the ultimate users of research results, with the formulation and execution of research programmes of research establishments. It was suggested that funds should be freely made available for the posting of personnel from research organizations to manufacturing units in industry to organize follow-up of their processes taken up by industry. Another fruitful line of collaboration suggested was the establishment of joint functional research cells entrusted with the task of thoroughly going into the economic and technological feasibility of every project before it is taken up for execution by a laboratory.

**First get-together of research and industry, December 20-21, 1965 — Recommendations* (Council of Scientific & Industrial Research, New Delhi), 1966. Pp. viii+124.

Some of the papers submitted for the get-together as well as discussion held by the working groups served to draw attention to the basic drawbacks in the approach and outlook of research establishments towards the conduct of research programmes. The most important among them is that while great emphasis is laid on applied research in the laboratory, the importance of developmental research, which is so necessary to carry the know-how developed on a laboratory scale to the stage of commercial utilization, has not received sufficient attention. The recommendation of the working group on 'Research utilization, cooperation between research and industry, policies on research and development' that the laboratories should forge close links with technical consultancy bureaux and design engineering firms existing in the country for joint planning of the project engineering and technical feasibility studies is an important one. For the research establishments to gain the confidence of industry, a shift in the basic pattern of research, particularly in institutions engaged primarily in applied research, has been advocated, so that more stress can be laid, at least in the initial stages, on meaningful, short-ranged and specific projects instead of diversifying effort over a large number of areas and problems.

It has been recognized that the availability and deployment of research and technical personnel in the country at present is not conducive to the rapid growth of indigenous research-based industry. In India, personnel engaged in research careers outnumber technologists. This factor, while hampering rapid exploitation of research results on a industrial scale, in most cases, leads to obsolescence of research. For healthy growtn of industry it is important that steps are taken to make available, adequately trained technologists, with training in modern concepts of industrial management and market research.

Much painstaking effort has gone into this meeting, and the result has been very rewarding at least from one point of view. The get-together has provided industry an idea of the research talent in the country which could be profitably utilized by it and has thus aroused its interest. This is a signal achievement. It is hoped that the get-together is the beginning of the process of forging stronger and more intimate links between research and industry, so indispensable for the industrial progress of the country. Much depends on the follow-up of the decisions arrived at by the working groups. It is heartening to note that this aspect received special attention during the discussions at the conference and has been embodied in the recommendations. It has been decided that the get-together will be an annual event and the task of implementing the recommendations has been entrusted to the working groups which have been placed on a permanent footing. This is an important recommendation and should go a long way in bringing about the much needed close liaison between research and industry.

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

AT their meetings held in New Delhi on 15 and 16 April 1966 respectively, the Board and Governing Body of the Council of Scientific & Industrial Research (CSIR) sanctioned 237 research projects of immediate industrial and economic interest, recommended by the 'Get-Together of Research and Industry' held in New Delhi during 20-21 December 1965. Approval was accorded to the following proposals: (1) expansion of the fine chemicals project at the National Chemical Laboratory, Poona, into a national project, so that it can not only meet the requirements of fine chemicals of the various research institutions and university departments in the country, but can also undertake, for defence and industry, the bulk production of the urgently needed fine chemicals; (2) establishment of an Explosives Unit, in collaboration with the Indian Detonators Ltd, Hyderabad, which would undertake work mainly on the development of indigenous know-how for the manufacture of known explosives of proven value for civilian use; (3) setting up of a Fire Research Division at the Central Building Research Institute, Roorkee, to work in coordination with the Fire Service Research and Development Establishment of the Ministry of Defence, New Delhi, on such problems as fire resistance of building materials, building components and buildings; assessment of internal and explosive hazards to personnel of buildings and other hazards; and designing and development of fire fighting equipment and components.

The taking over of the Shri Ram Institute for Industrial Research, Delhi, by CSIR was agreed to. A proposal to set up a national science library was accepted in principle. It was decided that the non-ferrous metals research at the National Metallurgical Laboratory, Jamshedpur, should be strengthened.

The setting up of the following pilot plants was agreed to: (1) pulp and paper plant at the Regional Research Laboratory, Jorhat; and (2) silicon carbide plant at the Regional Research Laboratory, Hyderabad. Financial assistance was approved for the Electronics Research Association, Bombay, and the Cement Research Institute of India, Bombay. A proposal for providing financial assistance to the All-India Manufacturers and Dealers Association to bring out an All-India Directory of Instruments and Manufacturers and Dealers of Instruments in India was approved.

Some Notes on the Economics of Natural Resources Utilization in India*

M. S. ADISESHIAH†

WHAT are natural resources? What are their scientific content and technical composition? How should they be defined and constituted in India? What contribution does resource availability make to economic development? Is there a relationship between the volume of available resources and the Indian rate of growth? What of our under-utilized, un-utilized and mis-utilized resources? What kind of national policy with regard to resource management and resource research does an examination of resource availability and utilization suggest? It is to some of these questions that the present paper is addressed.

Problems of Classification and Definition

The general concept of natural resources is easy to define, for it is all embracing. Everything in the universe that can be utilized by man, including man himself, is a natural resource. Within this comprehensive definition, the traditional scientific classification establishes five categories: (i) the land surface, rocks and air, including the endless vistas of resources which may become available from outer space; (ii) water and soils; (iii) wild plants, forest and arable agriculture; (iv) wild and domestic animals, insects, fish and marine resources; and (v) man. In addition, a further distinction is normally drawn between renewable and non-renewable resources, with the first group comprising land, rocks, air and space described as non-renewable, and the other four referred to as renewable. But when we pass from this kind of comprehensive description to attempts at quantification of any particular resource, complex problems of definition arise.

India has a total geographical land area of 326·3 million hectares, of which the reporting area is 291·8 million hectares. The net area sown in 1965 is estimated at 135 million hectares, which represents an increase of some 5 per cent in the last decade[1-6]. But if to this total is added the area sown more than once, which has increased by more than 50 per cent during the same period, the gross area amounts to 162 million hectares. How then are we to define Indian land resources? And what significance is there in the fact that while the net area sown has increased by only 5 per cent, the rate of increase of the area sown more than once has been ten times faster?

Or again, taking India's surface water resources, the annual rainfall over the country is estimated at 3000 million acre ft of water. Allowing for losses due to evaporation and transpiration, which are estimated at 1700 million acre ft, and losses into sub-soil due to topography, flow characteristics, climate and soil conditions, which account for another 850 million acre ft, there are 450 million acre ft available for industrial, agricultural and human consumption. At present, only about one-third of this resource — 150 million acre ft — is being utilized. Even so, this represents a 33⅓ per cent increase over the past decade.

Tagore's great poem which is today our national anthem and the venerable vedic hymns remind us that our country's natural resources are the gifts of nature. But they are not all used, and they are not simply gifts. For they become resources only as a function of current technology — the level and stage of our scientific knowledge and technical know-how. What makes a plot of land, for example, arable and not waste is first and foremost the state of man's knowledge.

Within my lifetime, dramatic transformations have taken place, transformations often invisible to the naked eye. I think of the change that has come about in the alluring sands and the hardy, black rocks on the beach of a lovely, South Indian locale in which I used to spend so much of my time as a boy, with my parents and companions of similar age, running my fingers through the soft sands, building sand huts and carving figures of men and animals on the rocks. During the last fifteen years, this area has developed into an important source of minerals for nuclear industry. The sands we used to build our beautiful huts with, and the rocks that we threw at each other or into the sea, still sand and rock, are no longer just that. Because of the development and application of the corresponding metallurgy and technology, they have become a valuable resource. Such transformations are less and less extraordinary. They are indeed a fundamental element of the concept I am trying to define and, as such, have far-reaching implications which have not yet been sufficiently taken into account in economic thought or the practice of planning.

In fact, if the amount of the net sown area and particularly the amount of the area sown more than once, which I have referred to earlier, is a function of the state of a country's agricultural technology, then the traditional distinction between renewable and non-renewable resources becomes impossible to apply. Indeed, there are really no non-renewable resources in India or in the world in the absolute sense of the term, for our fast developing scientific and technical knowledge makes it possible either to increase every resource, or to find or create a substitute for it. In the United States, the President's Materials Policy Commission addressed itself in 1952 to one major aspect of this question[7], and the exhaustive studies undertaken

*Lecture delivered by Dr M. S. Adiseshiah, Deputy Director-General, Unesco, during the Seminar on The Economics of Natural Resources Utilization held in New Delhi on 17 Jan. 1966 under the joint auspices of the University Grants Commission and the Education Commission, Ministry of Education, New Delhi.

†This is one of several papers written on the basis of personal research undertaken by the author and expresses personal views. In no way does it express the views of Unesco and its organs.

by the Commission provide the final answer to this basic issue: what is a resource, bearing in mind its supply and demand function? It was an urgent question for the United States, not only because of the deep-rooted emotional fervour evoked for more than half a century by the conservationist movement in both the United States and Canada[8], but also because the United States was and is the largest consumer of what are called non-renewable resources — consuming over 50 per cent of the total world supply of petrol, rubber, iron ore, manganese, zinc, etc., compared to the 5 per cent which the developing countries taken together consume. Indeed, during the 35 years between 1915 and 1950, the United States consumed more minerals and metals than all the rest of the world had consumed throughout all human history previous to 1915. No attempt will be made in this paper to summarize the basic assumptions, the impressive analysis, statistical and scientific, and the wide ranging forecasts and conclusions contained in the five volumes of the Report of the Materials Policy Commission. Its broad conclusion is that, because of the progress of technology and know-how, there is no general problem of scarcity of non-renewable resources. In particular, the following factors are cited: (i) the constantly expanding resource base; (ii) the factor of substitutability; (iii) the multiple use of each resource; (iv) the import possibilities for any particular country, particularly the United States with its worldwide trade network; and (v) the programme of resource research leading to development and better management of resources. The implications of this important and far-reaching conclusion, namely that technology is itself the primary resource, will be pursued later in this paper. I should clarify now, however, that there is one category of resources which really is limited in an absolute sense — the category of environmental-ecological factors in industrialized and urban-based societies. For me, I am sorry to say, this limitation is demonstrated every August in Paris. Some two million Parisians flee from the city at midnight on 31 July, choking the air and railway transports and crowding the roads, to the point that a pleasant 8 or 10 hr car journey to the Côte d'Azur takes two and sometimes even three days of endless delays and frustration. This frantic search for fresh air, the healing powers of the sun and the sea, the rigours of outdoor 'camping' (now a French word), which extends to the butcher, baker and candlestick maker (everything in Paris, laundries, shops, theatres, is closed down in August) is an indication of environmental scarcity. The need to restore the distorted ecological balance, to preserve the beauty of the landscape (Unesco is developing an international convention to assure this), to combat the dangerously high air-pollution in the cities and countryside and to reverse the wastage and contamination of water resources — is an expression of the absolute limits of our ecological-environmental resources.

Having touched upon this first determinant in the definition of natural resources, the state of knowledge and technology, I now turn to a second determinant, which emerges when we consider the expansion of the area sown more than once in India, which has increased by 50 per cent over the past decade, and of water utilization in the agricultural parts of this country, which has increased by 33⅓ per cent over the same period. This second determinant is the cultural-economic state of wants in the country and their market expression. The demand for agricultural products generally, and for food in particular, is rising steeply in this country for a variety of reasons — the rate of population increase which is currently over 2 per cent, the rising tempo of industrialization, creating a growing demand for food for the population employed in secondary and tertiary occupations, which has increased by over 200 per cent during the last decade and a half, and the structure of food habits of the people, the vegetarian sector, the rice as distinct from the wheat consuming group, the toll of the numerous festive occasions, sacred and secular, etc. (for the purpose of this analysis, the additional and tragic, short-term pressure caused by droughts, such as the one facing the country today, is not taken into account). This increasing demand for food — with its characteristic high income elasticity of demand — accounts, in part, for land previously reported as waste, water-logged or barren becoming culturable and for the increases reported in the double or triple crop area. It also brings into being water utilization schemes previously classed as uneconomical or unnecessary. Because of such demand, water, for example, in the Ganges-Brahmaputra basin is no longer just flowing freely and wastefully into the Bay of Bengal; it is now a resource both for generating electricity and increasing food production[9].

In thus defining natural resources as the creation of man — man's knowledge and man's wants — the place of man in any investigation into natural resources availability and utilization becomes crucial. Human resources are not only an essential part of natural resources; they define the scope, development and endless utilization of all other natural resources. And so an examination of human resources development and use in India is an essential part of the task assumed in this paper. Although this field is not treated in the present paper, as it is the subject of a separate analysis[10], that analysis and its accompanying conclusions should be referred to and incorporated into the partial analysis attempted here, in any complete presentation of Indian resources need, availablity and utilization.

The Indian Resource Base

Natural resources in India, as outlined above, are beginning to be inventoried in scientific and technical terms. Such an inventory is most nearly available, I believe, only for our land resources (Table 1).

Even Table 1 contains obvious gaps. The 1959 Committee on Fallow Lands has identified a million hectares of waste land as available for reclamation, for example, and land surveys making more systematic use of photogrammetric techniques and collecting current data on land use, improvement and reclamation, need to be undertaken to complete

TABLE 1 — LAND UTILIZATION PATTERN IN INDIA

	Area in million hectares		
	1955-56	1960-61	1965-66
Total reporting area	291·4	291·8	291·8
Forests	50·8	53·0	53·4
Land under miscellaneous trees, crops and groves	5·6	5·7	6·1
Permanent pastures and other grazing lands	11·5	13·0	13·0
Culturable waste	22·2	19·0	16·2
Barren and uncultivated land and land put to non-agricultural use	48·7	46·1	46·1
Fallow lands other than current fallows	12·5	11·3	10·5
Current fallows	11·9	11·3	10·3
Net area sown	128·8	132·3	135·6
Area sown more than once	18·0	20·8	27·1
Gross area sown	146·7	153·2	162·7

the inventory. Further, the land requirements for other than farming and forestry uses should be carefully computed on a projection basis. These include land use for urban and transportation purposes — which are likely to grow rapidly in the future.

With regard to soils, a real start was made only a decade ago. As a result, only some 230,000 sq. km. have been the subject of detailed and/or reconnaissance surveys by the All India and States organizations, leading to some correlations of soils in the regions which have been surveyed. This represents less than half of the soils inventory which the country needs.

India's water resources availability is beginning to be established. The surface water inventory has been referred to earlier. The irrigation resources may be summarized as follows:

	Million acre ft	As per cent of usable flow	As per cent of total flow
1955	98	21	7
1960	120	27	9
1965	150	33	11

For ground water, the area was 15 million acre ft in 1951. But the potential from all sources, major, medium and minor irrigation schemes, is currently estimated at some 200 million acre ft[11]. This vital resource stands in need of further detailed surveys and studies, which should take into account such various uses of this resource as (a) the withdrawal use which takes place in cities, industry and irrigation; (b) the flow use primarily for turning hydro-electric turbines; (c) the on-site use, for example, in swamps used by flora and fauna; and (d) the flood use. It would be possible on the basis of such studies to construct a realistic inventory of water supply by regions and localities, because all water situations and problems are local and regional and not national.

Our forest resources inventory is fairly well established. Out of a total geographical area of 326 million hectares, some 700,000 sq. km., or 21·8 per cent, consists of forests, some 7 per cent of which are temperate and 93 per cent tropical. Forest product exports currently amount to Rs 100 million and imports to over Rs 300 million, of which 80 per cent are for paper pulp.

Our sea resources are still largely unknown. With a coastline of 5681 km. and a continental shelf of more than 25,000 sq. km., there are vast uncharted potentialities of marine resources, in the form of marine algae, fish and minerals. A preliminary survey conducted by the Central Marine Research Station indicates vast quantities of economic seaweeds. Similarly, 1·1 million of the 1·4 million tons of annual fish production are marine, representing, according to the Indian Ocean Expedition, only 1-8 per cent of the fish available just on the eastern and western coasts of the country. The mineral resources of the sea consist of salt and, in potential terms, more than 100,000 tons of potassium chloride, 10,000 tons of bromine and unknown quantities of manganese, cobalt, nickel, copper and thorium.

Other known mineral resources are: (i) coal, estimated at 120,000 million tons, within a depth of 2000 ft and in seams of four or more feet of thickness, at least 10 per cent of which is of metallurgical grade; (ii) 2000 million tons of lignite; (iii) sizeable reserves of mineral oil and natural gas in Assam and Gujarat; (iv) proved iron ore reserves estimated at 7800 million tons, with possible reserves of 19,500 million tons; (v) reserves of manganese ore currently estimated at 180 million tons, (vi) other minerals whose potential is being assessed like copper ore, sulphur-pyrites, bauxite, magnesite, gypsum, limestone, lead and zinc.

Estimates of energy resources must begin with the fact that at present more than 60 per cent of India's energy comes from the non-commercial sources of cattle dung and firewood. Of the annual availability of 1200 million tons of cattle dung, 400 million tons are used as fuel, 215 million tons as manure and the rest wasted. The consumption rate of firewood is around 60 million tons annually. The major commercial source of energy, electricity, has registered a 300 per cent increase during the past decade, from 3·42 MkW. in 1955 to 10·35 MkW. today. The potential of water power for the country is estimated at about 41 MkW. Monazite deposits are estimated at 5 million tons. Within other ores thorium content of some 0·45 million tons and uranium content of 15,000 tons are recorded. In addition, uranium ore reserves in Singhbhum, Bihar, alone are estimated at 33 million tons. Unconventional energy sources include solar and wind energy, for which surveys and studies are under way.

These estimates of a part of India's resource base represent in most cases but a beginning, and in many instances are all too sketchy and scanty. But they are a move in the right direction towards formulating a complete and exhaustive inventory. And from the scientific and technical point of view, the current stage of inventorying our resources none the less represents an achievement, given the brief period of 15 years within which most of the survey,

reconnaissance and partial assessment has had to be carried out.

Economic Interpretation of Natural Resources Availability and Use

This not unsatisfactory rate of progress recorded in the purely scientific and technical aspects of our natural resources analysis contrasts sharply with the state of knowledge in the economic interpretation of our natural resources. There is no generally accepted method of evaluating the economic availability of natural resources. Indeed, economics text-books are silent on this subject. Economists have always been concerned, of course, with the resource called land from the very infancy of their discipline, but there is a large gap between even the widest possible definition of land and what today we call the natural resource base.

This neglect of the place of natural resources in growth economics is no accident. It is not an Indian phenomenon but is generally true everywhere. I have already referred to the Report of the Materials Policy Commission in the United States. I should add that all subsequent studies, research analysis and conclusions on natural resources have taken that report as their starting point, and in particular its conclusion that while there may be particular bottlenecks in this or that resource, and while there may be short-term critical shortages in certain specific areas, there is no problem of general scarcity or overall limitation with regard to natural resources[12-18]. Natural resources, in western economics literature, are, therefore, treated simply as one more input factor in any given line of production, and not a key or crucial factor at that. As a consequence, resource development has not been considered to be a necessary and sufficient condition to economic development. The fear that economic growth is or will be inhibited by a lack of natural resources is held to be a deep-rooted tautology, stemming from the dominant preoccupation of all economics — the process of economizing. There have been lone voices[19,20] raised in protest against this general optimistic position, but even these dissents are based on such external factors as the population explosion, the expending of the nation's capital, or human gluttony in the novel forms which seem to be found in affluent societies. And so these protests lead more to policy admonitions as to population control, living on one's income instead of consuming capital, and the combating of 'selective myopia', rather than to economic analysis of resources. It is thus held that the supplies or supply prices of natural resources as input items need not now or in the future constitute a bottleneck to growth in the West, for the western world has met its expanding resource demands with expanding supplies, without a rise in their costs. Since the turn of the century, their real costs have in fact been falling — calling for fewer hours of work and smaller amounts of capital per unit of materials. Even in the dim, distant future, if there is to be a rise in costs, this rise will take place slowly and gradually. Why? When a particular resource bottleneck arises, technology and substitutability go to work as correctives, the most dramatic recent demonstration being the cessation of Russian manganese exports to the US in 1948, which was until then the sole supply source to the United States. Indeed, under this analysis, the primary resource is clearly technology itself, and behind it, the people, their values and behaviour patterns. Labour too is a produced rather than original factor of production for development theory and growth policy. The state of knowledge, know-how and technology, on the other hand, is a highly dynamic element. It is this which has increased output and which accounts, for the most part, for the spectacular rate of increase in the gross national product, which has come to be called the modern miracle[21-24].

If a resource, it is held, cannot come into being without the prior evaluation of an art or technology to exploit it, then it is clear that the study of fluctuations in the supply of resources or resource availability must in fact concentrate upon a study of the changes in the state of knowledge, which determine what is profitable and not profitable in resource investments. The result of this approach is that the relationship between the volume of natural resources and growth, between resource availability and development, remains an unknown quantity. Nothing more than a vague presumption is left, that despite countries like Sweden, Switzerland, the United Kingdom and four other western European countries and Japan, with their high per capita income and narrow resource base, a relationship does exist between natural resources use and economic growth. Even this rather vague presumption is further confused where growth analysis for developing countries is involved, by the ongoing chicken and egg controversy: which should come first, the Big Push in agriculture or large-scale investments in heavy and medium industries, as the precondition to take off, to self-sustaining growth? For the economist in India and other developing countries today, what exists then is an unproved sixth sense that a country which has a large backlog of underutilized and uninventoried natural resources has an advantage in the growth race.

Criteria for Investment in Natural Resources

Given the assured and expanding resource base, full employment and factor mobility that characterize the developed economies of the West, the basic criteria which they apply for investment in natural resources is and has to be efficiency. This gospel of efficiency started as an engineering approach to resource utilization, emphasizing multiple use, highest use and efficient use. Today, the economic model for investment in natural resources employed in the United States and Europe, as it is expounded by their economists, is no different from that employed for all types of factor and investment. In these societies where the marginal propensities to save and to invest are high, investments in any resource are carried to the point where the marginal rates of substitution among resources and other input factors are directly equal to the ratio of their prices. Under these conditions, changes in resource investments result in redistribution of incomes, rather than increases in the gross

domestic product. Even such redistribution effects are minimal because, in contrast to countries like India, where the ratio of natural resources to all resources employed in income production is 25 per cent, in the United States and other high income countries, it is as low as 5 per cent[25-30]. Further, while the US per capita income rose by 150 per cent between 1900 and 1950, its consumption of raw materials was rising by only 25 per cent, and in the case of food, the rate is actually declining. It is no wonder then that for the professional economist in the West, the role of natural resources in their process of economic development has not been worth much attention. To him, the role of resources in relation to economic growth is a passive function, the object of improvement rather than the driving force of development.

Economic Interpretation of Indian Natural Resources

While the danger of absolute limitation or complete scarcity of natural resources is no more a problem for us in India, or for any of the developing countries than it is for the developed countries, it is, nevertheless, urgent for us to fill the economic void left in the whole area of the economics of natural resource availability and utilization.

Surely we have a long road to travel before attaining that stage of an assured and expanding resource base, with its characteristics of substitutability, transformability, transportability and multiple use, which would justify our treating resources as a minimal factor in national income production. Nor is the efficiency criterion, based on full employment, factor mobility and high propensity to save, in and by itself, relevant to our economy. Our constraints in India are not simply efficiency and its accompanying reallocations of incomes. Our overriding concerns for the present must be to reduce the growing unemployment backlog, including its under-employment and disguised unemployment components, to meet the growing food deficit of our expanding population, including the large numbers employed in secondary and tertiary industries and occupations, and to expand the export sector as a means of furthering our industrialization programme. In this effort, we have little to draw upon from the study of resource economics, as it has been practised in the developed countries.

I acknowledge the handicaps imposed by this discontinuity in the exchange of knowledge and experience, by the fact that the preconditions and processes of resource development are largely unknown, and by the further complexity and number of supply and demand factors involved, which make it difficult, at present, to use in this area the usual mathematical tools. Attempts at using statistical evidence and aggregate and sector models of production in resource analysis are hampered by the fact that they can refer only to patterns of production and import-export trends of countries at different stages of development[31-33]. There are two obvious limits to these first attempts at mathematical analysis of the past history of resource use: first, they do not deal with the key question of how resources contribute to growth; secondly, both past and current production patterns and foreign trade trends in most developing countries are more the result of their past colonial relationships than of any determined and economically rational policy of resource use. Despite these limitations, I am inclined to start with the common sense position that a nation's resources are a measure of its potential welfare.

Historical evidence is cited[18] in order to demonstrate that the rhythm of India's economic development from 1880 onwards was considerably retarded by the fact that the agricultural resource sector did not back up the lead given by the urban sector. The transport and communication explosion, the growth of urban agglomerations and the developing capital and entrepreneurial supply in the country did not lead to growth because of the low supply elasticity of agricultural resources. While not being able to accept this analysis completely, I do believe that, on the basis of general historical evidence, a country's resource endowment influences the form and pace of its development. I will go even further and hazard an intuitive guess that resource planning, development and management, as part of its industrial and agricultural growth, is for India, at its present stage of development, the necessary and sufficient condition for its economic development and one of the two preconditions for its sustained growth (the other being the development of its human resources). For India, the take-off will be a consequence, not of sustained or uniform growth rates in all sectors, but of intensified efforts in certain strategic areas, and particularly in the leading resource sectors (which in my opinion are water and energy), sectors from which efforts will spread out to other related industrial areas, where these resources are input items.

What does this view of resources as an essential factor of growth mean for India? What policy conclusions follow?

Analytical Research and Investigation

Our first task must be to intensify in a more systematic and continuous manner the current programme of gathering, interpreting and analysing the facts and phenomena of all our natural resources. Only such analytical investigations will reveal the fundamental problems relating to our natural resources development. The kind of detailed studies[34-38] being undertaken by the Planning Commission's Committee on Natural Resources, on groundnuts, wastelands, cotton, jute and mesta, and coconut are pointing up the deficiencies in the development of these resources and the means of improving the economic yield of land resources and their use. They need to be extended to other resources. Similarly, the first attempt to make an inventory of irrigation potential has shown the way forward, for we are today using only one-third of this resource. The study of forest resources shows that the shortage of timber and firewood, and more generally of fuel energy in the country, leads to the burning of 400 million tons of cattle dung which, if used as manure, would yield an

additional 3 million tons of badly needed rice. (This is not to say that we should continue to rely on the non-commercial energy resource of firewood. I will return to this later.) The studies on energy resources and mineral potentials are just beginning. When completed they will provide a clear picture of the Indian resource base which is indispensable for its economic growth. In such work, the results of investigation into the interrelations between climate, soils, waters, vegetation and human activity, which vary considerably from one sub-region to the other, will also be of particular importance. Thus the establishment of a complete analytical inventory of all our resources is the first major task awaiting our scientific and technical institutions.

Such studies can also indicate what kind of conservation policy needs to be followed with regard to particular resources. Conservation does not simply mean storing up. It means wise use of overtime, and in some cases it may well mean intensive use. We conserve fugitive resources, like natural gas, by making them do as much work as possible before they expire. We conserve our coal resources when we burn them in appropriately efficient furnaces, not when we leave them underground. Forestry resources, on the other hand, take a long time (20-30 years) to mature and become commercially useful. Both the rate and absolute volume of growth of India's forest resources depend on the size of the annual cut. The real growth rate for this resource must be calculated by subtracting the years' cut from the years' net growth, and it is this growth rate which is the indicator for our forest conservation policy. Conservation also involves avoidance of waste and substitution of scarce materials by those which are abundant in the country. This aspect of conservation is particularly relevant when evaluating the economics of our coal resources, their mining processes and byproducts, a subject to which I shall return. Finally, the simplest formula in the economics of conservation is to be found with regard to soils, where unless input equals output in the long run, soils lose their fertility and begin to deteriorate.

An Economic Balance Sheet of Resources

A second imperative is the use of balance sheet methodology, a methodology which juxtaposes the supply side of the resources registered in inventories, and the demands for their use, taking into account the trends of population growth, production techniques, consumption patterns and internal and international trade indicators, as appropriate. These indicators have to be continually reviewed on a case by case basis. Each resource is influenced by particular supply and demand factors and in appropriate cases these forces are also at work with regard to its external trade potential. Recent studies[39,40] of these indicators have shown that the only reliable forecast is the maintenance of maximum flexibility in economy. This can be attained by the proper deployment, education and training of the human resources of the country. Our balance sheet must also take account of policy objectives as defined by parliament in terms of self-sufficiency in certain sectors, defence needs, industrialization goals, etc. This complex and comprehensive task which is both inter- and multi-disciplinary, and which is the joint responsibility of scientific institutions and university departments of economics, is particularly necessary if we are to avoid the danger of considering the mere listing of resources as sufficient in itself to the process of growth and development.

In two resource areas — water and energy — a useful beginning has been made in this balance sheet approach, and a careful study of these two cases indicates the strengths and weaknesses of the equipment currently available to deal with this formidable task. In irrigation, there has been a kind of ad hoc interest rate approach, combined with a system of norms of capital outlay per acre, and perhaps a little too much pragmatism has been practised in this attempt at assessing the feasibility and productivity of the country's water resource utilization. I would suggest that the familiar cost-benefit methodology be used in the case of this particular resource, provided: (i) that policy objectives as to depressed or specially needy areas are not brought under the same analysis; and (ii) that all costs and all benefits are taken into account — including secondary and indirect effects such as those on local and national levies and cesses, railway and shipping earnings and costs, etc. This, in turn, calls for a rather sophisticated system of statistics and data collection, to which not only the national scientific and technical institutions but also the universities should address themselves.

The balance sheet of Indian energy resources as set forth in the Report of the Energy Committee[41] is more along the lines of the kind of economic appraisal needed for all of the country's natural resources. This first assessment of the country's energy resources reveals several remediable weaknesses in the pursuit of the balance sheet approach. There is first the discontinuity of statistics and lack of basic data collection, which it is recommended that the current Energy Statistical Group and the Survey of Industries regularly and uniformly undertake. Even more serious is our lack of a research base for this kind of economic appraisal, which requires investigation into various input-output alternatives in the energy resource field. Such a research programme should be the responsibility of the departments of economics of the universities and the central scientific institutions such as the Central Water & Power Commission, the Indian Bureau of Mines, the Atomic Energy Commission and others.

It has been found that, apart from Goa, Indian iron and steel exports are at a disadvantage in foreign markets, with Indian prices ranging from 4 to 12 per cent higher than European or Latin American prices. To make iron and steel more competitive and to conserve coking coal and save [illegible] byproducts, it is recommended that steel plants be given every kind of encouragement, through the price structure and tax deductions, to reduce their coke-to-pig iron ratios. A second important recommendation is the expansion again through a system of differential taxes and subsidies, of low temperature carbonization plants, soft coke, briquettes and similar familiar domestic fuels based

on coal or lignite, in order to reduce the demand for non-commercial fuels like firewood, and to eliminate the use of cattle dung. A third important policy suggested is that, in view of the shortage of high grade coal and a surplus of the low grade and its byproducts, a pricing policy should be introduced which will encourage power stations and industrial users to install plants which can use the lowest grade coal. If this means that account has to be taken of the opportunity cost of the byproduct of waste coal to any industry or sector that can use them, it should be squarely faced that, from an all India point of view, such opportunity cost is zero. Electricity generation planning should thus be based on the use of byproducts of coal which are available at zero cost. This would have a direct bearing on assessing the relative cost-benefit analysis of hydro versus thermal generation.

With regard to oil, the balance sheet analysis reveals that India will be short on middle distillates and long on light end-products. This means that the potential surplus in motor spirit and naphtha must find outlets in road transport and the iron and steel industry. Some important policy conclusions are also indicated with regard to electric energy. During the next plan period the investment in transmission, where a high indigenous and low import content is involved, should at least equal investment in generation, where these proportions are reversed. The method of generation should in turn be determined by its fuel cost which should be equal to the scarcity value of the fuel, with the delivery cost representing the true transport cost. Finally, the conclusions with regard to rural electrification have probably the most immediate bearing on the projected growth rates of the country and welfare optima of its peoples.

On unconventional sources of energy, an encouraging start has been made. Solar energy is being harnessed for cookers, evaporation, windmills and dehumidification of factories. In addition, a preliminary survey of wind velocities indicates areas where wind power could be used as a resource. The proposed programme[42] of desalination of brackish water, which is at present at the laboratory stage in five institutions in the country, concentrates on water distillation and the development of ion-exchange resins and membranes. When this resource comes to be developed, it is proposed that various energy resources appropriate to the different parts of the country be used: solar energy in the Rajasthan area; petroleum crudes for the distillation plants in the Gujarat area; waste heat from the projected nuclear power reactor in the Madras State — a project which has just been announced, etc. Such use would be along lines of the priority programme in respect of energy resources recommended by the National Resources Committee with regard to: (a) coal, lignite and coal gas; (b) oil and natural gas; (c) hydel resources; (d) atomic energy; and (e) fuel problems of rural areas.

This balance sheet approach, as illustrated by the two resource areas, demonstrates the simple but oft forgotten truth that, in resource allocation, what is technically feasible is not necessarily economically feasible. The extent to which low grade coal can be considered as a natural resource for the country and its plentiful byproduct as a resource reserve depends on a wide-ranging economic analysis into relative and opportunity costs, investment opportunities and realizations in other industries, price policies and patterns and contribution to national income. In the last analysis this is the test which must at all times and everywhere apply to Indian natural resources utilization and management. What is its contribution to national income?

This kind of detailed economic assessment needs to be undertaken for every resource in the country and until this is done the planner will be operating in the dark in planning the country's economic development and charting its rate of growth.

Regional Planning and Development

A third imperative in India's resource economics picture, which takes its place alongside the reconnaissance and survey of particular resources, is the even further emphasis which should be laid on comprehensive regional and area planning and development. In different parts of the country such regional development programmes are either under way or about to be launched, and the experience in the Damodar Valley area has already given us many valuable lessons on resource development in general and for agricultural area programmes in particular, in its call for better management of the water used in agriculture, which can considerably increase both yields and levels of food consumption. In terms of the standards of food consumption for such area development programmes which have been laid down by the Indian Nutritional Council, a study on the Lower Ganges-Brahmaputra basin[9] has concluded that a wisely conceived and well-executed regional plan for the basin can, on balance, meet the food requirements for a balanced diet for double the present population — provided there occurs (a) a different pattern of resource use and production techniques involving land drainage, use of more and better fertilizers, hybrid seed strains and improved farm management; (b) a vigorous and effective programme of land reform; and (c) an efficient credit and marketing service. The kind of changed pattern which emerges from such a regional plan for the basin is presented in Table 2.

Table 2 excludes certain items for which either present production or future need could not even tentatively be established (tobacco, spices, etc.; also hides, skins, bones, etc.), as well as the products of forestry and fisheries. If one values a ton of wheat at Rs 350 (an approximate valuation for the early 1950's) the aggregate value of present production, on the basis of pre-war price valuations, would be about 16,000 million rupees (1600 crores); and under full utilization with the same price weight 62,000 million rupees (6200 crores).

Indian Consumer Satisfaction and the Welfare Criteria

A fourth area which demands attention in India is the relationship between the availability and utilization of resources and the long process they go through in being turned into consumer satisfaction. Built into these studies and research should

TABLE 2 — PRODUCTION AT PRESENT AND UNDER FULL UTILIZATION OF RESOURCES

Product	At present		Under full utilization		Index of change: present =100
	Million units*	% of total	Million units*	% of total	
CROP PRODUCTS					
Cereals	20	43·0	37	21·0	185
Pulses	2·5	5·4	7	4·0	280
Vegetables	6	12·9	22	12·5	367
Sugar	0·5	1·1	8	4·6	1600
Oilseeds	1	2·2	12	6·8	1200
Cotton (fibre)	0	0	11	6·2	—
Jute	4	8·6	5	2·8	125
Fruit	1·5	3·2	8	4·6	533
Tea	3	6·4	5	2·8	167
Total	38·5	82·8	115	65·3	299
LIVESTOCK PRODUCTS					
Milk	4	8·6	23	13·1	575
Meat	2·5	5·4	23	13·1	920
Eggs	1·5	3·2	15	8·5	1000
Total	8	17·2	61	34·7	763
Grand total	46·5	100·0	176	100·0	378

*The unit used is the pre-war (1934-38) average price of a ton of wheat, which has been given the weight of 1. All other products have been weighted according to the relation of their price to the price of wheat over that period.

be the welfare criteria of the optimum use of resources, both from the supply and demand side, involving public investment, a system of subsidies and other incentive measures. In this area the universities and their departments of economics and social research have not even begun to collect the basic information about the variables and interrelations necessary for projecting an optimum path of welfare, in time, in the kind of dynamic framework which India today represents. It is my hope that such studies on the welfare aspects of resource development and consumption will no longer be inhibited by outdated concepts of ethical neutralism (concepts on which I was nurtured in my student days). In its modern disguise, this posture is found in the sharp and absolute distinction drawn between endogenous and exogenous factors in development. The serious work on the welfare implications of resource analysis that is incumbent on the Indian economist will be of help to the policy maker in the country. It will provide him with a limited number of alternatives on the basis of which rational decisions can be made for successive incremental improvements in the welfare of the people. And I am led by these considerations to suggest, in view of the fundamental importance of this field, that Indian universities might give consideration to the development of resource economics as a sectoral discipline, within the broader studies involved in development economics.

Savings and Investment in Indian Natural Resources Utilization

According to the Planning Commission studies[1-6] the Indian rate of investment for all purposes, expressed as a percentage of national income, rises from around 7 per cent in the First Plan period to 13 per cent in the Third Plan, and to 16 per cent for the Fourth Plan, involving an incremental capital-output ratio rising from an initial 1·8:1 to 3·4:1 during the Fourth Plan period. This is somewhat pessimistic planning when compared to similar situations in Greece (2:1), Japan (1·7:1) and the USA (2:1). On the investment target, however, the Planning Commission is on the right lines. Economists generally regard an investment target of 12 per cent of the national income as necessary for self-sustained expansion, derived from the fact that it takes between three and four units of capital to produce an additional unit of national income and also allowing for a population increase of 1-2 per cent annually[43]. On the basis of the constraints of growth economics, I have computed that the Indian investment target should, by the Fourth Plan, be of the order of 20 per cent of the national income[44].

What of investments in natural resources development? The effective development of natural resources in India, as in other developing countries, requires large amounts of capital and labour. And in general, capital is perennially in short supply and shy in our countries and so is skilled labour. Capital investments in resources projects are usually lumpy and require some imports of machinery and equipment from abroad, at least in the initial years. Further, the period of gestation of such investment is long and there is a scatteration of benefits accruing from the investment, beyond the group — public or private — directly responsible for it. Hence it is important that capital which is in such short supply should be so invested as to bring maximum benefit in terms of the defined objective — whether that objective be a real increase in the gross national product, a rise in living levels or an increase in economic and social security.

Judged by these broad considerations, the investment policy recommended by the Committee on India's Energy Resources provides one of the few sound long-term projections in this field. This policy, which covers a decade and a half (1965-80)[41], may appear to involve considerable sacrifice. But its real burden or cost is lower than is apparent when account is taken of its scatteration effect and benefits to those not directly involved — as referred to earlier. These indirect effects include improvement and expansion of investments in railway communications, the locomotive industry and the iron/steel industry. When all these effects are taken into account, the investment policy which the Committee recommends is not more capital intensive than other investment alternatives within the energy sector.

Similar investment analyses and forecasts need to be undertaken for every major resource deployment in the country. There are no macro-economic criteria for investment in natural resources but only micro-economic ones. And here again, these analyses must be made urgently to inspire policy and inform needed action.

In addition, the question may be posed whether long-term investments in some of our natural

resources development sectors should be exempted from interest charges. This was the case with nineteenth century European investment in forests and is the case today with investment in the development of our human resources. I would suggest that the particular resource sectors which might be so exempted should be the subject of study and investigation in India.

Organization of Research and Investigation

In the organization of production and the economy generally, research enterprise may now take the place formerly reserved for enterpreneur enterprise. For it is research which now embodies the traditional entrepreneurial qualities of innovation, invention and discovery, working out new resource combinations, adjustments and allocations. The days of the entrepreneur — the grand master of strategy, the reformer and revolutionary, the predatory giant — who brought his superior knowledge, forecasting ability and talents into play, have given way to the era of systematically organized research and investigation — which involves methodic exploration into the known and the unknown, the imperfect and the imbalanced[45]. For India and the developing countries generally, where there is, in general, a scarcity of skilled manpower, including in particular a scarcity of this unusual and outdated factor — the innovation-producing entrepreneur — organized research must be the answer. The institutionalization of research — at the national and sub-national levels, at the disciplinary, interdisciplinary and multi-disciplinary levels — is a direct consequence of this development.

In India, there are fourteen well-established and functioning scientific and research organs: Survey of India, Botanical Survey of India, Zoological Survey of India, Council of Scientific & Industrial Research, Central Water & Power Commission, Geological Survey of India, Indian Bureau of Mines, Oil & Natural Gas Commission, Atomic Energy Commission, Indian Council of Agricultural Research, Indian Agricultural Research Institute, Forest Research Institute, Committee on Natural Resources, and Energy Survey Committee. It is these institutions which must survey, identify and investigate resource availability and utilization. What they require urgently is adequate manning and financing for the vital and important tasks assigned to them, tasks which take on new dimensions in view of the long road which lies ahead of this country before the goal of an assured and expanding resource base can be reached (the scientific and technical manpower need for our resource management is another area requiring further research, in particular as it relates to our general educational framework). Whether we will in fact reach this goal, and when, depends first and foremost on the work of these institutions and of the Indian universities.

Scientific Research

As I have so far dealt with organized resource research, I wish to close with a few comments which underline the importance of the government's action in promoting and financing organized research — of both the scientific and development type. In western countries, such research and development expenditures are financed from two sources — private and public. Where market structures are imperfect — of the Chamberlin or Robinson type — participation by private business firms in the financing of research is clearly indicated. In India, where market structures are still undeveloped and large individual private business units are few, the financing of research is governmental responsibility. In the United States, United Kingdom and France, 40 per cent of the total research and development expenditure, and in other western European countries 60-70 per cent of such expenditures are financed by the private business sector. In India, starting from less than 5 per cent, it is proposed by one writer[46,47] that the private sector finance 15 per cent of total research expenditures, which would mean Rs 1300 million, for the Fourth Plan period.

In the non-socialist developed countries, at the micro-economic level, the funds for research allocated by monopolistic or oligopolistic firms — whether it be AT and T, IBM, Bull, Philips or Shell — are determined as a function of their projects, their scale of operations and share of the market. This generalization allows for the fact that small business units often have a more favourable attitude towards research and are more research intensive than the large ones, for I am here talking of sources of financing and not of attitudes. In this sector in the West, account must also be taken of the extraordinary and expanding infusion of American research into Europe.

For India and the developing countries, it is largely the case, for reasons that I have just referred to, that, allowing for detailed calculations of the needs of each research project and established research institutions, only a macro-economic approach to the financing of research is possible. Thus, for India, at this stage, the level of research expenditure has to be judged as a function of its gross domestic production. From this point of view, the level of Indian expenditure on scientific research is far from satisfactory. In the developed countries somewhere around 1·25-3 per cent of the gross domestic product is being used as at 1962 for research expenditures (USSR 3 per cent, USA 3·1 per cent, UK 2·2 per cent, France 1·5 per cent, Japan 1·3 per cent, Germany 1·3 per cent, Belgium 1·0 per cent, Netherlands 1·8 per cent, with particularly steep increases being registered during the past decade all round). If about 30-50 per cent of the figures for USSR, USA, UK and France are assumed to be military research expenditure, the norm of civilian research expenditure which emerges ranges from 1 to 2 per cent of the gross domestic product[48-51]. In India at present 0·2 per cent of the gross domestic product under one calculation, and 0·32 per cent under another[46,47], is being used for scientific research. There are some obvious limitations to these calculations, due to differing definitions of research, salary levels, costs of equipment, etc. And, of course, we are here comparing the results of the micro-economic approach of the developed economies (the total research expenditure being the sum of separate decisions) with the

macro-economic approach. Continuing this analysis, if the civilian research expenditures in 1960 are computed in relation to per capita GNP at market prices, India occupies the second lowest of some 16 selected countries: USA (1·9), USSR, UK and Sweden (1·8), Japan (1·7), Germany and Netherlands (1·5), France (1·3), Canada and Norway (0·8), Australia (0·6), Iceland and Finland (0·3), Ghana (0·22), India (0·2) and Philippines (0·15).

For Indian natural resources development and utilization, a clear need is thus indicated to provide a more adequate infrastructural base of oriented and applied research, by increasing the percentage allocation of the gross domestic product earmarked for scientific research. This increase should be, at a minimum, a quadrupling of the percentage if the 0·2 per cent base is taken or a more than doubling if the 0·32 per cent base is taken, to 0·8 per cent during the Fourth Plan period, and it should also include an appropriate share of foreign exchange resources, so essential to all scientific research everywhere and in all countries.

But while the broad directives are clear, the detailed economic investigations and testing of hypotheses remain to be worked out. Here, I believe, there is an imperative call to university and research economists in India to undertake the necessary studies and investigations of returns to expenditures on research in terms of output, patents, licences and unregistered processes, also giving attention to marginal expenditures on research. Such studies will serve a double purpose. They will aid the research worker and institutions in judging their priorities. They will also serve as a guide and counsel to the government in arriving at a more rational and adequate level of research expenditure for the next plan period.

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Genetics Today in the USSR

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DURING the last two decades, genetics as understood, developed and exploited in the rest of the world was considered in the USSR to be a sterile science based on questionable and incorrect foundations. This was due to the official acceptance in the Soviet Union of T. D. Lysenko's interpretation of Michurin's views on the mechanics of heredity and the consequent discouragement of research on Mendelian lines, a field of study in which the USSR held an eminent position until 1940. Lysenko's rise in power was in part due to the notion that his ideas would alone lead to a rise in agricultural productivity, a view which has since been proved to be incorrect.

The new vistas in crop production opened up by genetic engineering in the post-World War II period consequently remained ignored in the USSR and allied countries. Simple genetic manipulations like the incorporation of 'Norin' dwarfing genes in wheat, the 'Chu-wu-gin' dwarfing gene in rice and the exploitation of cytoplasmic male sterility in *Sorghum* and *Pennisetum* for the commercial production of hybrid seeds have provided eloquent testimony of the potency of such techniques in causing great spurts in yield. While Lysenko's domination led to the denial to Soviet agriculture the fruits of genetic research, the rest of the world benefited immensely by erecting their plant breeding programmes on the foundation of N. I. Vavilov's concept of the centres of genetic variability in crop plants.

Leading geneticists all over the world had expressed during the years 1948-64 extreme regret that in the field of scientific research there should be cleavage based solely on dogma and political ideology. It is hence a matter for great scientific rejoicing that during 1965, the centenary year of Mendel's discovery of the laws of heredity, there has been a revival of official recognition and patronage of genetics in the USSR. A Genetics Section has been created in the Soviet Academy of Sciences under the leadership of Academician N. P. Dubinin and a Genetics Institute with all the modern branches of this science represented will soon come into existence in Moscow. A journal of genetics named *Genetica* has been started with Prof. R. M. Zhukovsky as the Chief Editor and Prof. S. I. Alikhanyan and Prof. D. K. Beljaev as Assistant Editors. A symposium to commemorate the centenary of Mendel's discovery was held in Moscow on 25 June 1965, and the papers presented at this meeting have been published. A paper by Prof. V. V. Skripchinsky presented at this meeting has clearly brought out the futility of Lysenko's approach in yielding varieties of fruit trees (Table 1). Some of the leading Soviet geneticists also participated in the Mendel symposium held at Brno in Czechoslovakia in August 1965.

During a brief visit to Moscow in December 1965, to participate in the centenary celebration of the Timirazev Academy of Agriculture, I had the privilege of visiting some of the institutions in Moscow where genetic, cytogenetic and breeding research is in progress. I was deeply impressed with the volume and variety of genetic work that had been carried out even during the last two decades. Some of the lines of work and results obtained at these institutions are summarized below, since, owing to the results having been published in Russian, they may not be known as widely as they deserve.

Centenary Symposium of the Timirazev Academy of Sciences, Moscow

This symposium held from 29 November to 4 December 1965 dealt with different problems and possibilities in Soviet agriculture. A point of interest made by Prof. I. S. Kurshinov, Professor of Economics at the Timirazev Academy, relates to a positive correlation between average yields and the margin of profit obtained. The data given by Prof. Kurshinov are given in Table 2.

TABLE 1 — EFFICACY OF DIFFERENT TECHNIQUES IN EVOLVING NEW VARIETIES OF FRUIT TREES

Crop	No. of varieties	F_1 hybrids	Selections in F_2 and later	Selections from natural segregation	Introduction	Mentor method*
Apple	43	37	2	2	1	8
Pear	14	8	0	4	1	3
Sour cherry	25	11	7	5	1	2
Plum	14	10	0	2	2	1
Total of all the important fruit trees	126	72	10	26	12	14
Percentage	100	51·1	7·9	20·6	9·5	11·1

*Lysenko's method.

TABLE 2 — WHEAT PRODUCTION IN THE USSR

Year	Yield quintals per hectare	Cost of production per quintal (roubles)	Price of grain per quintal (roubles)	Profit %
1959	19·3	2·29	6·14	168·1
1960	23·9	2·09	6·10	191·9
1961	20·0	2·37	6·82	187·8
1962	24·8	2·02	7·78	285·1
1963	25·7	1·91	7·80	308·4

It was emphasized that greater attention will have to be paid to stimulating individual initiative in the collective farms. The same point was also made by Academician Vaschnil, Head of the Organization of Socialist Agricultural Enterprises. He emphasized that an important factor in achieving a further increase in yield and labour productivity would be the stimulation of the material interests of agricultural workers.

Laboratories of the Timirazev Academy

This Agricultural Academy named in honour of Prof. Kliment Timiryazev, a famous plant physiologist, is situated in a beautiful area in Moscow. The Academy has trained over 30,000 scientists in agricultural sciences during the last 100 years. It is one of the largest establishments in the educational Soviet Union in the field of agriculture. It has at present 6 faculties, viz. agronomy, horticulture, soil science and agro-chemistry, zoo-technology, economics and extension. There are currently 2500 students studying at the Academy of which 500 are doing postgraduate work. There are nearly 200 foreign students including 5 from India. The teaching faculty consists of about 300 professors and lecturers. The Academy has 10 experimental stations located at different places and there is a large laboratory for studying the effects of artificial climate on plant growth. In this laboratory the effect of changes in the intensity and length of exposure to light, humidity, temperature and the composition and physical structure of the soil, on plant growth are studied. As a result of the work done in this laboratory, several sources of artificial light — tubular luminescent lamps, arc lamps, mercury luminescent and xenon lamps — have been introduced in hothouses. Extensive experiments in plant nutrition and fertilizer application involving the use of radiotracers are in progress in the Department of Agronomical Chemistry under the chairmanship of Academician Klechkovsky. There has been great progress in the field of farm mechanization and at the Academy several new implements have been designed and fabricated. New varieties of grapes, apples and cherries have been developed and released. Interesting work on the development of roots and the relationship between the root system and spacing has been carried out by Prof. Kolesnikov of the Horticultural Department. On the basis of these studies, the optimum spacing that should be adopted in fruit orchards has been standardized. Prof. A. P. Gorin of the Genetics Department has been engaged in a study of pollen viability, extent of cross-pollination and seed development in wheat. He has found that under the climatic conditions of Moscow, about 2 per cent cross-pollination could occur in wheat. The pollen can travel up to 115 metres. Wheat pollen can be stored for 10-15 days in the laboratory by keeping the entire spikes at a temperature of 3-6°C. and 60-90 per cent relative humidity.

Institute of Biological Physics, USSR Academy of Sciences

At this Institute some of the leading geneticists like Academician N. P. Dubinin, Prof. V. V. Sakharov and Prof. B. L. Astaurov are working. Some of the principal problems under investigation are given below.

Early pioneers of mutation research in the USSR — It was emphasized that many Russian workers have contributed substantially to the growth of mutation studies. Kozjinsky in his book *Heterogenesis or Saltation* published in 1897 had expressed views similar to those published by Hugo deVries in 1901. Academician N. K. Koltzoff started work on induced mutagenesis employing radiations as well as chemicals as early as 1915. Nadson and Fillipov induced mutations in mucor with X-rays in 1925. Rapoport and Sakharov established the mutagenic properties of chemicals by 1939. Mutations of great agricultural value were isolated by Delaunay during 1930-35. It was felt that these contributions are not widely known outside because they are all published in Russian.

Polyploidy and radiosensitivity — No strict relationship between chromosome number and sensitivity to radiations has been observed. The genotype seems to play an important part in controlling radiosensitivity. Resistance to radiations can be increased by selection and in this way some highly resistant forms of buck wheat (*Fagopyrum esculentum*) have been isolated. Fast neutrons and chemical mutagens also do not affect the resistant genotypes selected in gamma treatments. The resistance is inherited and behaves as a dominant. Some F_1 hybrids between resistant and sensitive selections exhibit a marked heterosis with reference to radio-resistance. Many of the plant species collected from regions characterized by high natural radioactivity show resistance to radiations. Chromosome volume cannot be the sole factor in determining radiosensitivity, since genetic differences occur frequently. More chromatid aberrations are observed in polyploids than in diploids.

Polyploidy breeding — Tetraploid buck wheat is already being cultivated in some collective farms. The tetraploid has 32 chromosomes and the shattering of grains is less in the tetraploids as compared to the diploids. Tetraploid Pyrethrum is not promising, but the triploid with $2n = 27$ is very vigorous. No phenotypic mutations have been observed in colchicine-treated material of the type described in *Sorghum* by Dr Franzke and Dr Ross of the United States. Colchicine disturbs the arrangement of chromosomes and somatic reduction occurs in some of the treated material. The artificial induction of somatic chromosome reduction is considered a distinct possibility. Somatic pairing has also been observed. The induced tetraploids show a universality of resistance — higher degree of radio-resistance, cold-resistance, heat-resistance and *p*H-resistance. The reasons for this situation are being studied in detail by Prof. V. Y. Alexandrov at Leningrad.

Radiation Genetics Laboratory

This laboratory is under the charge of Academician N. P. Dubinin. Extremely interesting work is in progress at this laboratory on some of the important problems in radiation genetics.

Cosmic genetics — In this section, a unicellular algal, *Chlorella*, is being used for studying both the spontaneous and induced mutation frequency. Since

Chlorella can release oxygen during cosmic flights, there is interest in the development of strains which are superior in oxygen production. Also, increased radiation resistance and temperature resistance are being selected for. In general, there is a positive correlation between sensitivity to temperature and to radiation. The LD-50 dose for *Chlorella* is 10,000 rads. Inter-strain variations in LD-50 ranging from 10,000 to 30,000 rads exist.

Radiation protection — The effect of different radio-protective agents like S-2-aminoethylisothiouronium bromide hydrobromide (AET), streptomycin, etc., are studied in human cell cultures from embryonal fibroblast exposed to 10-50 rads. This method is used as a routine screening method for the identification of chemicals with a radio-protective action. Cancer cells have also been used in such studies. Cells from normal and malignant tissues are being subjected to a karyotypic analysis. It has been found that the chromosome number shows variation in 2-10 per cent of cells. Chromosomes do not occupy positions in the metaphase plate at random. Some lie at the centre and some at the periphery. This has been confirmed by labelling also. In certain types of inherited abnormalities such as Turner's or Kleinfelter's syndrome, chromosomes on the periphery are affected. The angle at which chromosomes lie in relation to each other appears to be fixed, homologous chromosomes lying near each other. A dose of 300 rads gives 40 per cent affected cells, while a sick child suffering from measles shows about 80 per cent affected cells. In one patient who had reached the metastase stage of cancer, trisomy for chromosome number 13 was found in all the malignant cells, irrespective of the precise location of the malignant tissue in the body. This strongly suggests a relationship between chromosome aberrations and cancer.

Chain mutagenesis — Prof. Dubinin visualizes the mutation process as one involving a set of chain reactions. Some potential premutational changes are induced in the G_1 stage and the development of these changes into mutations proceeds in a definite order. The nature of the different steps involved is not clear. In space flights some cultures of *Drosophila* had received as much as 100 rads of radiation.

Mutations in higher plants — The work done at this laboratory suggests that metabolic byproducts are largely responsible for spontaneous mutations. Different species respond differently to mutagenic treatments. In *Triticum*, the ratio between chromosome bridges and fragments ranges from 8:1 to 30:1. On the other hand, in *Allium*, this ratio is only 1:1. The addition of antimutagenic chemicals like sulphanilamide, cystemine, streptomycin, etc., reduces the mutation frequency but does not alter the spectrum. Thus, the protection seems to be more general than specific. Attempts are being made to produce very efficient mutagenic chemicals by combining several reactive groups (like phenyl, alkyl and nitroso groups) together in one chemical. One such chemical having the phenyl as well as the alkalyating groups gives high mutation rates and low lethality at a concentration of 0·00003 per cent.

Institute of Chemical Physics, USSR Academy of Sciences

Chemical mutagenesis — The section of mutations in this Institute is headed by Prof. J. A. Rapoport, who shares with C. Auerbach of UK and F. Oehlkers of Germany the credit for opening up the field of chemical mutagenesis. The primary aim of the work conducted here is the synthesis of highly potent chemical mutagens. Using the normal screening procedures, a large number of chemicals synthesized in the institute are being tested on *Drosophila* for their mutagenic efficiency. In order to work on a very extensive scale, Rapoport has fabricated some versatile equipment for making the feeding medium and filling the tubes with it. It takes only 1 min. to fill 128 tubes with the medium. He has also constructed a washing machine for cleaning the tubes quickly. Besides *Drosophila*, higher plants particularly wheat, barley and maize are being used in mutation experiments. This institute is helping a large number of agricultural research stations throughout the USSR in getting material treated with chemical mutagens. Very extensive field experiments are currently in progress and some varieties of wheat, cotton and peas developed by mutation breeding will shortly be released for cultivation. A group of nitroso compounds like N-nitrosomethylurea and N-nitrosoethylurea as well as 1,4-bis-diazoacetylbutane have been found to be highly mutagenic and have been designated as 'super-mutagens' (Fig. 1). They are effective in concentrations ranging from 1/2000 to 1/10,000 and are stable for 6-12 months at 0-1°C. Dominant and systemic mutations occur more frequently in material treated with N-nitrosomethylurea. Diethyl sulphate has been found to be more useful than ethyl methanesulphonate.

Mechanism of mutation and recombination — From work in *Drosophila*, Rapoport is of the view that many chemical mutagens produce their effects

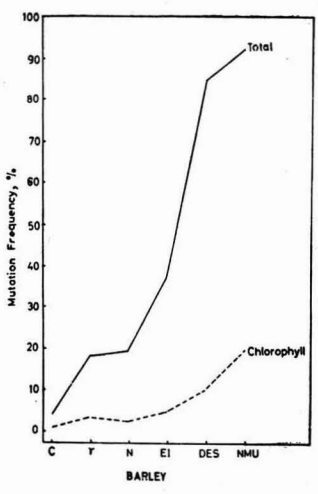


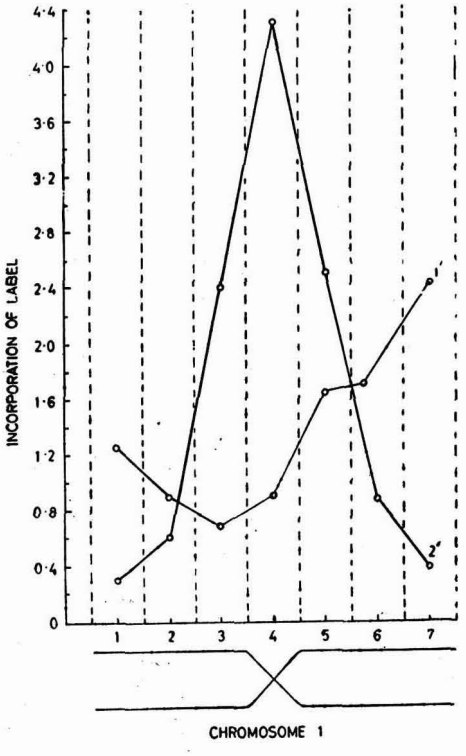
Fig. 1 — Mutation frequency (percentage of spikes segregating for mutations) in barley induced by different mutagens [(C) control; (γ) γ-rays; (N) neutrons; (EI) Ethyleneimine; (DES) diethyl sulphate; and (NMU) nitrosomethylurea] [From the work of Rapoport and colleagues]

through an action on proteins rather than on DNA. For example, ethyleneimine may block the carboxyl and the carbonyl groups of the gene proteins. Chromosome breakage is probably due to the influence of the active imino group on the carbonyl group of the peptide bond of the chromosome. Chemicals like diazopropylfluorine phosphate, which suppress the activity of several proteolytic enzymes, lipases and carbohydrates as well as oxidative phosphorylation, display a mutagenic effect. A reaction of the mutagen with tyrosine or serine on internal proteins appears to be the cause of mutations.

Rapoport holds the view that isomeric forms of amino acids may exist, which would explain the occurrence of several triplet codes for a single amino acid. As regards recombination during meiosis, it is postulated that the Dirac-Fermi law relating to particle distribution in quantum statistics would offer an explanation. Mixed states in the physical sense, one constituent being genetic and the other chemical, may occur during treatments with chemical mutagens. Thus, an exchange which cannot be observed in an electronic pair can be observed in chromosomes. A convincing argument in favour of crossing-over being a function of exchange comparable to real variations of quantum exchange is its independence from activation, its constancy and spontaneity. If, for example, crossing-over is forbidden by a special quantum rule for heterogametic sex (XY and ZW) in contradistinction to the homogametic sex (XX and ZZ), the resistance in overcoming the inhibition is even greater than in cases of artificial mutations.

Institute of Molecular Biology

This Institute was founded in 1958. The work here relates largely to the chemistry of nucleic acids and to the study of the sequence of nucleotides in the transfer RNA for valine. Nearly 70 per cent of the sequence has been worked out. Studies on transfer RNA and messenger RNA constitute the special fields of investigation in this institute. There is a laboratory of general and cosmic karyology attached with this institute. The famous cytologist Dr A. A. Prokofieva-Belgovskaya is in-charge of this laboratory. By using pulse labelling for 10 min. during 4 different stages in the synthesis of DNA, it has been observed that asynchrony in labelling is a common feature in human chromosomes. Chromosomes 1, 2 and 3 were divided into 6 or 7 regions and the time of synthesis of DNA in the different regions was carefully studied. It was observed that in chromosome 1, the telomeres got labelled first and the centromere region became labelled last. In chromosome 2, the pattern of labelling and speed of DNA synthesis was reversed (Fig. 2). While this was the condition in embryonic fibroblast, no such differences existed between chromosomes 1 and 2 in leucocytes. The pattern of DNA synthesis in specific chromosomes is now being investigated in cells from the lung, kidney and embryonic brain. Messenger RNA synthesis seems to take place more



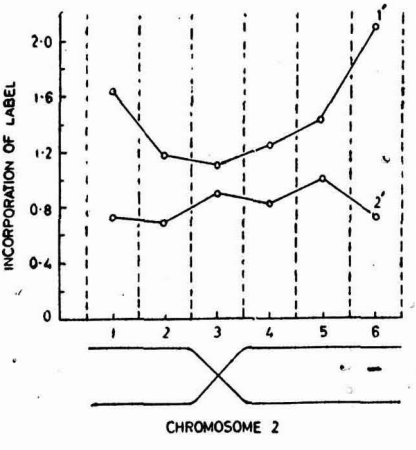


Fig. 2 — DNA synthesis in different parts of human chromosomes 1 and 2 [Curve 1 relates to the beginning of the synthetic period and curve 2, the end of the S phase. It is seen that in chromosome 1 the telomeric regions exhibit the maximum synthesis at the beginning of S phase, while the centric region shows the maximum labelling at the end of the S period. The trend is different in chromosome 2] [From the work of Dr A. A. Prokofieva-Belgovskaya]

in the despiralized region. The model of chromosome replication suggested by Taylor could not be verified. The rate of synthesis of DNA is not synchronous in both the chromatids of a chromosome in the first meiosis. Heterocyclicity appears to be a basic principle of cell division and function.

A multi-stranded model in which it is assumed that two protein matrices exist, each comprising several DNA chains, has been constructed. Such a model is consistent with both asychronous labelling in the first mitosis following the uptake of ^3H thymidine and the semi-conservative system of DNA replication.

Severtsov Institute of Animal Morphology, USSR Academy of Sciences

Prof. B. L. Astaurov has been working since 1934, on the artificial induction of parthenogenesis and polyploidy in the silkworm, *Bombyx mori* ($2n = 56$). He has found that when untertilized eggs are immersed in hot water (46°C. for 18 min.) meiosis is suppressed and diploid cleavage nuclei arise. During such cleavage, endo-mitosis takes place and polyploids as well as mixoploids are formed. The tetraploids and triploids can be propagated parthenogenetically. Neither triploids nor tetraploids are useful from the point of view of silk production. *Bombyx mori* has been crossed with *B. mandarina* ($2n = 56$), a wild silkworm species, and the hybrid caterpillars were reared quite successfully on mulberry. Through heat treatment parthenogenetic larvae were obtained from the hybrid, but neither the hybrid nor the polyploid was superior in silk production. The amphidiploid was backcrossed with the female of tetraploid *B. mori*. The fertility was rather poor in this cross and it seems possible that due to the close relationship between the two parental species the polyploid behaves more like an autoploid. It would be interesting to use a more distantly related species in the cross and observe the effects on fertility and breeding behaviour.

Institute of Agriculture, Non-Chernozem Zone, Nemchinovka

This Institute is located at a distance of about 50 km. from Moscow. Extensive experiments on the breeding of new varieties of wheat, rye, oats, maize and peas are in progress.

Wheat breeding — Hybrids between *Triticum* and *Agropyron* have been widely used as breeding material. One variety named Nemchenovskaya has yielded 45 quintals/hectare and has a seed weight of 55 g./1000 grains. The dose of fertilizer applied is 60 kg. nitrogen/hectare. A spring wheat variety named Moscowskaya capable of giving 3-5 tons/hectare has also been developed. The work of Prof. V. Pissarev has led to the production of several hybrids between rye and wheat (Triticales). The protein content of some strains of rye-wheat has been found on an average (10 years) to be 18·4 per cent in contrast to 13·5 per cent in bread wheat. Triticale strains have been crossed with wheat and some selections with 42 chromosomes having 16·8 per cent protein have been selected. In general, the 56 chromosome Triticale is not useful. Some of the 42 chromosome Triticales developed from *T. turgidum* are very promising. Work is also in progress on hybrid wheat. So far only 2 per cent of the hybrids have given superior yields by about 25 per cent in comparison with the normal varieties. The male sterile lines used in the synthesis of hybrid wheat are from *T. timopheevi* and *T. zhukovskyi*. Two restorers have been identified so far. The work on hybrid wheat is in progress at 6 different centres in the USSR, and it has been found that in an open pollinated male sterile parent 70-90 per cent seed setting occurs.

At this institute, Prof. Lobchenko is engaged in a very intensive study of wheat breeding on the basis of Michurin's ideas of distant hybridization. *Agropyron glacum* ($2n = 42$), *A. elongatum* ($2n = 70$), *A. tricophorum* have all been crossed with *Triticum* species. The main characters of interest in *Agropyron* are: (i) winter hardiness, (ii) high protein content, *c.* 20 per cent, (iii) stiff straw, and (iv) resistance to rust. In addition, *Agropyron* species have 60-80 grains per spike. In the USSR, 30 per cent of the wheat crop is killed by frost once in five years. From the second backcross to *T. aestivum* of the F_1 *T. aestivum* × *Agropyron* sp., it has been possible to isolate non-lodging types with very productive ears. The protein content is higher than in wheat. The winter hardiness has also been improved. Some branched wheats have been obtained from this cross, but so far they have not been found useful for release since the extent of branching decreases with close spacing. One segregate (No. 186) derived from this cross has been used extensively as a parent in the development of new varieties. In a cross between *A. glacum* and *A. elongatum* derivatives with 28 per cent protein content have been isolated. Some tri-generic crosses using *Triticum*, *Secale* and *Agropyron* species contain as many as 120-180 grains per ear.

Breeding forage crops — Several good varieties of Vetch, Lupin, and Horse bean (*Vicia faba*) have been bred. Mutation experiments in peas have given some dwarf, compact and large podded types. Two mutants are now under extensive trials and they have yielded 4 quintals/hectare more than the control.

Main Botanical Garden, Moscow

Academician N. V. Cicin gave an idea of the extensive collection of plants in the botanical garden. Over 2500 varieties of roses are maintained in the garden. Prof. Cicin's work is in the tribe Triticinae. He has attempted extensive crossing among members of *Triticum*, *Agropyron*, *Secale* and *Elymus*. In *T. aestivum*, he has developed several branched types which have been described as new varieties, namely *alboramosum*, *rubroramosum* and *multispicatovillosum*. All these types were isolated in *Triticum* × *Agropyron* crosses. While the yield of some of the normal varieties in the Moscow region is about 14 quintals/hectare, a variety of branched wheat has given as much as 36 quintals/hectare. Besides branched wheats, Cicin has developed a variety of wheat which can be used both for grains as well as fodder and another which has a perennial habit. In the grain-fodder variety, over 100 quintals of hay and 10 quintals of grain have been obtained during a period of three years. The protein content in the

grain and the hay is 23 per cent. Some of the promising cultures are 108, 1336, 1338 and 1345. They are drought as well as rust-resistant. During 1965, strain No. 1345 survived the Siberian winter while all the others perished. The perennial wheat variety can be grown for a period of three years for both grain and fodder. The grain-fodder variety has been designated botanically as *Triticum agropyrotriticum* Cicin ssp. *submittans* ($2n = 56$). The other subspecies of this species is ssp. *perenne*. In crosses between *T. aestivum* and *A. elongatum*, characters of wheat start appearing only after the F_1 has been backcrossed twice to *T. aestivum*. The F_1 and BC_1 cultures all have only *Agropyron* characters. Each spikelet has as many as 6 grains in some selections from this cross. In the branched variety, 12 grains per spikelet have been found. The promising perennial wheat cultures are M 458, 470 and 108. In the cross *T. aestivum* × *Elymus giganteus* ($2n = 28$) giant forms of ears with many spikelets have been found.

Distant hybridization has been practised in the genus *Nicotiana*. From the cross *N. rustica* × *N. glauca*, virus resistant perennial tobacco plants have been obtained. The cross *N. glauca* × *N. alata* has yielded a perennial variety with the leaves having an aroma which is different from that of the normal varieties.

The above account of some of the results obtained in recent years at a few institutions in Moscow would be adequate to indicate that with the eclipse of the era of dogma symbolized by Lysenko, the USSR will acquire once again a pre-eminent position in genetic research.

Symposium on Magnetohydrodynamic (MHD) Electrical Power Generation

This symposium, jointly organized by the International Atomic Energy Agency (IAEA), Vienna, and the European Nuclear Energy Agency, will be held at Salzburg (Austria) during 4-8 July 1966. The subjects to be discussed at the symposium include: Physical properties of the MHD working fluid (combustion gas and closed cycle fluid); Study of MHD flows and power conversion processes (continuous gas flows); AC power generation; Unconventional MHD conversion; Liquid metal MHD converters; Production of magnetic fields (conventional, cryogenic and superconducting electromagnets); Problems of materials; Open cycle converters; and Closed cycle converters.

Further details regarding the symposium can be had from the Division of Public Information, IAEA, 1010 Vienna, Austria, Kärntnerring 11.

Get-Together of Science & Industry

A TWO-DAY conference of scientists from various national laboratories and other research centres, and representatives from industry, held under the auspices of the Council of Scientific & Industrial Research, concluded its deliberations in New Delhi on 21 December 1965. Held at the suggestion of Shri M. C. Chagla, Union Minister for Education, the conference had before it the broad purpose of bringing about a better awareness of the problems and difficulties of industry by the scientists and conversely an appreciation of the role of scientific research in industrial development so that the necessary climate is created for the industry to appreciate indigenous research talent available in the country and make a convincing case for its not leaning heavily on foreign collaboration based on turn-key processes. Through pinpointed and specific recommendations about plans of work in different fields, the conference provided the starting point for imparting a sense of direction and purposefulness to indigenous research effort. The specific problems discussed at the conference included: (1) development of substitutes for imported raw materials; (2) indigenous manufacture of essential components hitherto imported; (3) development of indigenous know-how at a sufficiently advanced level so as to be commercially utilizable in respect of those articles on which repeated foreign collaboration has been sought; and (4) measures through which the programmes of industrial research could be oriented to the needs and requirements of industry.

Over 800 delegates, more than half of them from industry, participated in the deliberations of the conference. The number of papers submitted for discussion exceeded 400. After the inaugural session on the morning of 20 December, addressed among others by Dr Husain Zaheer, Director-General, Scientific & Industrial Research, Shri M. C. Chagla, Union Minister for Education, Shri T. N. Singh, Union Minister for Industry, Shri Asoka Mehta, Deputy Chairman, Planning Commission, Shri K. Raghuramaiah, Minister for Supply and Technical Development, Shri S. G. Bharve, Member, Planning Commission, and Dr M. S. Randhawa, Director-General, Intensive Agricultural Areas, the conference split into 15 working groups devoted to the following fields: (1) Electronics, instruments, radio, television, public address systems, etc., standards, physics-based industries; (2) Industrial organic chemicals, biochemicals, dyes and intermediates, rubber, resins, adhesives, plastics, paints, varnishes, surface coatings, etc.; (3) Inorganic and heavy chemicals, fertilizers, cement, marine chemicals; (4) Drugs and pharmaceuticals, medicinal and aromatic plants, public health engineering; (5) Chemical plant and equipment, electrical and mechanical engineering, cables, batteries, power plant, agricultural, textile and mining machinery, automobiles, etc.; (6) Food, agriculture, agro-industries, fish, meat, sugar, tea, coffee and industrial crops, oilseeds, edible oils; (7) Metallurgy, iron and steel, non-ferrous metals; (8) Paper, pulp, forestry, textiles, man-made fibres, wool, leather, plywood; (9) Mining, ores, minerals, geophysics, oceanography; (10) Petroleum refining, petrochemicals, petroleum technology, and oil and gas exploration; (11) Energy, coal, etc.; (12) Glass, ceramics, enamels, clays and refractories, mica, etc.; (13) Aeronautical engineering: aircraft structures, materials, propulsion systems, aviation fuel, etc.; (14) Buildings, roads, civil engineering, materials, etc.; and (15) Research utilization, cooperation between research and industry, policies on research and development.

In view of the diverse nature of fields covered under each working group and the paucity of time, instead of each paper being presented and discussed individually, the discussions at the working group meetings were based on key papers prepared by the respective conveners of working groups, based on the papers received. After discussion for 6 hr the working groups formulated their recommendations — both specific and general — as to the ways and means of speeding up action in respect of the objectives set for the conference. The delegates met at a combined final session on the afternoon of 21 December at which the conveners presented the recommendations of their respective working groups.

Electronics and Related Industries

The key paper, based on about 30 papers received, envisaged a total investment of Rs 1800 million during the next decade. Detailed breakup for different sectors of the electronics industry was presented. The requirements of the industries were considered under the heads: equipment and systems, component units, components and raw materials. The major bottleneck in the development of the industry was the non-availability of components due mostly to lack of manufacturing capacity and basic raw materials. In the recommendations originating from this working group items deserving attention on priority basis were listed category-wise. The items listed under 'Materials' included: aluminium wire or foil as possible substitute for copper; aluminium sheet of uniform thickness for capacitors (variable); precision rolled (grain oriented) steel sheets; winding wires and copper foils, high permeability alloys; oxygen-free high conductivity copper; brazing alloys (e.g. Al-Si, Au-Ni, Ag-Pb-Sb); glass and alloys for glass to metal seals; silica tubes; high alumina ceramics for glass to metal seals; low-cost optical glass (for larger lenses); bulbs for television picture tubes; ferrites in rod and ring forms; carbon tracks for volume controls; polyester films; semiconductor grade chemicals; photo-resist for printed circuits; printed circuit boards with epoxy glass base; paper for paper condensers and pen recorders; pulp for loudspeaker cones; photographic bromide paper in rolls; and impregnating compounds. Under 'Components', a variety of capacitors, resistors, inductors and transformers, switches, connectors and relays, and transducers were listed.

Under 'Instruments', priority was recommended for optical pyrometers, microscope optics, general purpose recorders, testing and process control instruments for the textile industry, a number of electromedical instruments, and about forty electronic instruments.

Industrial Chemicals

Though the Indian dyestuff industry is producing a total of 272 dyes belonging to almost all the important classes of dyes, the indigenous production is based mostly on imported intermediates. Therefore for attaining self-sufficiency, concerted efforts towards indigenous production of intermediates, particularly copper phthalocyanine derivatives (perchloro, alcians, reactive dyes and solvent stables and speciality pigments), alizarin and its derivatives, benzoyl chloride, dimethyl sulphate, diethyl sulphate, and sodium cyanide was stressed. In the field of rubber and plastics, the items for which technical know-how needs to be developed on a priority basis are: neoprene rubbers, nitrile rubbers, thiokol (polysulphide) rubber, silicon rubber, MMA plastics and resins, epoxy plastics and polyurethanes. The working group listed the following industrial organic chemicals as deserving priority for research and development work: phthalic anhydride, maleic anhydride, chlorinated hydrocarbons, aliphatic amines, alkyl and alkanol phenols, cyclohexylamine, fluoro compounds like fluoroacetic acid, freon, etc., hydrocyanic acid, phenol/cresol, and various catalysts required for organic chemicals industry. A number of specific projects to be undertaken on crash basis were listed.

Inorganic and Heavy Chemicals, Fertilizers, Cement and Marine Chemicals

With almost total dependence on imports for sulphur and a wide gap between the availability and requirement of fertilizers, it was inevitable that both in the key paper for the third working group and the discussions at the working group meetings, these two items received maximum attention. It was reported that against 0·28 million tons of sulphur (valued at Rs 5·42 crores) imported during 1964-65, the estimated requirement is likely to be 1·2 million tons during 1970-71 and 2·0 million tons during 1975-76. Among the suggestions put forward for enhancing the indigenous production of sulphur and sulphuric acid and for conserving sulphur were: (1) speeding up work on pyrite mining projects; (2) development of a process for the beneficiation of Amjor and Mysore pyrites; (3) development of an economic process for exploiting calcines from pyrites; (4) development of an economic method for producing elemental sulphur from sulphur dioxide obtained from roasting of various pyrites ores; and (5) development of a suitable method for the production of sulphuric acid from gypsum. The use of hydrochloric acid in place of sulphuric acid, wherever possible, was recommended for the following processes: (1) production of fertilizers; (2) pickling of steel; (3) production of titania; (4) regeneration of ion-exchange beds in water softening equipments; (5) neutralization of raw water for pH control; (6) fixation of ammonia in coke oven gases; (7) manufacture of bleaching earth; and (8) refining of sugar. Considering the acute shortage of potassium and phosphatic fertilizers, the working group recommended: (1) intensive studies on reaction between urea, nitric acid and rock phosphate for making water-soluble phosphatic fertilizers; (2) techno-economic survey on the preparation of phosphatic fertilizers from rock phosphate by electrothermal or thermal processes, or using hydrochloric acid; (3) pilot plant studies on the production of mixed potassium and calcium phosphate fertilizers using felspar; and (4) studies on the use of the available indigenous potassium sources, such as distiller waste from molasses and waste material from cashewnut industries. Important among the other recommendations emanating from this working group were those relating to: (1) the development of a national design of diaphragm cell of 30,000 amp. with a minimum of imported components; (2) substitution of imported asbestos diaphragms by indigenously available material; (3) studies on reducing loss of mercury in electrolytic mercury cells; (4) techno-economic survey of production of caustic soda by chemical, mercury cell and diaphragm processes; (5) study of different aspects of the production of soda ash and ammonium chloride by direct reaction of salt, carbon dioxide and ammonia; (6) exploring the possibility of substituting caustic potash by caustic soda wherever possible; (7) development of a method for the manufacture of potassium carbonate from indigenous sources; (8) studies on the chlorination of minerals, such as those pertaining to raw materials like titanium, niobium and tantalum; (9) studies on the upgrading of ilmenite using hydrochloric acid; (10) studies on desulphatation of brine in salt production from marine sources; (11) development of an indigenous process for the production of special grade magnesia and magnesium salts; (12) investigations on the increased use of ethylene dibromide, methyl bromide, etc., in place of fumigants based on imported raw materials; (13) development of know-how for special grade cements required for petroleum drilling; (14) development of know-how for acid-alkali resistant and high temperature setting cements; (15) investigations on the beneficiation of indigenous fluoride minerals and production of anhydrous hydrogen fluoride and fluorine; (16) production of sodium nitrite and nitrate from waste gases in nitric acid plants; (17) production of activated carbon suitable for use in gas masks and other applications involving adsorption of gases; (18) production of activated alumina and special grade silica gel; (19) manufacture of cyanide from the purge gases of ammonia factories; and (20) extraction of lithium salts present in lepidolite mineral available in the country.

Drugs and Pharmaceuticals

Large-scale dependence on imported raw materials and intermediates in the manufacture of drugs and pharmaceuticals was pointed out as the major obstacle in the growth of the indigenous drugs and pharmaceuticals industry in the key paper for this working group. The paper listed 53 basic raw materials whose production is essential for the proper growth of the industry. These include toluene-based chemicals, tar distillation products, amines, phosgene and some inorganic chemicals.

The working group recommended: (1) speeding up the establishment of distillation units at coke oven and other gas plants; (2) a time-targeted programme to be drawn up by CIMPO within 6 months for the cultivation of the major medicinal plants for the production of active principles and essential oils, such as liquorice, *Digitalis lanata*, pyrethrum, *Dioscorea kazeri*, *Atropa belladona/acuminata*, *Podophyllum emodi*, ergot, *Rauvolfia serpentina*, *Mentha arvensis* and *M. piperata*; (3) increased cultivation of lemongrass and afforestation of cocoa beans and *Szygym aromaticim*. Specific recommendations were made in respect of production of antibiotics and modernization of slaughter houses.

Plant and Equipment

The key paper mentioned equipment design and material substitution as the crucial considerations for the expansion of various engineering industries. The situation is complicated by the multiplicity of specifications resulting from innumerable collaborations originating from different parts of the world. Rationalization of specifications was considered necessary to reduce the problem to manageable dimensions. It was felt that a few selected alloy steels could cover the requirements of a wide variety of slightly differing specifications. Thus while copper, zinc, lead and stainless steel can be replaced by aluminium in many applications, PVC and polystyrene linings could replace stainless steel, paper insulation and lead linings. The working group recommended a number of well-defined tasks to be undertaken and completed within specified time limits by different institutions. These include development of wire, wire rope and cable-making machines, chip and hardboard making plant designs, minor irrigation turbine pumps, diaphragm pumps for high pressure low discharge, dial gauges of various ranges, 8-10 h.p. agricultural tractors, economical warehouse steel structural designs, high pressure heat exchangers, freeze drying machinery, automatic welding machines, fluxes and electrodes based on indigenously available materials.

Food and Agriculture

The lacunae in the existing programmes of augmenting and preserving food resources in the country formed the subject of the key paper for this working group. It was reported that against the normal shortage of about 6 million tons of food per year, valued at Rs 3500 million, the losses due to rodents, insects and microorganisms and due to defective methods of processing, handling and distribution account for as much as approximately 50 per cent of the food raised in the country, valued at Rs 46,000 million. Stressing the need for raising the technological level of the food industry, it was rightly emphasized that preventing food losses is no less important than increasing food output through better use of water resources, improved seeds, modern fertilizers and plant protection. Revealing disparities in the world averages and maximum yields of the major field crops and the corresponding figures for India were reported. The average yields of cereals, pulses, oilseeds and potato in India are 0·80, 0·52, 0·63 and 8·28 metric tonnes/hectare. Against this the world averages are 1·40, 0·64, 0·77 and 11·20 respectively and the maximum yields attained 4·4, 1·6, 2·0 and 29·0 respectively. Thus by bringing the yields at par with world averages alone, about 60 per cent increase in food supply can be assured.

Metallurgy, Iron and Steel and Non-ferrous Metals

The main problems facing the iron and steel industry as outlined in the key paper for this working group are: beneficiation of raw materials (iron ore, limestone, coal, etc.) and increased production of ferro-alloys and refractories. Among the short-term recommendations made by the working group were those relating to: (1) immediate establishment of alloy steel industries and production of ferro-alloys; (2) rationalization of specifications for ferrous and non-ferrous alloys; (3) provision of facilities for the supply of cryolite and aluminium fluoride for aluminium production; (4) exploring the possibility of substituting imported anthracite coal by petroleum coke and other alternate materials; (5) production of high and super purity aluminium; (6) establishment of secondary refining capacity for the recovery of non-ferrous metals from the byproducts, drosses, wastes and scraps; (7) exploring the possibility of substituting non-ferrous metals in short supply by those ferrous and non-ferrous metals which are indigenously available; (8) increasing adoption of aluminizing process where it can suitably replace galvanizing of steel; and (9) early establishment of silicon and magnesium production capacity in the country to meet the demands for pure metals. In its long-term recommendations, the working group stressed the urgency of (1) a rational survey of the entire mineral resources of the country; (2) study of projected demands of plain carbon, alloy, tool, special and stainless steels during the successive five-year plans; (3) establishment of adequate production capacity for titanium, zircon, germanium, etc.; and (4) a concerted effort towards the development of substitute family of alloys.

Paper, Pulp, Forestry, Textiles, Man-made Fabrics, Wool, Leather and Plywood

The working group anticipated 320 million lb./year shortage in cotton production in the country by 1970-71, the shortage being mostly in respect of medium and long staple cottons. For meeting the situation, the working group recommended: (1) intensive studies on the upgrading of Indian cottons for substituting imported ones; (2) systematic studies on blending of natural and man-made fibres; (3) studies on the improvement of technological processing methods for 100 per cent viscose staple fabrics to minimize their shrinkage and crumpling so that they could satisfy some of the requirements for which imported cottons are used; (4) study of the effect of fabric construction on fabric properties, particularly durability; and (5) operational research study of the feasibility of reducing total values of cotton imports without reducing the yardage of cloth produced from imported cottons. In respect of wool textile industry, the working group recommended among other things: (1) extensive work on blends of wool with man-made

fibres for defence and civilian requirements to examine the possibility of import substitution; (2) developmental research on the production of foam-backed fabrics and their evaluation as substitutes for woollens for specific end uses; (3) basic research on the causes for harshness and yellowing of Indian wools and the ways of overcoming them; and (4) basic studies on felting and setting characteristics of Indian wools for increasing their use for apparel fabrics. In respect of jute textile industry the need for intensive research on the possibilities of economic utilization of fibres from certain agricultural residues, such as cotton stalk barks and of indigenously available but less known fibres such as ramie was stressed. The working group recommended intensive product development studies, particularly on: (1) easy care cotton fabrics, including wash-and-wear and permanent press type of finishing; (2) stretch cotton yarn and fabrics; (3) laminates of cotton and textiles, particularly with polyurethane foams; (4) jute fabrics suitable for canal linings and for upholstery and tapestry; and (5) flexible and rigid laminates from jute fabrics. For overcoming the acute shortage of raw materials for the pulp, paper and rayon industries, the working group recommended: (1) studies on the exploitation of bagasse for paper pulp manufacture; (2) extension of the use of bamboo pulp for paper and rayon industries; (3) afforestation programme for fast growing tropical hardwood, such as eucalyptus and tropical pine; and (4) evaluation of various agricultural residues, grasses, reeds, etc., for the manufacture of paper boards and different varieties of paper. Other recommendations made were: (1) thorough evaluation of the pre-hydrolysis-sulphate process for making rayon grade pulp from tropical hardwoods; (2) exploration of semi-chemical pulp methods for various indigenous raw materials; (3) intensive research on the manufacture of speciality papers; and (4) indigenous development of instruments for testing, quality control and process control. In respect of leather industry, the working group recommended: (1) intensive studies on finding suitable substitutes for wattle bark; (2) development of technical processes for making sophisticated leather products; (3) formulation of an integrated plan for the manufacture of various chemicals and auxiliaries; and (4) improvement of the quality of hides and skins through modernization of slaughter houses.

Mining, Ores, Minerals, Geophysics and Oceanography

The key paper, while presenting an exhaustive survey of the existing status and future requirements of the important minerals in India, stressed the urgency of extensive mining of the established reserves of strategic minerals, such as copper, lead, zinc, pyrites, antimony and phosphates, and intensive exploratory efforts to establish reserves for future requirements. Among the specific recommendations made by the working group were: (1) discouraging the use of copper and nickel for non-essential purposes; (2) systematic examination of base metal mine dumps and pegmatite deposits for the recovery of antimony, tungsten and other rare metals; (3) intensive studies on the use of calcium sulphate in sulphuric acid manufacture; (4) investigations on ways of finding larger use for trimolite in asbestos cement; (5) possibility of large-scale production of coal gas from low grade coal; (6) economic feasibility of production of synthetic petroleum from low grade coal; (7) investigations on the production of barium and calcium compounds from barytes; (8) critical examination of the problem of supply of ground barytes of the requisite specifications for petroleum industry; (9) exploration and exploitation of mineral deposits, including petroleum, in offshore areas; (10) investigations on the utilization of large quantities of quartz and felspar obtained as byproducts in mica mining; (11) systematic investigations for locating bentonite deposits to meet the requirements of mud chemicals for oil industry; and (12) detailed commodity appraisal of basic minerals for drawing up individual mineral development programmes. Intensive research on rock mechanics, anisotropic behaviour and development of stresses was considered necessary. The working group recommended beneficiation and pelletizing of low grade iron ores near ports, organized iron ore mining, research on beneficiation of manganese ores, geological and geophysical investigations for ground water exploration; speeding up exploitation of known deposits of apatite, etc.

Petroleum Technology

The working group considered the lack of design and fabrication facilities for equipment and plant as the major lacuna hampering progress in these fields. The setting up of a high powered design-cum-planning cell for this purpose as well as for examining the specifications and availability of alloy steels and other construction materials was recommended. Priority for research and developmental work in respect of production of oil field chemicals and catalysts needed in the refining and petrochemical industries was stressed. For reducing the import of superior grade kerosene and maximizing its production, adoption of hydrogenation of straight run kerosene was recommended. Among the other recommendations made were those relating to: (1) stepping up the production of solvents and other non-energy petroleum products; (2) priority for the establishment of industrial units for the regeneration of used lubricating oils; and (3) development of technical know-how on processes and design of equipment and plant for petrochemicals.

Energy, Coal, etc.

The key paper for this working group presented an exhaustive survey of the pattern of energy consumption and the existing and projected facilities for the various power generation systems. The economy likely to accrue from the introduction of integrated operation of power systems was stressed. The working group recommended accelerated development of indigenous commercial sources of energy, i.e. those based on coal, nuclear fuels and hydel power. It was reported that at the present rate of development and the current trend of increasing dependence on petroleum and petroleum products, by 1975-76, India will have to import about 30 per cent of her commercial energy requirements valued at Rs 200

crores per year, representing one-third of her total import capacity. Therefore, immediate shift towards the development of energy resources based on coal, nuclear fuels and hydel power was stressed. The working group recommended that urgent steps be taken for creating capacity for the manufacture of power equipment currently imported. Important among the other recommendations emanating from this working group were: (1) need for developing know-how for electronic grade silicon crystals and kraft paper used as insulating material for transformers and cables; (2) standardization of specifications for boiler plates; (3) utilization of engineering fabrication facility existing in the country to the maximum extent; (4) study of technical problems involved in the provision of extra high voltage transmission lines; (5) diversion of sized middling in coal washeries for domestic fuel manufacture and undersized coal for power plants; (6) establishment of regional low temperature carbonization plants for providing low temperature fuel; (7) developmental work on the recovery of sulphur from high sulphur coals and coke oven plants; and (8) replacement of coking coal by other coals in non-essential applications.

Glass, Enamels, Clays, Pottery, Refractories and Mica

The working group recommended intensification of work on (1) survey and evaluation of indigenous clay deposits and other ceramic raw materials with the specific aim of eliminating imports of ball clays, china clays, bentonites, etc.; (2) survey and economic proving of ceramic and refractory raw materials, such as magnesite, refractory grade chromite, kyanite, bauxite, high alumina clays, plastic clays, etc.; (3) beneficiation of magnesite and chromite; (4) establishment of a second development-cum-production unit for optical glass; (5) replacement of imported materials like selenium and decolourizing chemicals by indigenously available materials; (6) adoption of lead, boron-free glazes and zircon opacifiers; (7) expedition of pilot plant work on silicon carbide; (8) standardization of pyrometric cones manufactured indigenously; (9) establishment of structural clay products industry on scientific lines; (10) designing and fabrication of special dies and punches for producing fabricated mica; and (11) development of special steels for making moulds of presses.

Aeronautical Engineering

The subjects covered by the working group perhaps represent areas of maximum dependence on imports and foreign collaboration and therefore necessitate the largest volume of basic work. In view of the fact that engine design and development work has not received due attention so far, the working group recommended that while entering into technical collaboration, a design and development cell must be organized in the various industrial organizations which should have access to the basis of the design of various components, so that it may be able to undertake original design work progressively. The following were among the specific recommendations made: (1) augmentation of technical evaluation and inspection facilities for proving the indigenously produced components and materials; (2) development of know-how for various ferro concentrates and heat resisting alloys, specially those needed for engine manufacture; (3) rationalization and standardization of materials with a view to evolving common specifications for aeronautical design work; and (4) providing incentives to industry engaged in the manufacture of allied equipment, materials and standard parts to take up the production of aeronautical items; to begin with, ground handling and servicing equipment required on the operational side could be taken up.

Buildings, Roads, Civil Engineering, Materials, etc.

In contrast to the preceding working group, this working group covered areas of negligible dependence on imports. It was felt that in these fields, the desired tempo of developmental activity could be maintained and significant savings effected by practical application of the proven techniques emerging out of research effort in India and abroad in respect of (1) adoption of modern design and construction techniques; (2) increased production of traditional building materials; and (3) manufacture of accepted substitutes for conventional materials of construction, including maximum utilization of waste products from agriculture and industry. The working group recommended: (1) cutting down the projected requirement of 100 million tons of cement during the Fourth Plan by 15-20 million tons by resorting to increased use of puzzolanic and slag cement, lime-reactive *surkhi*, lime-puzzolana mixtures, kankar, hydraulic limes, fly ash and lightweight aggregates; (2) recognizing and encouraging the use of soil and other inferior locally available aggregates for use in the construction of roads, runways, buildings, etc.; (3) adoption of modern design methods, such as prestressing, use of high strength deformed bars and high strength function group holds, extended use of built up lightweight and tubular sections and use of welding in place of rivetting as measures for economizing on steel; (4) increased use of seasoned and properly treated locally available low grade timber, particle boards, hard and soft quality boards; and (5) introduction of mechanized brick plants to produce a variety of structural clay products, such as hollow clay, facing, perforated bricks and quarry tiles for flooring, etc.

Research Utilization

The last working group dealt with the key problems that come into play in linking up industrial research with industrial utilization of the results. Thus, the discussions and recommendations pertaining to this working group impinged in one way or the other on all other working groups. The key paper, based on about 60 papers received, discussed the various problems under the heads: (1) user participation in planning and organization of industrial research — concentration of research effort in selected areas; (2) technological gap between industrial research and its utilization; (3) problems in the development of indigenous know-how — positive and negative aspects of foreign collaboration, and

standardization, import substitution and spares; (4) cooperative research associations; (5) finances for industrial research; (6) incentives to industry for setting up its own research units; (7) personnel training; (8) patent policies; and (9) machinery for implementation of recommendations. Concluding the discussions, the working group recommended: (1) closer association of personnel from industry with the formulation and planning and evaluation of research programmes of laboratories; (2) joint examination of projects reaching pilot plant stage by teams of scientists and technologists from research and industry; (3) examination of the economic and technological feasibilities of research projects by functional research cells prior to starting work on them; (4) forging of close link between laboratories and technical consultancy bureaux and design engineering firms for purposes of joint planning of project engineering and feasibility studies; (5) special encouragement and support in licensing and industrial promotion to processes and projects based on indigenous know-how; (6) speedy formulation of Indian standards for spares, components and raw materials to promote speedy industrial development and utilization of indigenous raw materials; (7) establishment of an advisory committee to identify areas where foreign collaboration is no longer necessary and to suggest steps for gradual elimination of services like project engineering equipment design and feasibility studies from foreign technical collaboration arrangements; (8) creation of conditions for large size firms to set up research, development and design units of their own; (9) strengthening of channels of communication between research organizations and industrial firms; and (10) establishment of cooperative research associations by groups of industries.

General Recommendations

Besides specific recommendations pertaining to areas covered under each working group, a number of recommendations of general nature emerged from the get-together. Important among these were: (1) statutory provision of a levy of 5 per cent, with suitable tax relief, on the annual turnover of each industry for research and development purposes; (2) establishment of standing technical advisory bodies consisting of representatives of laboratories and industry to look into all practical aspects of creating and maintaining active liaison between research and industry; (3) strengthening of design engineering facilities which are vital to the speedy and effective exploitation of technical know-how developed in the country; (4) creation of a suitable machinery charged with the two-way task of identifying problems and feeding them to research laboratories and bringing to the notice of industry results of indigenous research effort; and (5) creation of a suitable follow-up machinery for implementing the recommendations emerging from the conference.

Symposium on Site Investigations for Foundations

A three-day Symposium on Site Investigations for Foundations will be held at the Central Building Research Institute, Roorkee, during February 1967. Discussions at the symposium will be on the following subjects: (i) Organization, planning and economics of site investigations; (ii) Methods and extent of investigation (aerial survey and mapping, geological and geophysical exploration, boring techniques, sampling techniques); (iii) *In situ* tests (load tests, penetration tests, field vane shear tests, *in situ* moisture density measurements); and (iv) Special site investigations for specific purposes (roads and runways, embankments, machine foundations, nuclear power installations, rocket sites, etc.).

Summaries (about 300 words) of papers intended for presentation at the symposium should be sent to the institute by 31 June 1966 and full papers by the end of August 1966. Further details can be had from Shri P. L. De, General Secretary (Symposium), Central Building Research Institute, Roorkee (UP).

Ninth International Conference on Cosmic Rays*

THE Ninth International Conference on Cosmic Rays, organized by the International Union of Pure & Applied Physics during 6-17 September 1965 at London, was attended by about 300 scientists from 25 countries. About 300 papers were presented at the conference. The discussions centred mainly on (i) high energy nuclear interactions and extensive air showers; (ii) cosmic ray mu-mesons and neutrinos; (iii) cosmic X-rays, gamma rays, electrons, protons and heavy nuclei; (iv) temporal variations of cosmic ray intensity and modulation effects in the vicinity of the earth; and (v) origin of cosmic rays and related topics. Some of the significant achievements reported at the conference are as follows.

In the field of extensive air showers (EAS) some exciting new approaches were presented. In the Bolivian Air Shower Joint Experiment (BASJE) being carried out with international collaboration, at Mount Chacaltaya in the Bolivian Andes at an altitude of 4300 m., attempts are being made to search for primary gamma rays of energy greater than 10^{14} eV. by looking for air showers which are extremely poor in mu-mesons — something which is to be expected if the initiating primary particle was a gamma ray multiplying in the atmosphere. The BASJE has furnished almost conclusive evidence for the existence of such events. These high energy gamma rays can either arise from discrete sources, perhaps quasi-stellar radio objects or as a result of cosmic ray collisions in space, and experiments of the BASJE type can throw light on these points. A new development in the field of EAS has been the search for massive elementary particles. If such particles are produced in high energy collisions associated with EAS, because of their large mass, they will travel a bit slower than the electron front of the EAS which moves with the velocity of light, hence these particles can be detected with fast electronic circuits which can measure delay times as short as a few nanosec. Details of two experiments in this direction were reported: one conducted at the Tata Institute of Fundamental Research (TIFR), Bombay, and the other at the Institute for Theoretical Physics, Copenhagen. No positive evidence has so far been obtained for the existence of such particles; nevertheless the importance of these investigations will be far-reaching in the field of particle physics if they are discovered.

Intense efforts towards determining the intensity of cosmic ray particles of exceptionally great energies are in progress and an exciting approach in this field has been attempted at Jodrell Bank (UK) where it has been possible to detect radio emission associated with EAS. This may prove to be a major break-through for studying particles of the highest energies found in cosmic rays.

In the field of high energy nuclear interactions, it has become clear that significant progress can take place only when the problems of particle identification and energy measurement at very high energies have been solved. Unless some technical break-through is effected in this direction, this field is likely to remain, in some senses, stagnant. Russian scientists reported at this conference the first attempt to fly aboard their 12-tonne satellite, proton-1, a massive detector to study high energy nuclear interactions. Only very preliminary results could be presented at the conference, because proton-1 was launched only in July 1965. It is, however, expected to yield interesting results in the months to come.

First experimental evidence was presented for interactions produced by high energy neutrinos presumably originating in nuclear collisions of cosmic ray particles in the atmosphere. These results were obtained from experiments carried out in the deep gold mines at Kolar, India (by scientists of TIFR, Bombay, the Osaka City University, Japan, and the Durham University, UK) and near Johannesburg, South Africa (by scientists from the Case Institute of Technology, Cleveland, USA, and the University of Witwatersrand, Johannesburg).

A new experimental detector system for neutrino experiments, which will be operated in 1966 and which appears to have great promise, was described by a group from the University of Utah, USA. It is clear from the results reported that it is possible to perform cosmic ray neutrino experiments up to quite high neutrino energies. Such experiments may be expected to throw light on high energy weak interaction physics and on the presently hypothesized vector boson which is supposed to mediate weak interactions.

In the study of the different radiations of cosmic origin, new results have been obtained from the use of sophisticated electronic detector systems operating in high flying balloons and space vehicles. At the University of Chicago, solid state detectors have been used for the first time for the study of low energy cosmic ray protons and heavy nuclei. These detectors permit charge and energy measurements with such precision that a very detailed analysis of the data is now possible. Such high resolution experiments, coupled with high counting rates (possible with satellite pay loads), have opened up a new class of investigations on the low energy cosmic radiation. Similar results were reported from the University of Minnesota and the Goddard Space Flight Centre (USA) from somewhat conventional detector systems having high resolution and flown on balloons and satellites. Results on the primary electron component presented from Chicago, Milan-Saclay and the TIFR aroused considerable interest because of their great astrophysical significance.

Confirmatory evidence was presented by the Chicago group for the long-time emission of high

*Summarized from the report published in *Nuclear India*, **4** (No. 2) (1965), 2.

energy particles from disturbed regions of the sun. These beams of particles co-rotate with the sun, sweeping the earth every 27 days for many solar rotations. In this experiment, the presence of helium nuclei was detected for the first time in addition to the proton component. This strongly suggests that these particles are brought from the sun, but it was not quite clear whether they are accelerated near the sun or in interplanetary space. From an experiment using nuclear emulsions flown to high altitudes, workers from TIFR, Bombay, and the Physical Research Laboratory, Ahmedabad, presented evidence for a finite flux of high energy neutrons reaching the top of the atmosphere. These were attributed to a visible solar flare which occurred a few hours before the balloon reached ceiling altitude.

The TIFR group also presented interesting result from studies of cosmic ray produced aluminium-26 (half-life *c.* 700,000 years) isotope in deep ocean sediments. From this experiment the mean flux of solar cosmic ray protons, averaged over the past 100,000 years, has been deduced.

The impression carried by the delegates at the close of the conference was that the scope of research in many fields of cosmic ray studies has greatly expanded and that a number of new avenues have opened up for investigation. Some of the areas of work which hold great prospects for the future relate to primary electrons, gamma rays, X-rays, primaries of EAS, cosmic ray neutrinos and observations on primary nuclei with high resolution detectors. The next conference will be held in Canada in 1967 probably in June.

Twentieth International Congress of Pure & Applied Chemistry

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THE Twentieth International Congress of Pure & Applied Chemistry, sponsored by the International Union of Pure & Applied Chemistry, was held at Moscow during 12-18 July 1965 at the invitation of the Academy of Sciences, USSR. The congress was, as usual, preceded by Twenty-third IUPAC Conference at Paris (2-9 July 1965). The main objectives of IUPAC are: (i) to promote permanent cooperation between the chemists of the member countries (at present 39 members); (ii) to study topics of international importance to pure and applied chemistry which need regulation, standardization or codification; (iii) to cooperate with other international organizations which deal with chemical topics; and (iv) to contribute to the advancement of pure and applied chemistry in all its aspects.

Congress Sections

The inauguration and closing of the congress took place at the fabulous Palace of Congress of Kremlin. Academician Kondratiev of Academy of Sciences, USSR, took the chair on both the occasions, each of which lasted for about an hour.

The scientific sessions of the congress were held at the Moscow State University on the beautiful Lenin Hill (Leninskye Gory) in the central building (30-storeyed) and Departments of Physics and Chemistry. Altogether 600 papers were presented in the following divisions: (i) Physical chemistry of surface phenomena and disperse systems (134); (ii) Radiation chemistry (119); (iii) Cosmic chemistry (57); (iv) Inorganic chemistry (110); (v) Analytical chemistry (120); and (vi) Principles of chemical technology (50). In these divisions some 25 plenary lectures were presented by noted authorities in their respective fields. In this report an attempt has been made to spotlight on the more significant contributions at the congress.

Physical Chemistry of Surface Phenomena and Disperse Systems

The plenary lectures were based on such topics as the nature of surfaces of solids (Brunauer, USA), modern state of the theory of gas and vapour adsorption by microporous adsorbents (Dubinin, USSR), investigation of surface films (Sheludko, Bulgaria), processes of development of three-dimensional structures in disperse systems (Rehbinder, USSR), thermodynamic and kinetic aspects of the electrochemical double layer (Overbeek, Netherlands), and effect of surface forces on the properties of boundary and thin layers of liquids and disperse systems (Deryaguin, USSR).

Both theoretical and experimental work have been surveyed and extended on the interactions between adsorbed molecules, particularly of the noble gases on various solids. The nature of the heterogeneous surface of a number of typical semiconductors, adsorbents, catalysts and fillers of polymers has been explored using tools such as mass spectroscopy, IR, NMR, ESR, etc. Molecular statistical expressions have been derived for the adsorption isotherm. Electron spin resonance (ESR) has been shown to be a powerful tool for investigating the nature of the adsorbed state of free radicals

a metal oxide. A theoretical investigation of the forces which are responsible for the low temperature adsorption of the hydrogen isotopes on Al_2O_3 surface has shown that polarization forces are responsible for the adsorption phenomena. The kinetics of chemisorption on semiconductors has been investigated from the point of view of the electron theory. The stability of lyophobic and lyophilic sols, stability of metal hydrosols, polyelectrolytes at the liquid-liquid interface, mechanism of spontaneous emulsification in terms of condensation and dispersion have been reported.

Radiation Chemistry

The plenary lectures were based on radiolysis of solid and liquid systems (Dainton, UK), polymerization in solids (Magat, France), chemonuclear and radiation chemical process (Steinberg, USA), and radiation-catalytic and heterophase processes (Polak, USSR).

The fundamental processes in radiation chemistry of liquids — hydrocarbons, alcohols, etc.— and of aqueous solutions have been the subject of many investigations. The reactions of radiation-produced electrons, ions and free radicals in polar and non-polar systems have been studied. Some recent work has been concerned with the investigation of chemical processes in irradiated frozen aqueous systems at low temperatures (77°K.) by electron spin resonance and absorption spectroscopy. It has been established that both excitation and ionization processes result from absorption of high energy radiation (γ-rays, X-rays, etc.) and lead to the formation of the active primary species which are responsible for the chemical effects of these radiations. Radiation has been used as initiator of polymerization and copolymerization in several interesting monomers and cyclic monomers. Low temperature polymerization of systems like acrylonitrile has been investigated with reference to the nature of active centres initiated by radiation. Among interesting radiation syntheses mention may be made of higher carboxylic acids from ethylene and carbon dioxide, sulphochlorination of polyethylene and substituted aromatic compounds.

Cosmic Chemistry

The plenary lectures were devoted to the origin and evolution of meteorites (Urey, USA), the matter of meteorites (Vinogradov, USSR), and element abundances in meteorites (Suess, USA).

The study of chemical composition of meteorite has provided information about the chemical evolution of the solar system, chemical history of the meteorites and planets and also the nature of the processes by which the elements originated. Carbonaceous meteorites have been of particular interest in recent years especially in the detection of molecules of the same type as those found in biological systems. Several trace elements including Ga, In, Se and Te have been measured by neutron activation analyses to account for trace element fractionations in meteorites. Activation analysis using neutrons has been applied to the determination of several trace elements in a wide range of meteorites. Some new data have been reported on the age of the earth by K-Ar and Rb-Sr methods. The Re-Os method has been recently applied to some geological and cosmological dating problems.

Inorganic Chemistry

The plenary lectures were based on coordination compounds (Bailar, USA), formation and transformation of inorganic polymers (Thilo, E. Germany), chemistry of semiconductors (Goryunova, USSR), and recent chemical knowledge in the light of the periodic law (Palit, India).

New simple and complex fluorides of the noble metals such as $Pd^{2+}[GeF_6]^{2-}$, $Pd^{2+}[PtF_6]^{2-}$ have been synthesized. Stable compounds of xenon in +2, +4, +6 and +8 oxidation states have been isolated. A number of interesting polymeric and monomeric boron-nitrogen compounds have been reported. These include BF_3NR_3, $(BFNR)_3$, BF_2NR_2 where R = alkyl group. The formation of compounds of rare earths with carbon, nitrogen and silicon and their properties have been reported. Several polymeric tin phosphides have been synthesized by reaction of elemental phosphorus with stannic derivatives. The physico-chemical properties and reaction mechanism have been investigated. Other novel groups of polymers are highly polymeric silicon layers with partial radial character, prepared from $CaSi_2$ with various reagents and also Al-O-Si polymers. Researches on semiconductors are mainly centred on chemical bonding and crystal structure, lattice defects, synthesis of new semiconductors, etc. The use of statistical methods in studying the mechanism of physico-chemical processes is gaining significance in recent years.

Analytical Chemistry

The themes of the plenary lectures were analytical applications of chemical reactions of organic compounds (Feigl, S. America), triple complexes in photometric analysis (Babko, USSR), separation and concentration of trace elements (Minczewski, Poland), and spectrochemical analysis (Scribner, USA).

Atomic absorption spectrophotometry has been increasingly used in recent years using metal complexes in organic solvents, high temperature lamps, resonance monochromators, etc. Various heavy metals have been determined by atomic absorption methods which are simple, rapid and precise. Recent trends in spectrochemical analysis include elimination of matrix effects by d.c. plasma jet, scintillation method of spectral analysis, vacuum emission, etc. Trace analysis has gained increasing popularity in recent years in nuclear science and industry using mass spectrometry and isotopic dilution methods for stable isotopes and activation methods for radioactive isotopes. New spectrophotometric reagents of very high selectivity have been devised by simultaneous reaction of the cation or anion concerned with chelating agent to produce coordinatively unsaturated chelate and with a ligand which reacts datively or by ion-association. Another approach makes use of reagents possessing π-bonding systems in conjunction with masking agents. Solvent extraction continues to play its mighty role in separation and concentration of elements. Important reports in this area include

systematic schemes of qualitative and quantitative analysis, extraction by 2-thenoyltrifluoroacetone, tertiary and quaternary amines, alkyl phosphoric acids and substoichiometric determination of traces of metals. Ion-exchange separation of some elements has been reported employing chelating ion-exchange resins, redox exchangers, etc., as new types of resins. High purity metals are successfully analysed by chemical concentration of impurities by methods of precipitation, distillation, solvent extraction, etc., followed by spectrographic analysis. Ultrapure materials are produced by repeated normal freezing and zone refining and analysis of impurity content by activation analysis.

Principles of Chemical Technology

The plenary lectures were devoted to diffusion phenomena in heterogeneous catalysis (Sherwood, USA), optimization of chemical processes (Boreskov, USSR), adsorption of gases in liquids (Danckwerts, UK), and theory of processes of mass transfer in chemical technology (Levich, USSR).

Studies of chemical macrokinetic reactions in high temperature gas jets are becoming of ever-growing importance. Investigations of mass transfer efficiency on high turbulent gas or vapour-liquid interaction have provided basis for design of improved mass transfer apparatus for absorption and distillation. Electronic computers have been used for the development of commercial synthetic processes. Automation is being employed considerably as a means for optimization of chemical processes.

During the congress week the Moscow State University faculties and scientific institutes at Moscow threw their doors open to the congress participants. This added excellent flavour to the congress programmes as the participants got the rare opportunity of visiting the leading research laboratories in USSR which are considered very extensive set-ups throughout the world.

Acknowledgement

The author wishes to express his grateful appreciation to IUPAC, Moscow, for the invitation to serve as the chairman of two sessions in the Analytical Chemistry Division and to present an invited lecture, and also to the University Grants Commission, New Delhi, and the West Bengal Government for financial assistance. The kind cooperation of Jadavpur University authorities is also thankfully acknowledged.

Endeavour Prizes

Prizes totalling over £ 200 have been offered by Imperial Chemical Industries Ltd for essays on any of the following subjects: (1) Mechanisms of morphogenesis; (2) The pattern of subnuclear particles; (3) Microcircuitry; (4) Chemicals in agriculture; (5) The cell surface; and (6) Recent advances in thermochemistry. As an alternative, competitors can attempt the following: "Extrapolation of present trends shows that if expenditure on research were to continue to increase at the present rate, the advanced nations would be devoting their entire resources to it before the end of the century. Discuss how this paradox will be resolved."

The competition is restricted to those whose twenty-fifth birthday falls on or after 1 September 1966. Essays, which must be in English and typewritten, should not exceed 4000 words in length and should reach the following address by 1 June 1966: The Deputy Secretary, British Association for the Advancement of Science, 3 Sanctuary Buildings, Great Smith Street, London SW 1.

Enzymes* in Sewage & Sludges

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A LARGE volume of literature has accumulated on sewage and its treatment processes, but the available information on enzymes in sewage and sludges is meagre. This is somewhat surprising because it has long been known that sewage teems with microorganisms and that its purification is based on microbial activity in which enzymes play a vital role. Although the idea of ' organized ferments ' in the purification of sewage was conceived as early as in 1877 by Schloesing and Muntz[1] in the course of their studies on the purification of sewage during filtration through a column of sand and limestone, practically no work was done during the next 35 years on any aspect of the enzymes in sewage, sludges, or on their relation to biological treatment processes. In 1908, however, Wilson was led to suspect that the slime formed on the surfaces of the particles of material in an active sewage filter might contain a ' clotting enzyme ' which can clot the colloidal matter in fresh sewage just as rennet clots the casein in milk. Some of the coating scraped from filter medium when shaken with fresh sewage was found to produce a certain amount of purification, but air was not blown through the sewage. Fowler acknowledges that this idea of a clotting enzyme was one of the factors contributing to the elaboration of the new process[2,3]. Around this time the concept of enzymes was being more actively developed, particularly by the work of Buchner, Harden, Sorenson, Michaelis and Willstatter[4]. In 1912, Mumford and Fowler[5] suggested that sewage colloids could be flocculated by the enzymes of a specific bacterium M7 in the presence of traces of iron salts.

Since 1912, and notably after the development of the activated sludge process, some work has been done on the enzymes in sewage matter, filter material, sludge from the septic tank, activated sludge, in a few bacteria isolated from sewage and activated sludge and on the effect of some biocatalysts on sewage purification. A brief account of this work is given here.

Enzymes in Raw Sewage

Domestic sewage is composed mostly of faecal matter, urine, soil and other washings. The observations on the enzymes in these constituents and in the sewage as a whole may first be briefly considered.

Faecal matter — In the course of studies on the enzymes in a variety of biological materials, since 1908, some observations have also been made on faeces and urine. Thus lipase, diastase and catalase were shown to be present in faeces[4]. But the difficulty of distinguishing between the enzyme activity of intestinal organisms and of internal secretions greatly detracted from the value of the studies on the enzymes in faeces.

Urine — The enzymes in urine have also attracted the attention of a number of workers[4,6]. It has been shown that the total daily excretion of diastase is fairly constant in normal individuals, an average of from 10 to 20 units (Wohlgemuth[7]). Pepsin and lipase have also shown to be present in urine, but the amounts of these increase during certain pathological conditions. The amount of catalase in urine is an index of the number of cells therein and the urine of patients suffering from pyelitis can be differentiated from that of normal individuals by its catalase content.

Soil — In 1909, Russell and Hutchinson[8] noted that ammonia could be produced in soils treated with toluene. This was re-examined in more detail by Conrad, who showed that soils so treated still possess the power " to hydrolyse urea and some other amides to ammonium carbonate, presumably through the action of urease enzymes present in the soil which have been released there during the decomposition of added plant and animal tissues"[9]. The presence of proteases was also demonstrated in the early years of study of enzymes in soils[10].

In recent years the activities of enzymes in soils have been receiving considerable attention and the subject has been reviewed recently by Briggs and Spedding[10] and by Quastel[11]. Most soils possess large numbers of enzymes, which are largely cellular and derived from microorganisms. Some of the enzymes are free and capable of adsorption on clay minerals. Some of the enzymes whose activities in soil have received attention recently are phosphatase, invertase, saccharase, β-glucosidase, amylase, protease, levan sucrase, catalase, uricase and urease.

Raw sewage — Von Guth and Feigl[12] reported that diastase, trypsin, pepsin, lipase as well as ' disaccharide ' enzymes are nearly always present in domestic sewage, that they are partly derived from animal and vegetable waste products, and that they are continuously formed by the microorganisms.

Koppen[13,14] applied the principle of decomposition of hydrogen peroxide by catalase for rapid detection and determination of toxic compounds present in sewage, which are harmful to aerobic biological waste treatment processes. He added known amounts of

*Some of the trivial names of the enzymes given in the original papers reviewed in this article are, according to the *Enzyme nomenclature, Recommendations* (1964) *of the International Union of Biochemistry on the nomenclature and classification of enzymes, together with their units and the symbols of enzyme kinetics* [Elsevier Publishing Co., Amsterdam, 1965], to be read as follows: diastase = amylase; proteases = peptide hydrolases; invertase = β-fructofuranosidase; saccharases = carbohydrases; uricase = urate oxidase; disaccharide enzymes = disaccharide lyases and ligases; oxidases = oxido-reductases; dehydrogenase = oxido-reductase; indophenol oxidase = a group of oxido-reductases which oxidize reduced indophenol dye; zymase = a complex of enzymes consisting of α- and β-ampylases and dextranases; and dehydrases = hydro-lyases.

catalase to sewage, along with a variety of inhibitors, such as mercuric chloride, lead chloride, phenol, benzoic acid and aniline, and found that the catalase activity was retarded. The observations of Eddine[15] suggest that catalase activity may be used as an indirect measure of biochemically oxidizable substances in water and may, therefore, be employed to supplement the values for biochemical oxygen demand (BOD) and oxygen consumed.

Enzymes in the Material on the Percolating and Sand Filters

Von Guth and Feigl[12] recorded that the slimy deposit adhering to the filling material of the percolating or trickling filter was richer in enzymes and that it might probably contain oxidases and peroxidases. He also noted that in well-purified effluents only traces of enzymes were present.

According to Thomson[16], the film in the second layer of sand filter showed the maximum microbial activity and the enzymes present catalyse the breakdown of maltose, dextrose, sucrose, proteins and urea. Lactose-splitting enzymes, however, were not found. He also pointed out that the micro-organisms in the filter film were similar to those occurring in the soil.

Enzymes in the Sludge from Septic Tank

Rudolfs[17] recorded the presence of diastase, lipase, pepsin, trypsin, catalase, invertase and rennin in septic sludge. These enzymes were found to vary in abundance, some of them increased and then decreased before others reached their maximum. With regard to catalase in this connection, it may be of some interest to note the observations of Prevot and Thouvenot[18], who reported that catalase in anaerobes is an endoenzyme and that it protects the anaerobe against the bactericidal action of hydrogen peroxide. In a recent study, however, it was recorded that the sludge from septic tank did not show any catalase activity[19].

Chamberline[20] studied the activity of lipase, pepsin, trypsin, rennet and diastase in the breakdown of the different constituents of organic matter. The enzymes showed activity to varying extent at different stages of digestion. He suggested that in a properly seeded mixture the nitrogenous compounds are first decomposed by rennet, and the fats, proteins and starches are simultaneously decomposed by lipase, pepsin, trypsin and diastase.

The observations[21] at New Jersey Agricultural Experiment Station showed that the digestion period of sludge was greatly decreased when the temperature was raised from 55° to 82°F. and was further decreased by heating to 120°F. Satisfactory results were not obtained when ' cultures of enzymes ' from ripe sludge were added to fresh sludge. Chamberline[22] added lipase, diastase, rennet, pepsin and trypsin, singly as well as in combinations to sewage solids and sewage-sludge mixtures and studied the effect of these on gasification and liquefaction. These enzymes did not bring about any appreciable liquefaction of fresh sewage solids. Trypsin increased liquefaction of seeded sludges under optimum conditions; lipase, rennet and diastase increased gasification; and trypsin enhanced the dewatering of the solids. The studies of Goudey[23] showed that in order to procure a digested sludge with a lower water content, attention must be paid to enzymes, catalysts and filamentous bacteria.

Evereinova[24] found that diastase was adsorbed on the sludge in methane-generating septic tanks. He showed the presence of protease in the sludge and in the supernatant liquor.

Enzymes in Activated Sludge

Occurrence and activities of enzymes in the sludge — Wooldridge[25], working with activated sludge, sludge from sedimentation and humus tanks, demonstrated the presence of ' dehydrogenase ', indophenol oxidase and urease activities. Activated sludge and crude sewage did not show the presence of catalase; the sludge showed a doubtful peroxidase activity. It was further shown that sterile sewage was oxidized readily by non-sterile activated sludge and by bacterial suspensions, less rapidly by protozoal suspensions, and that activated sludge contains many oxidation-reduction enzymes[26].

Heukelekian and Ingols[27] studied the rapid hydrolysis of starch during aeration with activated sludge and they reported that the rate of hydrolysis was more in the case of sewage-sludge mixtures rather than either of them alone. They concluded that the hydrolysis of starch was due to the presence of diastase in the sewage. They studied the activity of proteolytic enzymes in activated sludge upon gelatin, peptone, albumin and albumin digested with trypsin, and showed that the rate of hydrolysis was greater with simple than with complex molecules.

Ingols[28] studied the enzymes in activated sludge during its development from sewage. He found an 18-fold increase in pepsin and only 2- to 3-fold increase in lipase, diastase and trypsin. Pepsin, lipase and diastase were found only on the surface of the sludge floc, whereas trypsin was found also in the liquor surrounding the floc. He showed that the addition of various substrates enhanced the activities of the respective enzymes. The enzyme activities of a mixture of sewage and activated sludge changed little during aeration for 6 hr. Variation in the *p*H value from 6·48 to 7·9 caused no marked change in the rate of hydrolysis. A detailed study was made on diastatic activity in the sludge under various conditions. Various salts and volatile organic solvents, when added to a suspension of the sludge, increased the activity of diastase. This increase, he suggested, might be due to plasmolysis of the sludge. Magnesium sulphate was found to retard the diastase activity. He concluded that the ability of sludge to clarify sewage depends on the biophysical properties of the sludge floc and that purification may be correlated with the biochemical property, i.e. enzyme activity, of the sludge floc.

Watanabe[29] used a bacteria-free liquid from activated sludge as the fermenting solution and reported the presence of hydrolytic enzymes such as amylase, protease and lipase. ' Zymase ' was not detected in the sludge. The action of trypsin was found stronger than that of pepsin. The optimum *p*H value for lipase was about 6·5. His studies showed that biological, enzymic and physical factors are concerned in the activated sludge process.

Ljubima and Kagan[30] observed urease and proteolytic activity in activated sludge and did not find any enzyme activity in the supernatant liquid.

Lenhard *et al.*[31] obtained evidence of a rapid synthesis of oxidative enzymes when fresh feed was added to a unit, resulting in maximum 'dehydrogenase' activity of the mixed liquor between 1 and 6 hr later. Prolonged aeration resulted in a drop in enzyme activity.

Matsushita[32] extracted a raw enzyme from activated sludge and purified it by ammonium sulphate fractionation. The preparation showed a protease activity with an optimum *p*H 7·8-8·0 and an optimum temperature of 22·5°C. Chromium ions were found inhibitory to the enzyme.

Vaicum *et al.*[33] studied the activity of certain oxido-reductive enzymes (catalases, dehydrases) and of urease in the activated sludge developed from synthetic media. The results of their studies showed that the activities of these enzymes followed closely the variation of other physico-chemical indicators commonly used in the checking of purification plants.

Sridhar and Pillai[19], working with activated sludge produced from domestic sewage, showed the presence of catalase in crude extract and studied its properties. The enzyme showed activity over a wide range of *p*H 5-9, with an optimum at 7. It showed optimal activity between the temperatures —10°C. and 20°C. The activity decreased as the temperature increased beyond 40°C. No catalase activity was found in sun-dried activated sludge powder. The sludges which purified sewage more efficiently showed more catalase activity.

Views on the relation of enzymes to the purification of sewage — Mohlman[34] assumed that the effluent from the activated sludge process contained hydrolytic enzymes and accordingly diluted the sewage with the effluent. As he did not notice any clarification of the sewage, he concluded that the clarification was not dependent on enzymes. However, in a paper read at the Annual Summer Conference of the Association of Managers of Sewage Disposal Works at Glasgow in July 1926, Harris *et al.*[2] reported that the biochemical changes brought about in sewage "must be attributable to enzymic rather than to direct bacterial action".

Theriault[35] pointed out that biological elements could not be considered to play a major part in the primary clarification of sewage unless direct absorption by bacteria, etc., without accompanying oxidation was assumed. He suggested that attention might be focused on the floc itself as the primary absorbent, apart from the embedded bacteria, secreted enzymes or attending protozoa. According to Coste[36], the flocculation by activated sludge is primarily a physico-chemical phenomenon and the clotting role of enzymes or bacteria is relatively insignificant. Ingols[37], however, concluded that oxidation-reduction enzymes are essential for the production of activated sludge and for the purification of sewage by this process. He found that the activity of these enzymes was affected by temperature, amount of oxygen supplied, *p*H value and the types of food available. The activity of the sludge was dependent on the concentration of these enzymes. The sludge contained greater concentration of these enzymes than the sewage.

Dickinson[38] studied the adsorption by activated sludge of a number of easily reducible dyestuffs of similar structure under aerobic conditions in order to correlate the extent of adsorption with the oxidation-reduction potential of the enzymes in the sludge. The results showed that activated sludge reduced a definite amount of the dye which it took up apparently in preference to oxygen. The reduction was found not to be dependent on the activity of indophenol oxidase. In the course of further studies, Dickinson[39] observed that the sludge heated to 50°C. lost its power to reduce methylene-green. Consideration of this, together with the results of other workers, led him to conclude that physical and biochemical factors are interdependent from the moment of mixing activated sludge, sewage and air.

Enzymes in Some Bacteria and Protozoa from Sewage, Activated Sludge and Laboratory Stocks

Wooldridge and Standfast[40] reported that the most important factor in sewage purification was a series of catalysed oxidation-reduction reactions determined by enzymes present in either living or dead bacterial cells and liberated by them into the fluid of the reacting system. They inoculated sterile sewage with a suspension of washed cells of *Pseudomonas fluorescens* sterilized with formaldehyde and found that they absorbed oxygen. This observation led them to conclude that life of the bacteria was not necessary for oxidations. These investigators then examined the ability of a number of pure bacterial suspensions to oxidize sterile sewage[41]. *Bacterium alcaligenes, Proteus vulgaris, Ps. pyocyaneous* and *Ps. fluorescens* were found most active. *Bacterium coli* was less active and *Staphylococcus aureus* and *Streptococcus faecalis* had little effect. The protozoa *Polytoma uvella* and *Euglena gracilis* free from bacteria had a definite power of promoting oxidation, although it was comparatively poor.

Mihaeloff[42] recorded the presence of two distinct enzymes in filamentous bacteria which were always present in activated sludge from any source. One of these enzymes oxidized ammonia to nitrites and the other converted nitrites to nitrates.

Matsushita[32] isolated 22 strains of bacteria from an activated sludge and studied five strains of potent gelatin-liquefying activity in 'terms of bacteriological characterization' and protease action.

Effect of Added Biocatalysts on the Purification of Sewage

Several workers have carried out experiments on the effect of added biocatalysts, which are either concentrated bacteria or concentrated enzymes, on the purification of sewage and sludge digestion. McKinney[43] reported that a biological treatment system, which is designed properly and operated according to the design principles, would function at the maximum efficiency without the use of additional organic catalysts; that addition of various catalysts to a treatment plant operating at lesser efficiency, however, brought about some improvement; and that unless their use was continued the system

would revert back to its normal equilibrium conditions. McKinney and Poliakoff[44], in their laboratory experiments, added the biocatalysts to crude sewage, synthetic sewage, and a synthetic industrial waste water, which were treated by the activated sludge process. They did not find any improvement.

Heukelekian and Berger[45] carried out a series of experiments in order to determine the effect of pure enzymes, enzyme and bacterial culture preparations and baker's yeast on the digestion of sewage solids and on the quality of the effluent. They did not find any improvement due to addition of any of these biological preparations to sterile and non-sterile fresh solids and to sewage. The addition of pure enzymes to sterile fresh solids increased the BOD of the supernatant liquid, but in presence of bacteria and their enzymes, as found in fresh solids, artificial addition of enzymes did not increase liquefaction.

Wells and McKinney[46] did not notice any significant reduction in scum formation in the digester to which 'Bionetics' (a concentrated bacterial preparation) was added, nor did they observe any marked improvement in digestion. Similar reports are available on biocatalysts[47,48], although a reference may be made to the successful use of 'Enzymatic' (a concentrated enzyme preparation) in the control of operational difficulties of a sewage works[49].

Present State of Knowledge and Future Lines of Work

Although it had been known for many years that purification of sewage is brought about by micro-organisms, the possible involvement of enzymes in the process was not envisaged until after 1908 with the more rapid development of the general concept of enzymes. In the early years, the knowledge of the enzymes in biological materials, such as faeces and urine, was naturally applied to the study of enzymes in sewage, the material in sewage filters, and in the anaerobic systems of sludge digestion and gas production. The evidence thus obtained was, however, very limited.

The advent of the activated sludge process as a more rapid and efficient method of sewage treatment has afforded an interesting biological material for the study of enzymes as well. Since, however, our knowledge of the specific organisms in the activated sludge concerned with the purification of sewage has been rather meagre, it has not been possible to obtain precise information on the enzymic aspects of the purification process. Some evidence has been collected on the enzymes in activated sludge as a whole and in a few organisms, mostly bacteria, isolated from the sludge and also from sewage, but this evidence does not seem to be of much significance in the elucidation of the purification process, chiefly because the extent of influence of the enzymes from the sludge on the purification has not been demonstrated and the organisms studied in this connection themselves are not of much consequence in the process. Moreover, the commercial biocatalysts such as the bacterial preparations or concentrated enzyme preparations have not been found to be effective in the purification of sewage or in the digestion of sludge.

There has been no sustained or continued interest in the study of enzymes in sewage and sludges. This is largely due to the failure in the earlier years to demonstrate the presence of a definite clotting or clarifying enzyme in the material of sewage filters, activated sludge, or in any of the organisms examined. In a recent investigation[50], flocculation comparable to activated sludge was not easily achieved with a number of bacterial strains isolated from activated sludge and strains obtained from laboratory collections, including representatives of the genera, *Pseudomonas*, *Alcaligenes*, *Achromobacter* and *Zooglea*. Further, the various other theories put forward from time to time for explaining the mechanism of activated sludge process, such as the adsorption[2,51], the colloidal[52] and the biozeolitic[53] theories, have not required a close study of the enzymes.

A useful line of approach seems to be the examination of the enzymes in the most dominant organisms which, in their ability to purify sewage, are comparable to activated sludge. It is essential, therefore, to look for the proper organisms not only in activated sludge but also in other systems of purification. It is likely that the most efficient organisms in activated sludge will also be found in other systems of sewage purification, including the more natural systems of soil and water, which are presumably the original sources of these organisms. A more systematic survey and study of the organisms of sanitary significance and of their enzyme activities will possibly be of greater interest and value in the elucidation of the biochemical principle of the purification process.

Summary

The available evidence on the various aspects of enzymes in sewage and sludges has been examined. These aspects include: the enzymes in raw sewage, the material in biological filters, septic tank sludge, activated sludge, and in bacteria from sewage, activated sludge and laboratory stocks; the relation of enzymes to purification of sewage; and the effect of added biocatalysts on the purification process and on sludge digestion. Future lines of investigation have also been indicated.

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Recent Trends in the Application of Fatty Acid Derivatives in Textile & Other Industries*

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DURING the last decade rapid strides have been made in the application of fatty acid derivatives in textile and other industries and it would be of interest to review the developments over the past 5-6 years. The subject has been dealt with under the following heads: (i) Esters, (ii) Nitrogen derivatives, (iii) Sulphur derivatives, (iv) Phosphorus derivatives, (v) Metal salts and miscellaneous derivatives, and (vi) Emulsifiers.

The major applications of fatty derivatives in textile industry are shown in Chart 1.

Esters of Fatty Acids

Sorbitan Fatty Acid Esters

Partial fatty acid esters of sorbitan go under the name Spans in commerce; their ethoxylated derivatives are known as Tweens[1]. Spans are usually obtained by carefully heating a well-agitated 1:1 mixture of anhydrous sorbitol and fatty acid, in the presence of a suitable catalyst at elevated temperatures and preferably under reduced pressure. The catalyst may be acidic or alkaline, though generally alkaline catalysts are preferred because of the light coloured products obtained with them[2].

Preparation and properties — The preparation of Spans is complicated as undesirable diesters and triesters are likely to be formed, if the reaction conditions are not properly controlled.

Anhydrous sorbitol on heating carefully loses a mole of water forming 1,4-anhydrosorbitol or sorbitan. Further loss of water (1 mole) leads to the formation of the undesired sorbiden. Sorbitan, on the other hand, reacts with one mole of fatty acid to yield the sorbitan monoester, Span, with the loss of a mole of water. Usually the reaction conditions are so adjusted that starting with sorbitol and fatty acid, two moles of water are removed and thus only minimum amounts of the byproducts are formed.

Usually Spans are mixtures of partial esters and are not pure compounds. They are normally soluble in organic solvents and insoluble in water, though they are easily dispersible in water. Hence

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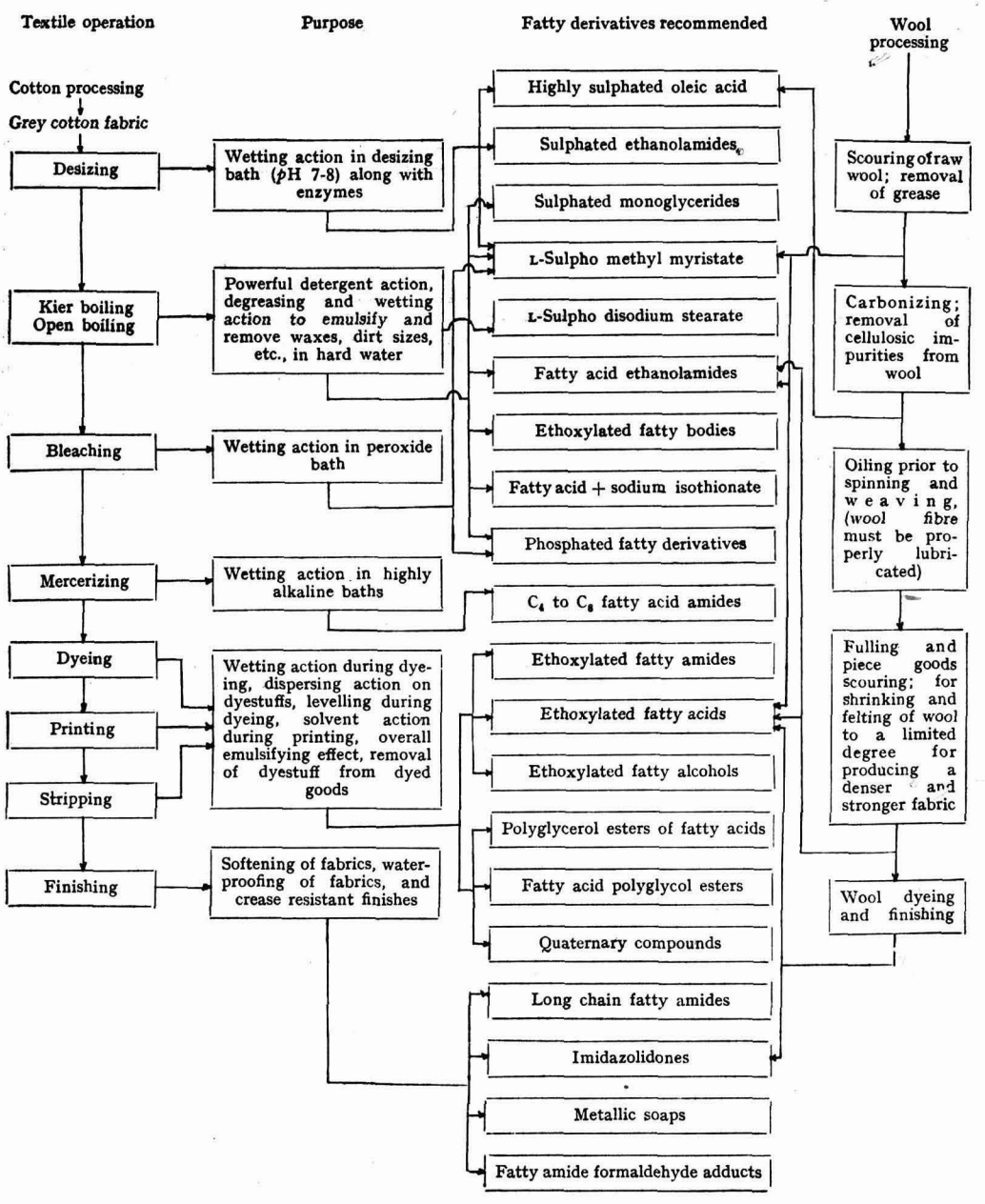


Chart 1 — Applications of fatty derivatives in different textile operations

they are used as dispersions in water or as solutions in organic solvents.

Spans are carefully ethoxylated with ethylene oxide in the presence of a catalyst (usually basic catalysts, e.g. NaOH or K_2CO_3) and at elevated temperatures, to obtain polyoxyethylene sorbitan fatty acid esters or the Tweens. These are light coloured liquids, freely soluble in water.

Some of the more common Spans and Tweens in use today [also sold under the trade names Glyco sperse (Glyco Chemicals Inc.) and Poly sorbates (PFeisers)] are:

Fatty acid ester	Span	Tween
Sorbitan monolaurate	Span-20	Tween-20
Sorbitan monopalmitate	Span-40	Tween-40
Sorbitan monostearate	Span-60	Tween-60
Sorbitan oleate	Span-80	Tween-80
Sorbitan tristearate	Span-65	Tween-65
Sorbitan trioleate	Span-85	Tween-85

Applications — Spans and Tweens are widely used in a number of industries, their non-toxic, non-irritant nature having special appeal in the food and cosmetic industries. Depending on the end use, they are purified suitably and sold under various forms, e.g. cosmetic grade, food grade, textile grade, etc. In cosmetics, they are used as humectants for moisture conditioning purposes in the emulsification and smooth application of creams. In pharmaceutical preparations their main function is to reduce the antagonistic forces which exist between water and oil or waxy substances so that such incompatible materials may be readily mixed into stable ointments, creams and lotions (e.g. vitamin solubilization, manufacture of suppositories, antihistamine ointments, scalp lotions[3]). In food industry, they find numerous applications, mainly as emulsifiers (e.g. baking emulsifier, in liquid ice cream emulsifier, in chocolate coating, etc.). Their surface active properties, coupled with their oily or waxy nature, make them excellent lubricants and softeners for textiles and hence they are used for obtaining soft finish in textile finishing. They also find application as antistatic agents in textiles. Tween-20 is particularly suited for this application.

In general, Spans and Tweens are powerful emulsifiers and as such find increasing application as insecticide emulsifiers. Considering the rapid industrialization of the country, Spans and Tweens or their equivalent products derived from fatty acids have a great future in India.

Sucrose Esters of Fatty Acids

A new class of synthetic detergents (nonionic and non-toxic in nature), based on sucrose and fatty acids, are in use in UK and USA for general washing purposes, and in food, pharmaceutical and cosmetic industries.

Some of the more common sucrose esters in use today are sucrose esters of lauric, myristic, palmitic, oleic and stearic acids[4-6].

Preparation and properties — These esters are prepared from higher alkyl bromides and sodium sucrate in dimethyl sulphoxide or dimethyl formamide solvent.

For large-scale manufacture in India, the Zimmerman process[7], based on castor oil or hydroxy fatty acids and sugar, seems to be most suitable. Zimmerman process is a two-step process, involving first the esterification of hydroxy fatty acid/castor oil with methanol or ethanol, followed by the reaction of the ester with sugar, with the removal of methanol or ethanol from the system. The reaction products (75 per cent monoester and 25 per cent diester) are further purified to yield the desired product.

Compared to the conventional sucrose esters of fatty acids, the esters obtained by the Zimmerman process are based on sugar and naturally occurring hydroxy fatty acids or oils and their preparation does not involve the use of large amounts of costly solvents. Hence these esters are relatively cheap. The presence of one hydroxyl group on the fatty chain enhances the washing ability of the products.

The mono-, di- and triesters can all be dispersed in water and they are soluble in alcohol, organic solvents, vegetable and mineral oils. The emulsifying power of sucrose esters is excellent. They produce oil-water emulsion when present in low concentrations (1-3 per cent) and water-oil emulsions at higher concentrations (3-10 per cent), especially when used in conjunction with glycerol monostearate or esters of sorbitol.

Applications — As detergents, sucrose esters equal in performance the best nonionics available. Their powerful detergent action, fully biodegradable nature[8], coupled with the most desired low foaming property make sugar esters the most suitable substitutes to the currently widely used alkyl benzene sulphonates. Sucrose esters being 90 per cent biodegradable[8] as against 20 per cent of alkylbenzene sulphonates are the obvious successors to the currently used detergents. With abundant supplies of sugar and fatty acids and castor oil, India could undertake the manufacture of these products which have a promising future.

Fatty Acid Polyglycol Esters

These esters, owing to the balance that exists between the hydrophobic long chain acid portion and hydrophilic polyoxyethylene chain, exhibit marked surface activity. These surfactants are of nonionic type and, therefore, unlike the conventional soaps they are not precipitated by hard water or decomposed by mild acids. Depending on the conditions of use they can act as emulsifiers, wetting agents, dispersants or detergents. Hence they are the most widely used fatty acid derivatives.

Preparation and properties — The fatty acid esters of polyethylene glycols are prepared from fatty acids (C_8-C_{22}) by either of the following procedures: (i) polyglycol condensation methods, wherein the polyglycol of the desired molecular weight (62 to 2000) is reacted with the fatty acid at elevated temperatures (140-50°C.), in an inert atmosphere, in the presence of acid catalyst like sulphuric acid, hydrochloric acid, or *p*-toluene sulphonic acid, alkylbenzene sulphonic acid, and (ii) ethylene oxide condensation method involving condensation of ethylene oxide on the fatty acid in the presence of a

catalyst at elevated temperatures. Method (ii) yields a greater range of desired products and the length of the polyoxyethylene chain (and hence the molecular weight of the compound) can be controlled to the desired extent. However, this method suffers from the disadvantage of requiring specialized equipment and hazards involved in the handling of ethylene oxide. The polyglycol method is more commonly used because of the ease of handling and also as it does not need any specialized equipment. By changing the fatty acid and adjusting the length of the hydrophilic polyglycol it is possible to produce a specific product from high boiling liquids to waxes required for any specific purpose.

Applications—The mono- and diesters derived from polyglycols (mol. wt 400, 600 and 800) and lauric, palmitic and stearic acids find wide application in textile operations such as wetting, emulsification, dyeing, pigment dispersing, softening and as textile lubricant[9]. Glycol stearate is added to lubricating oils to improve their viscosity index and depress their pour points. Dispersions of triethylene glycol fatty acid esters are used as lubricants for alloys, stamping and drawing of nickel alloys, brass and similar other alloys. The lubricant film formed on the surface is easily removed during the subsequent annealing operation. Diethylene glycol derivatives of fatty acids are also used for softening and plasticizing rubber, chlorinated rubber and vinyl plastics. Mixtures of polyethylene glycol esters such as laurate, oleate and stearate (mol. wt 400, 600 and 1000) are used as rewetting agents for paper towels. These esters are particularly useful as emulsifiers for insecticidal and herbicidal preparations because of the ease of formulation and the stability of the resulting emulsion in hard water. Quick breaking emulsions, often used in agricultural sprays, are readily produced with these. Diethylene glycol esters of fatty acids are used as vehicles for water-soluble dyes, solvents for aniline dyes, etc. Diethylene glycol stearate is used for stabilizing pigment dispersion in paints and varnishes and as an aid for pigment suspension in ink. Stearates of polyethylene glycol (mol. wt 400, 600 and 1000) are used in various cosmetic products ranging from calamine lotion to hand creams, hair conditioners, shave creams and ink remover creams.

With the plentiful availability of the fatty acids and the establishment of petrochemical industries leading to abundant supplies of ethylene oxide and polyglycols, the fatty acid polyglycol esters have a bright future in India.

Glycerol Fatty Acid Esters

Monoglycerides like glycerol monostearate, glycerol monolaurate, glycerol monooleate and monoricinoleate are the most important members of this class. With balanced hydrophobic liphophilic balance to give them polar characteristics, these compounds are soluble in oxygenated, aromatic and halogenated solvents and mineral oils. They have, in general, a powerful emulsifying effect, usually forming water-oil emulsions when introduced into oil-water system or in themselves they are dispersible to form oil-water system in water.

Preparation and properties — Technical monoglycerides are usually prepared by heating fatty acids and glycerol at elevated temperatures (160-200°C.) and in the presence of catalysts (NaOH) and in an inert atmosphere till the required amount of water of reaction has been removed and the required acid value reached[10]. The reaction mixture consists of mono-, di- and triglycerides along with free glycerol. The catalyst is decomposed with H_3PO_4 and then the free glycerine layer is removed; the residual product is the technical monoglyceride with varying amounts of di- and triglycerides present as impurities.

In commercial products, monoglyceride content seldom exceeds 60 per cent. Since they are to be incorporated with edible products, the presence of di- and triglycerides rarely affects their antistaling properties when incorporated in bread and cakes. However, when they are used as emulsifying agents, the di- and triglycerides present serve only as expensive diluents. Elimination of di- and triglycerides enhances the emulsifying powers of the monoglycerides and at the same time, the separated di- and triglycerides can be reused for the preparation of more monoglycerides.

Purified monoglyceride[11] is obtained by extracting crude monoglyceride with hexane followed by fractional crystallization to remove 2-glycerides from 1-glyceride. The higher glycerides and glycerol are insoluble and hence are eliminated. Several other methods have been reported for the manufacture of high purity monoglyceride, using solvents like pyridine, phenol, etc., but these are rarely used in industry.

Applications — The monoglycerides are widely used in the manufacture of detergents, speciality surface active agents, oil-modified resins and potentially important 'tailor fats'.

As surfactants[12], these esters find use in the form of (i) sulphation bases yielding powerful detergents, but with unsatisfactory stability (sodium salts of glycerol monomyristate and oleate), (ii) ethoxylated derivative (5-20 units), reported to be superior to Tweens, (iii) oil-soluble emulsifiers for various pharmaceutical and cosmetic emulsions, and (iv) as surface active agent, in dentifrices, etc. In food industry[13] they are used as (i) additives to margarine for preventing the 'sweating' of water, (ii) antistaling agents for improving the keeping qualities of breads and cakes, and (iii) ice cream stabilizer for giving a 'dry' smooth texture to ice cream.

In plastics and rubber industries, they are used as (i) lubricants in the extrusion and molding of polystyrene and polyethylene, (ii) internal lubricants for vinyls and ureaformaldehyde resins, (iii) plasticizers for natural and synthetic rubbers (ricinoleate and stearate), and (iv) dispersing agents for pigments.

In the paints, they are used as emulsion paint stabilizers (ricinoleate) and as odourless bases for paints (oleate).

In cosmetics, these esters find use as emulsifiers for producing stable emulsions over wide ranges of temperature and for improving shelf life. Being compatible with sulphated alcohols, cationics and

other anionic emulsifiers, they are used as emulsifiers, thickeners, stabilizers or opacifiers and bases for many cosmetics like varnishing creams, lotions, cream shampoos, shaving creams and mascara.

Miscellaneous Esters

Fatty acid esters of lower aliphatic alcohols (methyl, ethyl, isopropyl and butyl alcohols) are finding increasing use in plastics, cosmetic and pharmaceutical industries. Methyl, ethyl, butyl/oleate/stearate/ricinoleate when used in conjunction with dioctyl phthalate are known to improve the plasticizer efficiency, colour, low temperature flexibility and heat stability of the molded poly (vinyl chloride) sheets[14]. By themselves or in amounts greater than 10 per cent they have no beneficial effect. Hence they are invariably used along with dioctylphthalate (DOP) to obtain the best results. Incorporation of these esters with DOP has no adverse effect on tensile strength, elongation and light stability properties of the products. Isopropyl esters, especially isopropyl myristate and isopropyl palmitate, are widely used in cosmetic industry, because of their ability to impart a non-greasy soft effect to the products. Isopropyl esters are also used as vehicles for pharmaceutical ointments because of their superior skin penetrating properties and solvent solubilizing action towards medicaments. As liquid vehicles for preparations containing high pigment concentration, these esters promote fluidity, facilitate smooth application and remain stable, despite the presence of materials that induce oxidative rancidity.

Fatty acid esters of higher alcohols are finding increasing application as synthetic lubricants. Natural lubricants do not meet the exacting demands of lubricants required for operations at high altitudes or at extremely low temperatures. Such lubricants should have low pour points (−50°F.) and not be unduly viscous at these temperatures (i.e. satisfactory viscosity index in the desired temperature range). Synthetic lubricants meeting these requirements (pour points −50° to −70°C.; viscosity index, about 120) are being manufactured from fatty acids and isoalcohols in USA and Germany. Similar compounds have been synthesized by Pathak and Subba Rao[15] from fatty acids and higher fatty alcohols containing suitable branch chains. Some of the promising compounds are: α-*n*-octoxylauryl ester of α-*n*-octoxylauric acid; α-*n*-butoxypalmitic ester of α-*n*-butoxypalmitic acid and isopropyl ester of α-ethoxybehenic acid. Though costly, lubricants derived from fatty acids have been found satisfactory as watch and clock lubricants[16] and for lubricating instrument panels of automatic field guns required for operation at high altitudes; the two grades required for two different purposes vary in their fine specifications, which is accomplished by suitable blending of two or more synthetic lubricants.

Polyglycerol esters of fatty acids[17] are obtained by heating glycerol with sodium acetate to 160-80° with the removal of water. The molecular weight of the polyglycerols can be adjusted by the extent of water removal. Polyglycerol when condensed with coconut fatty acids forms water-soluble products which are mainly used as surface tension reducing agents in food products. Their condensation products with saturated fatty acids (e.g. stearic) are good oil-soluble emulsifiers.

When 1,3-dioxane is reacted with a fatty acid in the presence of BF_3 catalyst, surface active agents with strong activity are formed[18]. Thus, with stearic acid, a colourless product, stearic acid 1,3-dioxalane polymer having strong surface active properties is formed. It is mainly used as an emulsifier.

Methyl glucoside fatty esters and their ethoxylated derivatives[19] prepared by heating fatty acid (C_{12}—C_{18}) to 180°C. in an inert atmosphere and adding catalyst ($SnCl_2$) and methyl glucoside till the acid value drops to 3 in about 4 hr as such or after ethoxylation exhibit good film-forming properties and hence they are used in emulsion paints.

The ethoxylated derivatives (products similar to Tweens) are powerful nonionic emulsifying agents, specially for paraffin and heavy duty mineral oils.

Nitrogen Derivatives of Fatty Acids

Fatty Acid Amides

Fatty amides are a unique group of solid compounds of high surface activity. They have high melting points, high stability and extremely low solubility in all common solvents at room temperature. They behave in diverse ways on different surfaces and hence are widely used in the surface treatment of textiles, paper, wood, metal, rubber and plastics[20].

Preparation and properties — Fatty amides are prepared from fatty acid and ammonia or amines, followed by dehydration of the soap formed. India could develop the manufacture of these products as unlimited resources of fatty acids and ammonia are available and even if only the amides are used for established uses, a flourishing industry could be established.

Contrary to the common belief that amides are unreactive, fatty amides undergo several reactions leading to even more useful fatty amide derivatives.

Despite their high stability under processing conditions fatty amides react with formaldehyde or paraformaldehyde when heated in the presence of a catalyst (boric acid or NaOH) and in a solvent medium (benzene or alcohol)[21].

The N-methylol fatty amides themselves may be isolated as high melting solids. More often they are only the intermediates and are further reacted. The N-methylol derivatives on reaction with dry hydrogen chloride yield the chloromethyl derivatives of the fatty amides[22]. Sulphonate derivatives like $RCONHCH_2SO_3Na$ are obtained when the N-methylol derivatives are reacted with $NaHSO_3$(ref. 23). Methylene bisamides are obtained when N-methylol-amides or $RCONH_2$ and HCHO are heated with fatty acid or with mineral acids respectively[24].

Ethoxylated fatty amides result when fatty amides are condensed with ethylene oxide at elevated temperature, in the presence of a catalyst and in an inert atmosphere.

Applications — In textile industry, fatty acid amides and their derivatives find use as (i) water

repellents, (ii) softeners, (iii) antistatic agents, (iv) foam stabilizers, and (v) detergency boosters.

The long chain saturated fatty amides, stearamide and behenamide, when chloromethylated and quaternized with pyridine, give the 'Zelan' type or 'Phobotex' type quaternary compounds which when applied to the fabric and cured at 130-50°C. form bisamides on the fabric and render the textile surface water repellent[25]. This type of water repellent finish has high durability and is resistant to both laundering and dry cleaning. Fatty amides and formaldehyde or N-methylol fatty amides when further reacted with melamine and formaldehyde (or methylolmelamine) and then padded on to the fabric with a catalyst and cured, the treated fabric becomes both water repellent and crease resistant[26]. Repellents of this type have a firm, full hand and are widely used on cotton textiles. Fatty amide derivatives act as internal lubricating finishes for textiles, improving resistance to abrasion and increasing tear strength or restoring tear strength loss suffered during resin treatment[27-29]. Softeners for this purpose may be simple N-methylol fatty amide or its condensation product with thioglycolic acid (anionic) or triethanolamine/polyamine (cationic) or with ethylene oxide or acid chlorides (nonionic). Many textile fibres and fabrics, particularly synthetics, pick up static electricity both during fabrication and in use[30]. Diethanolamine salts of ethoxylated fatty amide derivatives are among the most effective antistatic agents.

Fatty amides, when added to sulphonate/sulphate ester detergents at 8-20 per cent level, improve their effectiveness.

Because of their high melting points and insolubility in water, fatty acid amides are used in paper industry (i) for rendering water repellency to paper surfaces, (ii) for improving the 'slip' and preventing 'blocking' properties of paper (handling characteristics), and (iii) for improving the spreading properties at the ink-paper interface and adhesion of ink to paper.

In resins and plastics industry[31,32] unsaturated amides (oleamide and erucamide) are commonly used (i) as slip and antiblock agents in polyethylene and other polyolefins, (ii) for increasing the adherence of inks on plastics and polyethylenes, and (iii) as antistatic agents in the fabrication of plastic articles from nylon, styrene, vinyl or butyrate resins.

In rubber industry[33] ethoxylated fatty amides are used as (i) mold releasing agents for molded rubber goods, (ii) pigment dispersants in rubber compounding, (iii) internal lubricants for extruded goods, and (iv) for curing and improving mechanical properties of butyl rubber (e.g. 1 part of stearamide to 100 parts of rubber).

In metal industry[34], mixtures of stearamide and stearyl alcohol (in 10-100 p.p.m. dilutions) act as efficient rust inhibitors in steam boilers. Methylene bisamides are used as binders in powder metallurgy. Diamides obtained from stearic acid and ethylene diamine/polyalkylene polyamines are used as anti-priming agents in boilers and steam generators[35]. Because of their orienting ability and release properties, fatty amides are also useful as lubricants for metal surface[36]. Insoluble greases for valves and bearings are prepared from 20-40 per cent stearamide and 60-80 per cent glycerol monoricinoleate. Methylene bis-stearamide is used as a die lubricant. As it volatilizes at 300-500°C., no carbon remains on the treated metal surface. Fatty amides obtained by reaction of fatty acids with polyalkylene polyamines are finding wide application in improved methods of applying asphalt to the road surface in the form of aqueous asphalt emulsions[37]. In this, the amides improve the adherence of the asphalt to the metal (stone) surface.

Stearamide and other saturated fatty amides, as well as their ethoxylated derivatives, are used at a concentration level of 2-5 per cent as emulsifiers or emulsion stabilizers in shampoos, in hair creams and other cosmetic goods.

Fatty Nitriles and Amines

Fatty nitriles themselves find limited commercial use, but are the intermediates in the production of fatty amines.

Preparation and properties — Fatty nitriles are invariably produced by the reaction of fatty acids and ammonia by either (i) vapour phase continuous method which involves blowing in excess ammonia into hot fatty acids and passing the resulting mixed vapour of amide and nitrile over heated alumina catalyst bed to complete the dehydration to yield fatty nitrile, or (ii) batch liquid phase method in which excess ammonia is blown into a hot pool of fatty acids containing manganese dioxide catalyst[36]. Both the methods give excellent yields of nitriles. The byproduct formation depends on the temperature of the reaction which has to be carefully regulated.

Fatty Amines

Preparation and properties — Primary fatty amines are prepared from fatty nitriles by catalytic reduction or chemical reduction[38]. Catalytic reduction (using Raney nickel, hydrogen under pressure and alkaline conditions) is the favoured procedure in industry; the chemical reduction process is adopted for the reduction of a fatty acid nitrile to yield unsaturated fatty amine.

Secondary fatty amines are also produced from fatty nitriles by effecting slight changes in the reduction conditions. Secondary fatty amines are also produced by reacting fatty amines with a ketone under reducing conditions.

Fatty tertiary amines which are among the most important fatty amines in use, are prepared by a number of methods:

(i) From fatty alcohols:

$$ROH + (CH_3)_2NH \longrightarrow RN(CH_3)_2 + H_2O$$

(ii) From fatty amines:

$$RCON(Me)_2 \xrightarrow{H_2} RCH_2N(Me)_2 + H_2O$$

(iii) From alkyl halides:

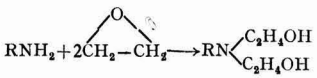
$$RCl + (CH_3)_2NH \xrightarrow{NaOH} RN(Me)_2 + NaCl$$

(iv) From fatty amines:

$$RNH_2 + HCHO + H_2 \longrightarrow RN(Me)_2 + 2H_2O$$

Reductive alkylation

(v) From fatty amines + ethylene oxide



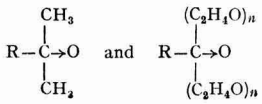
Fatty diamines are prepared starting from unsaturated fatty nitriles, epoxidizing them first, followed by reaction with ammonia.

Applications — Fatty tertiary amines find wide use as intermediates in the preparation of quaternary ammonium compounds and alkyl dimethylamine oxides. Primary fatty amines are used in the manufacture of fatty diamines and amphoteric compounds. When condensed with acrylic monomer, followed by hydrolysis, primary fatty amines give rise to the amphoteric type of compounds (e.g. Deriphats of General Mills). Because of their versatility, these amphoterics find applications in textiles, leather and lacquer industries, mainly as emulsifiers.

Fatty diamines, when condensed with ethylene oxide, yield ethoxylated derivatives, which find use in textile, leather and lacquer industries as speciality emulsifiers.

Fatty Amine Oxides

Though the detergent properties of fatty amine oxides have been known since 1939, it was only in 1961 that their importance was realized. Because of their unique surface active properties and complete biodegradability these compounds are assuming great industrial importance[39]. For suitability as cleansing, wetting and disinfecting agents, the amine oxides should be tertiary, such as alkyldimethylamine oxide or alkylpolyethoxyamine oxide of the general formula



where R is a long alkyl chain, derived from fatty acid (C_8-C_{18}).

Preparation and properties — These compounds are usually obtained by the reaction of tertiary amines with hydrogen peroxide[40]. They are difficult to dry, and hence special care is required in their handling.

Some of the compounds which have shown promise in the surfactant field are dimethyl dodecylamine oxide, bis-(2-hydroxyethyl)-dodecylamine oxide, N-dodecylmorpholine oxide, 1-hydroxyethyl-2-octadecylimidazoline oxide, N-octadecyl-1,3-propylenediamine-(N_1N_1N')-2-hydroxyethyl-N,N′ oxide, and sodium 1-oxy-2-octadecyl 1-ethoxy sulphonate.

Fatty amines can be prepared from a wide range of compounds with various groups and they find a multitude of applications. Fatty amine oxides are less basic than the parent amines but they form salts with strong acids in aqueous solution depending on the *p*H.

Applications — Alkyl amine oxides are excellent foam stabilizers and detergency boosters even at relatively low levels; hence they are invariably used as built-in-liquid detergents, especially in conjunction with alkylbenzenesulphonic acid. Being powerful emulsifiers they are used as textile assistants. Being mildly cationic, with strong amphoteric properties, besides stabilizing foam, they increase viscosity, contribute emollient, detergent and antistatic properties in various cosmetic products such as shampoos (lustre and manageability of hair improved) and dish washing formulations (with no ill after-effect on the hands). They are also used as pour point depressants in lubricants.

Quaternary Ammonium Compounds

High molecular weight quaternary nitrogen compounds are very stable, generally soluble or dispersible in water, odourless, possess high bactericidal activity and act as surface active agents. These properties have made them particularly attractive as germicides, disinfectants and sanitizing agents, especially in food and dairy industries[41].

The importance of the long alkyl chain and the quaternary nitrogen atom as fundamental structural units for the activity of the quaternary nitrogen compounds has been established for a long time[42,43]. The long alkyl group is invariably derived, directly or indirectly, from the fatty acids and the nitrogen may form part of the amine, pyridine or any other nitrogen heterocyclic. When halides are not tolerated in the quaternaries, quaternaries like stearyl trimethyl ammonium saccharinate are prepared (non-toxic, sweet and heat-stable antistatic agent).

Applications[42-44] — In hospitals, the germicidal, fungicidal and disinfectant properties of these compounds are made use of for the preparation of antiseptic lotions, sterilization of instruments, gloves and rooms. In dairy industry and eating establishments, these are used more as industrial sanitizing agents, deodorants-cum-disinfectants in the cleaning of milk cans, dairy equipments, bottles, dishes and other glassware. In pharmaceutical industry, lauryl isoquinolinium bromide is used as a dandricide, bis-quaternary ammonium compounds [$R_3N\pm(CH_2)_x\pm NR_3$] for curarizing effect (neuromuscular blocking potency highest with C_{10})[44]. Alkyl dimethyl benzyl ammonium chloride is used for swimming pool sanitation and algae control in water tanks, and in poultry drinking water supplies.

Being substantive to cotton, cationic quaternaries are used for imparting a soft hand to treated textile goods. They find use in stripping of insoluble and anionic vat dyes, as mordanting assistants in the dyeing of cotton, regenerated cellulose and mixed fabrics, as antistatic agents for synthetic fibres; for restoring tear strength loss sustained during resin treatment of textiles and for imparting water repellency to textiles.

Alkyl pyridinium halide type quaternary ammonium compounds are used in emulsion polymerization of butadienestyrene, butadiene-acrylonitrile to make synthetic rubber. In leather industry, these compounds are used for fat liquoring of leather to impart flexibility, fullness and softness. The emulsifying agents in fat liquoring are typical water-soluble cationics which yield oil-water emulsion.

In petroleum industry, cationics are the preferred agents for de-emulsification of water-oil emulsion

from oil wells. They find use as diesel and stove oil emulsifiers and as fuel additives to prevent sludge formation. A few other important uses are in paint industry and as floating agents in the beneficiation of minerals.

Speciality Amine Derivatives of Fatty Acids

Alkanolamines (reaction products of ethylene oxide and ammonia) can be combined with fatty acids to form the corresponding soaps[45]. Soaps prepared from monoethanolamine, monoisopropanolamine or triethanolamine, serve as excellent emulsifiers in the *p*H range 6-10. Mineral oils, hydrocarbon solvents and waxes can all be emulsified by using 10-15 per cent of alkanolamine soaps.

Another speciality product, cocodiethanolamide, widely used as a wetting agent and detergent in textile operations, is obtained by condensing one mole of coconut fatty acid with 2 moles of diethanolamine[46]. Though the product is termed cocodiethanolamide, it is a complex mixture of amide, ester and esteramide. It is also used as foam booster and viscosity improver (thickener).

Imidazolidones, obtained by reacting fatty acids with polyalkylene polyamines, are used as oil-soluble surfactants in the finishing of textiles and lubricating oil additive corrosion inhibitor in petroleum industry.

Another important compound of this class is Δ^2-imidazoline. It emulsifies diesel, stove, mineral and vegetable oils, pyrethrum and phenothiamine concentrate in as low as 2-4 per cent as compared to 15 per cent of soap. This has stimulated its use in printing inks, agricultural sprays, etc.

Sulphur Derivatives of Fatty Acids

Sulphated and Sulphonated Fatty Acids/Oils

Compounds in this class are in use for a long time. A universal textile auxiliary, which serves practically all purposes, is obtained by sulphating/sulphonating castor oil/fatty acids in the form of esters. Complete sulphation of OH groups in the triglyceride or ricinoleic ester gives a product with 19 per cent SO_3 content. Complete sulphation of both OH groups and double bonds in ricinoleic acid (with elimination of glycerol) gives a product with 29·5 per cent SO_3, while complete sulphation of oleic acid methyl or butyl ester gives a product with 19-20 per cent SO_3 in its sodium salt.

The above theoretical content of SO_3 is hard to reach in practice, but products with SO_3 content approaching this value are widely used in industrial operations, as they have satisfactory stability towards acids, alkalies, hard water, etc. In practice, products having the desired properties are obtained by sulphation of fatty acid esters at low temperatures (below 5°) and in the presence of dehydrating agents, such as acetic acid or phosphorous pentoxide, with strong sulphating agents like sulphur trioxide, oleum, chlorsulphonic acid or acetylsulphonic acid.

Different oils have been sulphated and the choice of oil to be used rests mainly on economic considerations. It is preferable not to use edible oils for this purpose.

Applications — Highly sulphated unsaturated fatty acids are used as (i) low foaming wetting agents, penetrants, dyeing assistants, antistatic agents for rayons, sizing and softening agents, (ii) emulsifiers for mineral oils (metal coolants), (iii) wool batching oils, and (iv) for fat liquoring of leather.

α-Sulpho Fatty Acids and Derivatives

Higher fatty acids can be sulphonated directly in the α-position by reaction with SO_3, $ClSO_3H$ or dioxane-SO_3. α-Sulphonation can also be accomplished indirectly by the Strecker reaction of an α-bromo fatty acid with sodium sulphite. The α-sulpho fatty acid is then esterified with an alcohol to get the α-sulpho ester, which on neutralization with alkali gives surface active products, which are valuable and versatile intermediates, having superior stability towards acids, alkalies and hard water.

Salts of methyl ester of a sulphomyristic acid and α-sulpho tallo acids find use in industry and are reported to equal the performance of sodium lauryl sulphate and alkylbenzene sulphonic acid. α-Sulpho fatty acid derivatives find use as shampoos, liquid syndets, detergents, paint additives, grease additives, lime soap dispersing agents, surfactants, emulsifying agents, etc.[47].

Sulphur Derivatives of Long Chain Fatty Acids

Thiol esters of fatty acids (e.g. methyl mercaptostearate) are prepared by the addition of mercaptoacetic acid or mercaptopropionic acid under ultraviolet radiations. They do not at present find many industrial applications; they are reported to be useful as lubricant additives, coatings and rubber substitutes.

Sulphation Products of Ethoxylated Fatty Acids and Fatty Alcohols

These compounds find use in cosmetic industry for imparting emollient effects to the cosmetic products.

Sulphation of lauryl, oleyl, cetyl and octyl alcohols with SO_3 or $ClSO_3H$, depending on the grade required, gives sulphated products which find use as speciality products, powerful detergents, wetting agents; in cosmetic and pharmaceutical formulations. Examples of this class of compounds are sodium lauryl sulphate, triethanolamine, lauryl sulphate and dioctyl sulphosuccinate.

Phosphorus Derivatives of Fatty Acids

Phosphated Derivatives (C-O-P Bonds)

Phosphate ester surfactants (emulsifying and dispersing agents) for producing or stabilizing water in oil emulsions are prepared by treating hydroxy acids, esters or derivatives with an amount of phosphating agent which is less than that needed for complete esterification of the hydroxy groups in the compound.

The following are typical examples of phosphate ester surfactants.

(i) Hydroxy fatty acids/esters/oils, on reaction with phosphorous pentoxide yield partially phosphated esters. For example, when castor oil (1 kg.)

is reacted with phosphorous pentoxide (25 g.), the resulting product is a powerful emulsifier, used in the fat liquoring of leather and as foam killer.

(ii) Fatty acids are condensed with different moles of ethylene oxide and then reacted with phosphorous pentoxide to yield a new range of soaps, detergents and emulsifiers.

(iii) Fatty alkylolamide (obtained from fatty acid and alkanolamine) on phosphation gives a product useful as lubricant in cellulose acetate yarns and also minimizes the accumulation of static electricity.

Products with modified surface active properties are obtained by phosphation of monoglycerides.

Phosphorus Derivatives of Fatty Acids (C-P Bonds)

These compounds are obtained (i) by the action of alkyl halides on trialkyl phosphates, and (ii) by the radical catalysed addition of dialkyl phosphonates to olefinic compounds. This method of adding dialkyl phosphonates to unsaturated compounds has been extended to include alkyl and glyceryl esters of unsaturated acids or mixtures containing them (phosphonated oils and phosphonated esters).

Applications — These compounds find use as lubricant additives, antiwear and extreme pressure agents. Their low pour points (—65°C.) and satisfactory viscosity index, make them suitable for use as speciality lubricants by themselves or in conjunction with other synthetic fatty acid esters.

Long chain phosphorus compounds such as dialkyl 9 (10) phosphono stearate are efficient primary plasticizers, imparting good low temperature flexibility to PVC compositions[48].

Metallic Soaps

Metallic salts of fatty acids, apart from their traditional use as common soaps, find use in several industries.

The method of their preparation depends on their 'end use'. Thus, when conductivity is not an important factor, they are prepared by reacting the sodium soap in water solution with the required amount of water-soluble metallic salt and digestion. The precipitated metallic soap is washed free of impurities and then dried to the required extent. Falling under this category are lead stearate, zinc stearate and aluminium stearate.

When the metallic soap is to be used in cables and electrical appliances, the product should have low conductivity. For this purpose, metallic soaps are prepared by heating the fatty acid and the corresponding metal oxide at elevated temperatures.

The most common metallic soaps in use in various industries are aluminium stearate, lead stearate, lithium stearate, magnesium stearate, zinc stearate and zinc palmitate[49].

Speciality Products

Aluminium oleate finds use in the composition of coatings clinging to metal surfaces; aluminium palmitate as a thickening and suspending agent; aluminium octoate in making firm gels for oil well sealing; iron stearate in petroleum industry; calcium ricinoleate as lubricant stabilizer in food packing; and cobalt stearate as an oxidation catalyst.

Depending on their end use, the metallic soaps are classed under different grades, such as cosmetic grade, grease grade, textile grade, etc.

Applications — Aluminium and lithium stearates are characterized by excellent water repellency, good adhesion to metals, good transparency, gelling in organic solvents, lubricity. Aluminium stearate is widely used but where operation over a wide range of temperatures is desired, lithium stearate is employed.

Calcium, zinc and magnesium stearates effect improved suspension of pigments and act as flattening agents for paints, varnishes and lacquers. Aluminium, lithium and lead stearates are used as rust preventives; aluminium and calcium stearates are used to impart water repellent properties to fibrous material, masonry and concrete structures, textiles, paper and treated ropes. Aluminium, calcium and magnesium stearates are used for dry lubrication in wire drawing, metal stamping and rolling. Lead stearate finds use as a lubricant for use under extremely high pressure conditions. Lead stearate is used as a heat stabilizer for PVC compositions. Zinc stearate is used as a mold lubricant and dusting powder in rubber industry. Aluminium stearate finds use as a high gloss jelly brilliantine from mineral oils and calcium stearate as a special emulsifying agent in the manufacture of creams and pastes. It is also a non-toxic lubricant in food and pharmaceutical industries.

Miscellaneous Fatty Acid Derivatives

One of the most important derivatives of fatty acids, which has yet to find application on a large scale (in India) is the fatty alcohol condensate with ethylene oxide[50]. It has been found to be very effective in controlling the evaporation of water from large reservoirs and lakes in the form of monomolecular layer over lake surfaces. These layers not only show better performance than cetyl-steryl alcohol mixtures used in USA and Australia, but also allow the oxygen of the air to penetrate into the water layer and thus allow the fish and other marine animals to thrive.

Emulsifiers

As far as India is concerned, the most important single class of compounds that could be prepared from fatty acids are emulsifiers. The demand for emulsifiers for use in the dispersion of pesticides in aqueous suspensions is expected to be considerable, with the intensification of plant protection programmes. The development of satisfactory emulsifiers for use with different types of pesticides and their concentrates using indigeneously available raw materials, particularly non-edible oils is, therefore, a problem of considerable importance.

Summary

The main recent advances in the preparation and industrial utilization of various types of fatty acid derivatives, viz. (i) esters, (ii) nitrogen derivatives, (iii) sulphur derivatives, (iv) phosphorus derivatives, (v) metal salts and miscellaneous derivatives, and

(vi) emulsifiers, have been reviewed. The fields holding special promise for India have been indicated.

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REVIEWS

ELEMENTS OF MODERN ALGEBRA by Sze-Tsen Hu (Holden Day Inc., San Francisco), 1965. Pp. x +208. Price $ 9.85

The modern mathematician has to introduce newer and more abstract notions partly in an endeavour to synthesize the various branches of mathematics and it is important that this material becomes available to the student of mathematics at an early stage. The theoretical physicist in trying to explain many of the baffling features of nature also has to make frequent inroads into what is conventionally called pure mathematics. Thus, books such as the present one on modern algebra will be required by a much wider circle of readers than they were intended for.

Starting with the definition of sets, functions, Cartesian products and relations, the first four chapters cover elements of semigroup and group theories, emphasis being placed on Abelian groups in the discussion. These chapters also contain notions of exact and semiexact sequences, tensor products and homology groups. (These last, in relation to integration over complex analytic varieties, have found application in elementary particle physics in the study of analytic properties of scattering amplitudes.) Chapter five deals with algebraic structures with two binary operations, viz. rings, integral domains and fields. Chapter six deals with structures which have in addition a scalar multiplication of the elements. These are modules, vector spaces and algebras. Graded algebras, tensor algebras, exterior and symmetric algebras are introduced. Finally, in the last chapter, categories and functors introduced by Eilenberg and Maclane are defined.

There are a number of exercises at the end of each section which adds to the usefulness of the volume. Altogether it is a pleasant little volume that Prof. Hu has given us.

K. VENKATESAN

SYMMETRIES IN ELEMENTARY PARTICLE PHYSICS edited by A. Zichichi (Academic Press Inc., New York), 1965. Pp. xi+429. Price $ 7.95 (paper); $ 12.00 (cloth)

The volume under review contains the proceedings of the second course of the International School of Physics 'Ettore Majorana' held in 1964 at Erice (Italy) and sponsored jointly by CERN, the Italian Ministry of Public Education and NATO. As the title indicates, the volume is mainly about the role symmetries play in explaining aspects of elementary particle physics. The interest in this field has had an upsurge in recent years due to the success of SU_3 symmetry. The initial impetus for the use of group theory in quantum mechanics was given by Wigner who stressed the fruitfulness of invariance considerations. Kabir's talk deals with some of these earlier notions including both continuous and discrete symmetries. Berman in his article on elements of SU_3 presents a neat account of the salient points of 'this fascinating and timely subject'. Without much pain he takes us through the general properties of the SU_3 group and its irreducible representations, tensorial methods, mass differences in multiplets due to violation of SU_3 and the electromagnetic mass splittings, and decay widths of the decuplet of baryon resonances.

The article by Feynman on the consequences of SU_3 symmetry in weak interactions is written with the author's characteristic vigour, freshness of outlook and the ability to present familiar things in a different way. The lectures were aimed at the experimental group attending the school. The first part of the lectures deals with the current-current theory and various ways of deriving the Goldberger-Treiman formula. SU_3 symmetry is introduced in a simple way and Cabibbo's theory of weak interactions is discussed as well as the attempts to deduce the $\Delta I=1/2$ rule. Feynman emphasizes that 'not all the difficulties (of weak interactions) arise from SU_3 nor do all of the successes'.

Gatto deals with the weak and electromagnetic currents in the eightfold way with first order symmetry breaking. To this order he proves a theorem that the vector coupling constants are not renormalized. The most interesting consequence of this result is the unique prediction of the vector coupling constants in strangeness changing leptonic decays. Zweig's talk is on the basic building bricks of the observed baryons and mesons (called aces or quarks) which are fractionally charged and Tarjanne's on SU_4. (The author says, "The most important reason to take up the study of SU_4 is that so many people do SU_3 work... and to ensure full employment, one has to find something slightly more complicated." This group seems to have no more significance than this to elementary particle physics.) Biedenharn's article on SU_n representations presents the methods of Weyl, Schwinger and Gelfand for constructing all irreducible representations for SU_3 and the idea of triality for SU_3 is discussed. Cabibbo discusses CP-violation in weak interactions, the various (unsuccessful) attempts to resuscitate the invariance and other theories to account for the smallness of the observed violation.

There are five articles on experimental methods — on methods for assigning spin and parity to baryon resonances by Ashkin, a review of neutrino physics by Bernardini and articles by Block, Conforto and Sherwood. The volume ends with the discussions (led by Feynman) which followed each lecture and which led to clarification of many points.

The volume is nice both in get-up and contents and will be welcomed by research workers in this field.

K. VENKATESAN

PHOTOELECTRONIC MATERIALS AND DEVICES edited by Simon Larach (D. Van Nostrand Co. Inc., New York), 1965. Pp. xi+434. Price $ 12.00

The various chapters of the volume under review are based largely on a series of papers on

optoelectronics published in the *RCA Review*, December 1959. The original papers have all been revised and expanded to make them more complete and up to date and a couple of new chapters added in order to effect a greater coverage of the field. A 99-page review on luminescence in solids forms the opening chapter. The succeeding 75 pages are devoted to photoconductivity and to infrared sensitive extrinsic germanium and germanium-silicon alloy photoconductor (Chapters II and III). Photoelectric emission is dealt with in 46 pages in Chapter IV. The problem of noise current finds a comparatively shorter presentation in Chapter V which is followed by one on photovoltaic effect. Chapters VII-IX, dealing successively with solid state optoelectronic devices, image intensifiers and the electrofax, together cover 150 pages. The volume ends with a carefully prepared subject index. Chapter I might as well be called a review on electroluminescence which includes (in sharp contrast to the prominent display on the flap !) a rather hurried reference to injection lasers. The emphasis is primarily on the physical and descriptive side avoiding details of analytical treatment as far as possible. Material technology finds adequate prominence at proper places. Speaking in general, each one of the chapters is a self-contained and illuminating account of the individual topic of discussions. The order of presentation of the various topics, therefore, does not affect ease of reading even though the reviewer would personally have liked a general discussion on noise current to precede a chapter containing discussions on S/N ratio and detectivity of practical devices. In a collection of papers like this a little duplication of materials — particularly the background ones — is of course unavoidable, but the present volume succeeds in keeping this within reasonable limit. Considerations of devices in the last three chapters constitute lucid expositions of a growing field without undue expenditure of space. The standard of printing and general get-up are of high order. As the editor himself points out, the volume does not constitute a complete review of the field on optoelectronics. One is, therefore, very likely to find that some topics of one's interest have been either left alone or treated inadequately, e.g. free carrier absorption type devices, photomixing, modulation and photon-coupled junctions. Within this limitation he would, however, find in it a comprehensive collection of informations on a set of related topics which together constitute a workable framework of this comparatively new arena of electronics. This alone makes the volume a significant contribution that should provide excellent starting material to the intending explorer in the field. Lists of references at the end of different chapters add considerably to the utility of the publication.

S. DEB

AN ATLAS OF MODELS OF CRYSTAL SURFACES by J. F. Nicholas (Academic Press Inc., New York), 1965. Pp. ix+229. Price $ 27.50

This book forms one of the titles in the series 'Material Science and Engineering Program' under the general editorship of G. J. Dienes and A. C. Damask. In recent years much work has been done on specific features of crystallographic surfaces and it has, therefore, become necessary to know as much as possible about the geometry of the surfaces used. In order to visualize the crystal surfaces, many workers have constructed models using spherical balls to represent the atoms. A general theory has been worked out by the author in collaboration with Moore for constructing models exhibiting ideal flat surfaces for a variety of crystal structures. In certain problems the need arises for comparing the geometrical features of several different surfaces. In order to meet such needs, the author has produced the present atlas which consists essentially of a series of photographs of models of flat surfaces in various important crystal structures. Each photograph is accompanied by a table of atomic positions concerning the geometrical arrangement of the surface atoms.

The volume under review is concerned entirely with the geometry of atomically flat surfaces. If an ideal crystal, consisting of an infinite regular array of atoms, is cut by a plane and all atoms whose centres lie on one side of this plane are removed, then the remaining half crystal is said to possess an atomically flat surface. The atlas consists of an introduction followed by 206 photographs of surfaces. Ball models showing the atomic arrangements at atomically flat surfaces have been constructed for surfaces of about twenty different orientations in each of the face-centred cubic, body-centred cubic, sodium chloride, diamond and hexagonal close-packed structures. In the introduction are described the following: (1) specification of a surface, (2) the representation of crystal surfaces by models, and (3) details of actual construction of models. For each surface, a scaled plan of a unit cell of surface has been drawn and the exact positions of the surface atoms associated with this cell have been tabulated. The interpretation of these plans and tables is also given in the introduction. For each surface atom the number of nearest neighbours has been found and the type of coordination is listed in the table of atomic positions accompanying each photograph. The terminology used in this has been explained in the introduction.

Some of the important crystallographic formulae necessary for the derivation of the exact positions of the surface atoms, etc., are given as an appendix.

For those interested in flat surfaces, the book provides photographs of models from which enough information could be gathered, thereby saving them the time needed for constructing models. The photographs given in the book refer to ideal surfaces and in any actual case, it is necessary to make necessary alterations taking into consideration the relaxation of the surface atoms, etc. These photographs would be of great use for constructing real surfaces. Crystallographers who are interested in the arrangement of atoms on particular crystallographic planes or in the arrangement of points on the planes of reciprocal lattices would find the photographs of ideal surfaces given in the book very useful.

The general get-up of the book is very good and the reproduction of the photographs of surfaces is excellent.

R. S. KRISHNAN

PROCEEDINGS OF THE FIRST AUSTRALIAN CONFERENCE ON ELECTROCHEMISTRY edited by J. A. Frieud, F. Guttman & J. W. Hayes (Pergamon Press Ltd, Oxford), 1965. Pp. xvi+954. Price £ 10

The subject of electrochemistry has developed in many new directions in the post-war period. It used to mean the physical chemistry of electrolyte solutions in the thirties and alas this view is still prevalent in many universities. Ionics, as this branch has been termed now, forms an insignificant fraction of the modern electrochemistry which has turned away from equilibrium properties to mechanisms and kinetics of electrode reactions, structure of interfaces, molten salt systems, semiconductor electrochemistry, etc.

The Proceedings of the First Australian Conference on Electrochemistry reflect this trend. Of fifty-nine contributed papers only about four are concerned with solution electrochemistry. This volume represents a cross-section of the topics in electrochemistry in which research is actively pursued. Those embarking on electrochemical research will know from this book where the frontiers of electrochemistry lie.

The organizers have nicely balanced the 'local' contributions against the rest of the world, both in respect of the chairmen of the sections, as well as in the contributed papers. Of the thirty-three outside papers, seventeen are from the USA, seven from UK. Japan and India have three contributions each. Since the major advances in modern electrochemistry were made by Frumkin and his school in the USSR, contributions from Russian electrochemists are conspicuous by their absence.

The proceedings are classified under the following 12 sections with the chairmen surveying the progress and problems in their respective fields: (i) Solid state chemistry (6 papers); (ii) Thermodynamics of electrolytes (5 papers); (iii) Corrosion (3 papers); (iv) Theory of double layers (2 papers); (v) Electroanalytical methods (7 papers); (vi) Applications (electroplating, anodizing) (7 papers); (vii) Non-aqueous systems (4 papers); (viii) Molten salts (5 papers); (ix) Fuel cells (5 papers); (x) Electrode processes (5 papers); (xi) Electrochemical processes (4 papers); and (xii) Electrowinning and electrorefining (6 papers). A careful perusal of the papers indicates that out of the 6 papers in the first section, the inclusion of three in a volume devoted to electrochemistry is difficult to justify. Papers on redox potentials and heat effects should not have found place in the section on thermodynamics of electrolytes. The section on non-aqueous systems could have very well been merged with the section on thermodynamics of electrolytes, assigning the last paper to the electrode kinetics section. There need not have been separate sections on electrode processes and electrochemical processes. Similarly, the last section on electrowinning and electrorefining could have been amalgamated with that on applications.

Discussion is by far the most useful part of such conferences. It would appear that in order to keep down the size and cost of this volume, discussions have been expunged, for it is impossible to imagine that the delegates come from all over the world merely to present papers without discussing them. The absence of recorded or even communicated discussions is a serious fault. It is also usual to present the theoretical sections before the practical applications. This natural order has not been observed, nor can the location sectionwise of some papers be condoned. Despite these drawbacks, the publishers are to be commended on bringing out this attractive volume within a reasonable time after the holding of the conference. Libraries will no doubt find this book an asset to their electrochemical collection, but the price tag of £ 10 will be deterrent to many chemists.

M. A. V. DEVANATHAN

CONFORMATION THEORY, Vol. 3 of ORGANIC CHEMISTRY by Michael Hanack (Academic Press Inc., New York), 1965. Pp. ix+382. Price $ 14.50

This book is Volume 3 in a series of monographs on organic chemistry edited by Alfred T. Blomquist. It is translated by Helmut C. Neumann from the German manuscript based on lectures given by the author at the University of Tübingen. The literature through 1963 has been covered, though complete coverage is not claimed by the author.

The recognition of the importance of conformational analysis in the study of acyclic, alicyclic and heterocyclic compounds has resulted in a large accumulation of valuable work during the last fifteen years. The ever-increasing literature has necessarily restricted the author from a detailed consideration of all the aspects of conformational analysis. The book is well written and is especially valuable as an introduction to the subject. The numerous references cited should be useful to the research workers in the field. The translation from German has been done lucidly.

There are eight chapters. After a short introductory chapter on historic survey, followed by a general discussion on conformational analysis, individual classes of compounds such as monocyclic, bicyclic, polycyclic and heterocyclic are discussed in the other chapters. There is also a chapter on compounds with boat conformations. Acyclic diastereoisomers are included in the last chapter, which normally one would expect to be dealt with in an earlier chapter. The importance of physical methods in the determination of conformation cannot be overemphasized. However, only a small section in Chapter 5 deals with this aspect with some scattered references in the other chapters. This treatment is far from satisfactory. The addition of a separate chapter on physical methods would have increased the value of the book considerably. The conformation of cyclopentanes discussed in detail in Chapter 3 should prove valuable. On page 89 under monosubstituted cyclohexanes it is mentioned that "the energy difference between conformers is too small to permit their individual isolation". The same view is given in page 91 as well. The individual conformers could not be

isolated not due to their small energy difference but because of the low energy barrier (activation energy) for interconversion. One other serious error should be mentioned. In the discussion on 1,2,3,4-tetra-substituted cyclohexanes the author records on page 138: " Two of them (Nos. 1 and 4 in Table VI) are optically inactive (meso forms) because they possess a plane of symmetry. Nos. 2, 3, 5 and 6 consist of resolvable *d,l* forms." Actually Nos. 1, 2, 3 and 4 are resolvable, whereas 5 and 6 are not. Most of the structures have been well written except those of the decalols on pages 181 and 189 which lack clarity with regard to the configuration.

M. BALASUBRAMANIAN

EMULSIONS: THEORY AND PRACTICE, ACS Monograph No. 162, by Paul Becher (Reinhold Publishing Corp., New York), Second Edition, 1965. Pp. xi +440. Price $ 22.00

This monograph is the second edition of an earlier one published in 1957. It is intended to serve as a self-contained discussion of emulsions in theory and practice. The book has already done valuable service to research workers and technologists in such widely diversified fields as food, textiles, pharmaceuticals, coatings and high polymers. The rapid development of the subject during the past several years necessitated a revision in many places where the information may be considered as out-dated or of limited value.

The general framework of the first edition has been maintained in this edition. The revision has been made extensively after critically evaluating the recent literature. Thus about one-third of the material in this volume presents new developments and the remaining portion is more or less rewritten.

After a very brief introduction (Chapter 1 in 3 pages) defining the terminology used in emulsions, the next chapter presents the basic theories of surface activity such as surface and interfacial tensions and other surface and bulk properties of surfactants. Chapter 3 deals with physical properties of emulsions which includes discussion of optical and electrical properties. In Chapters 4 and 5 the theory of emulsions with particular reference to its stability, creaming, inversion and demulsification has been discussed. Chapter 6 deals with the chemistry of emulsifying agents which are classified into major groups as anionic, cationic, nonionic and amphotylic. The techniques of emulsification are presented in Chapter 7. Chapters 8, 9 and 10 are especially concerned with the methods of production of more or less stable emulsions, its opposite process, i.e. demulsification or emulsion breaking, and the various testing procedures used in the evaluation of emulsions and the materials used for their preparation.

The book makes a pleasant reading. All the chapters are well balanced and provide an authoritative treatment of the current theories and connected practical applications in a coherent manner. It can be considered as a standard reference book for research workers and technologists who need a general but authoritative account of the recent developments relating to emulsions. The appearance of this revised second edition will, therefore, be considered as a welcome event to scientists and technologists interested in this subject.

A. B. BISWAS

COMPUTERS IN BIOMEDICAL RESEARCH: Vol. 1, edited by R. W. Stacy & B. D. Waxman (Academic Press Inc., New York), 1965. Pp. xxii +352. Price $ 20.00

The editors have made a heroic effort in compiling two volumes on the above-mentioned subject, assembled as a culmination of four years of activity in the field of biomedical computing. During the end of the last decade, many scientists had begun using computer technology in the field of research in biomedical sciences. This is a new field and the first few years have seen the development of techniques and approaches new to the medical science. It is hoped by some that such a development will represent one of the major contributions to biomedical science in this century.

In the first volume of this book, the work included is very diverse, as computation and automatic data processing is becoming the universal tool which can be applied in many fields. In different chapters of the book important contributions have been made concerning techniques of computation and data analysis as applied to life sciences, to biological laboratory studies, to bio-sciences, etc. The use of such computers has greatly helped in the analysis of data on cybernetic systems, specific bio-systems, neurophysiology, even techniques in medical diagnosis and laboratory medicine. They can even be used as aids in evaluating fetal distress, and radiation dosages, and even for automatic personality assessment, etc. Thus this work will be of interest to a wide range of scientists as there are few fields which cannot benefit from application of one or more methods described in this volume.

B. K. ANAND

CELLS AND TISSUES IN CULTURE, METHODS, BIOLOGY AND PHYSIOLOGY: Vol. 1, edited by E. N. Willmer (Academic Press Inc., New York), 1965. Pp. xiv +788. Price 168*s*.

The book represents a welcome addition to the not many existing books in the field which include *Cell and tissue culture* by John Paul, *The cultivation of animal and plant cells* by Phillip R. White, *Methods of tissue culture* by Parker, *Cell culture and somatic variation* by Morgan Harris and *A bibliography of the research in tissue culture* by Murray and Kopech.

The different volumes in the present series cover or are intended to cover (Volumes 2 and 3 are yet to appear) a much wider field with contributions from many leading workers in the field. The present volume covers the history and methodology of tissue culture and the biochemistry, physiology, morphology and cytology of cells, tissues, organs and embryos in culture. The problems of cell division, cytogenetics, cell differentiation and recombination of dissociated cells and the formation of cell aggregates have been covered in different chapters. The cultivation of embryos *in vitro* and the physiology of the developing embryos form the subject matter of a chapter on embryogenesis. The actions of hormones and vitamins (A and C) on cells and tissues

have been dealt with respectively by Ilse Lasnitzke (Chapter 16) and Fell and Rinaldini (Chapter 17). The five chapters devoted to the biochemistry of cells and tissues in culture deal with carbohydrate and energy metabolism (Chapter 7), amino acid and protein metabolism (Chapters 8 and 9), deoxyribonucleic acid and ribonucleic acid synthesis in cell cultures (Chapter 10) and mucopolysaccharide metabolism in tissue culture (Chapter 11).

The book makes lucid reading in spite of its multiple authorship. It is a pleasure to see what appears to be a complete and easy to use subject index at the end of the book as even major publications are sometimes wanting in this respect. The get-up of the book is excellent and although the price is perhaps a bit too high for Indian readers, the book will be most valuable for those engaged in the field of tissue culture. It will also be useful for biologists and biochemists who cannot afford to ignore the impact of tissue culture studies on the advancement of knowledge in their respective fields.

The forthcoming two volumes of the series, which will deal with special tissues cultivated *in vitro* and the application of tissue culture methods to problems in virology, immunology, radiobiology, pharmacology, neoplastic transformation, etc., will be awaited with interest.

C.V.

FUNDAMENTALS OF DAIRY CHEMISTRY edited by Byron H. Webb & Arnold H. Johnson (AVI Publishing Co. Inc., Westport, Connecticut), 1965. Pp. ix+827. Price $ 25.00

The book under review is the third edition of the first book on the principles of dairy science published in the year 1928 under the title *Fundamentals of dairy science* by the Associates of L. A. Rogers. The second revised edition of the book which came out in the year 1935 has been out of print for the past two decades. The present edition, though indicating an abridged scope in its title, covers a wide field and has been rewritten with the assistance of 28 specialists in each field. The topics covered are: Composition of milk; Composition of milk products; Proteins of milk; Composition and properties of lipids of milk; Deterioration of milk lipids; Lactose; Vitamins; Physical properties of milk; Physical equilibria of milk with relation to the fat phase; Coagulation of milk and protein denaturation; Rennin action and cheese chemistry; Fermentations; and Frozen dairy products. Thus, various aspects of the physical and chemical equilibria in milk and their influences on the manufacturing processes, as well as the keeping quality of milk and milk products, have been reviewed in detail. Each chapter has been made comprehensive to cover the related topics so as to give a complete picture and illustrate the interlink between different constituents of milk and the influence of each on the other. The literature under each chapter has been covered on a world-wide basis and references upto the year 1964 are included. These have been arranged in alphabetical order. The volume, issued in a limited print, will be a useful source book to the students of dairy science, research workers and food technologists. The text has been well illustrated and the volume printed clearly and bound attractively.

N. N. DASTUR

PUBLICATIONS RECEIVED

TRANSISTOR CIRCUITS by K. W. Cattermole (Gordon & Breach Science Publishers, New York), Second edition, 1965. Pp. xv+470. Price $ 14.50

AEROSPACE RANGES: INSTRUMENTATION, PRINCIPLES OF GUIDED MISSILE DESIGN by Joseph J. Scavullo & Frederick J. Paul (D. Van Nostrand Co. Inc., New York), 1965. Pp. xv+457. Price $ 15.75

MOLECULES AND LIFE by Robert F. Steiner & Harold Edelhoch (D. Van Nostrand Co. Inc., New York), 1965. Pp. 207. Price $ 1.95

OSCILLOSCOPE MEASURING TECHNIQUES by J. Czech (Centrex Publishing Co., Eindhoven), 1965. Pp. xviii+620. Price Rs 84

PHYSICO-CHEMICAL TECHNIQUES OF ANALYSIS: Vol. I, by P. B. Janardhan (Asia Publishing House, Bombay), 1965. Pp. viii+356. Price Rs 32

INTERACTION OF METALS AND GASES: Vol. 1—THERMODYNAMICS AND PHASE RELATIONS by J. D. Fast (Centrex Publishing Co., Eindhoven), 1965. Pp. x+302. Price Rs 40

ORGANIC REACTIONS: Vol. 14, edited by Arthur C. Cope (John Wiley & Sons Inc., New York), 1965. Pp. vi+498

ELECTROANALYTICAL METHODS IN BIOCHEMISTRY by William C. Purdy (McGraw-Hill Book Co. Inc., New York), 1965. Pp. xiv+354. Price $ 12.50

IMPROVING THE EFFECTIVENESS OF RESEARCH AND DEVELOPMENT by Robert E. Seiler, 1965. Pp. x+210

INTRODUCTION TO SPACE SCIENCE edited by Wilmot N. Hess (Gordon & Breach Science Publishers, New York), 1965. Pp. xv+919. Price $ 10.00 (professional edition), $ 29.75 (reference edition).

THE THEORETICAL SIGNIFICANCE OF EXPERIMENTAL RELATIVITY: DOCUMENTS ON MODERN PHYSICS by R. H. Dicke (Blackie & Son Ltd, London), 1965. Pp. xii+153. Price 32*s*. 6*d*.

FUNDAMENTAL ANALOGUE TECHNIQUE: ELECTRONIC User Series by R. J. A. Paul (Blackie & Son Ltd, London), 1965. Pp. x+216. Price 35*s*.

INTERPRETATION OF ORGANIC SPECTRA edited by D. W. Mathieson (Academic Press Inc., New York), 1965. Pp. ix+179. Price 42*s*.

STEREOCHEMISTRY, MECHANISM AND SILICON by Leo H. Sommer (McGraw-Hill Book Co. Ltd, London), 1965. Pp. xvi+189. Price $ 9.75

OSCILLOMETRY AND CONDUCTOMETRY: International Series of Monographs in Analytical Chemistry: Vol. 21, by E. Pungor (Pergamon Press Ltd, Oxford), 1965. Pp. xvi+239. Price 70*s*.

ELECTRON OPTICS by P. Grivet (Pergamon Press Ltd, Oxford), 1965. Pp. x+781. Price £ 10 net

NOTES & NEWS

Cold electron sources for mass spectrometry

A cold electron source that finds a ready application in mass spectrometry to produce ions from neutral molecules has been devised as a result of the experiments conducted at the Graduate Institute of Technology, University of Arkansas, Arkansas.

In these sources a relatively weak current from a primary emitter was amplified by an electron multiplier to provide sufficient electron current to ionize neutral gas molecules. The conventional thermionic emitter sources contain a hot wire in the proximity of the ionizing region which causes difficulties in the study of mass spectra. The cold electron source overcomes a number of these difficulties, viz. formation of insulating deposits on the sorrounding elements; changes in the mass spectrum cracking pattern arising from thermal variations in the ionizing region; selective gettering of the entering sample and the resultant sample modification; heat pumping or outgassing of the ionizing region; and the contribution to the mass 28 peak caused by carbon monoxide.

Two types of electron multipliers were used in these studies. The first one was a bucket-shaped ten-stage electron multiplier, the electron source mainly consisting of a photocathode excited by ultraviolet radiation. The electrons from this multiplier were found to be emitted in a unidirectional path over a short distance. This condition resulted in a higher ionization efficiency than that obtained by a thermionic emitter. It was observed that out of the different photocathodes used, tantalum provided the highest emission current. The second multiplier was of the resistance strip type. The sources of activating electrons for use with this multiplier were studied by using both beta-emitting radioactive materials as well as a photocathode. These multipliers were used as ionization gauges to test their sensitivity, response and stability. The operation of these multipliers as ionization gauges served to show feasibility of their being used as cold electron sources for mass spectrometry.

The test results have shown that the electron multiplier source in mass spectrometric and ionization gauge applications is highly efficient. It causes no deterioration in resolution and eliminates many of the ambiguities directly attributable to the presence of the thermionic emitter in the mass spectrometer.

Advantages of such a source over a thermionic emitter, including space applications are: appreciable decrease in power consumption; reduced outgassing; no getter effect; more rugged construction; and little emission fluctuations [*J. appl. Phys.*, **36** (1965), 2939].

A new spectroscopy — Optical spectra of multiply ionized atoms

Details of a new form of spectroscopy — the spectroscopy of multiply ionized atoms, which opens up many fascinating and fruitful fields of research — have been reported by Stanley Bashkin of the University of Arizona, Tucson [*Science*, **148** (1965), 1047]. Till now no attempt to study the spectra of multiply ionized atoms has been made obviously due to difficulties encountered in producing and photographing the spectra of multiply ionized atoms. Even though theoretically it is possible to remove several electrons from an atom by heating, and it is also possible to reach such high temperatures with existing thermonuclear machines, it is found that due to (i) non-avoidability of contaminants, (ii) the atoms not being ionized to the same level, (iii) the broadening of spectral lines due to thermal motion of the atoms, and (iv) inability to establish the exact number of emitting atoms, the attempts made in this direction so far were not successful. Another problem encountered in these attempts is the extremely short time (10^{-8} sec.) for which an electron can stay in the excited state.

In recent years the need for a study of the spectra of multiply ionized atoms was felt in three fields, viz. (i) determination of very high temperatures of the order of 10^6 °K. produced in thermonuclear devices, (ii) identification and assignment of spectral lines of solar corona and (iii) evaluation of the relative abundances of elements in celestial bodies.

The technique adopted by Bashkin in the production of multiply ionized spectra is briefly as follows: When a series of atomic particles are accelerated using a generator, a magnet can be used to select a particular kind of particle out of the emergent beam, to collide with a thin target, on passing through which the degree of ionization of the particles is altered. In this emergent beam along with the production of, say, n-fold ionized particles there should be some excited ions with only $(n-1)$ charges. In this state, particles in a comparatively more excited state would release their excess energy as light, thus offering the spectra of multiply ionized atoms for study. The first experimental test of this principle in addition to showing its practical feasibility gave an unexpected result of astrophysical significance, viz. an indication that the light emitted by Nova Herculis 1960 may be due in part to the motion of highly energetic particles through the atmosphere of the exploding star and not solely to the temperature of the stellar surface. An improved set-up, designed later at the Naval Research Laboratory, made it possible to study all the important characteristics of several components of the radiations from excited multiply ionized atoms. Observations made with the set-up enabled measurements of lifetimes of atomic energy levels, a type of information which will be useful in the study of excitation process and also gave promise of a method of producing absolute-intensity

standards over a wide range of wavelengths. Other fields in which the new spectroscopy is likely to have application are properties of thin films, mapping of nuclear charge distribution in an atom, determination of temperature of hot plasmas, absorption spectroscopy, experimental studies in the theory of relativity and astrophysics.

New X-ray diffraction microscopy technique

A novel X-ray technique, capable of recording large-area transmission topographs of crystal slices as are processed in modern semiconductor device technology, has been developed at the International Business Machines Corporation, Poughkeepsie, New York. The technique is non-destructive and, hence, crystal slices can be examined after each processing step. Because of the high sensitivity (capable of detecting minute traces of bending as strain), existing X-ray diffraction microscopy techniques pose a great problem for the recording of large-area topographs of crystal slices used in modern semiconductor technology, since strain-free crystals are not available. The non-availability of strain-free crystals is due to (i) residual deformation strains caused during the crystal growth; (ii) strains caused by substitutional solute atoms during doping of crystals; (iii) the introduction of strains during the different steps (at least 30) of processing; and (iv) strains caused while mounting the crystals for X-ray investigation.

The experimental set-up in the new technique is as follows. The line focus is made to pass through a 'soller' slit (to reduce the vertical divergence) and two vertical slits so as to reduce the angular spread of the incident radiation, and made to fall on the crystal to be tested. The crystal, a screen (which has a narrow slit through which the diffracted beam passes on) and a photofilm are kept parallel to each other under all diffraction conditions. The crystal and photofilm are ganged together and attached to a scanning mechanism, while the beam and the screen remain stationary. This arrangement facilitates investigation of large-area crystals and also eliminates the difficulties met with in the case of existing techniques. Exposure is controlled by varying the number of scans rather than by changing the speed of scanning since this procedure reduces the effect due to fluctuations in the X-ray intensity. In addition, the new technique is useful in correlating crystal imperfections and device reliability [*J. appl. Phys.*, **36** (1965), 2712].

New crystallization technique

In an effort to prepare pure, substances to serve as standard reference materials, Dr Saylor of the National Bureau of Standards, Washington DC, has developed a purification technique which lowers the concentration of solid insoluble impurities by 10^3 to 10^4 in each stage. The apparatus consists of a closed annular tube only partially filled with the material to be purified. The cross-section of the tube is not necessarily circular. The annulus rotates slowly about its own axis, which is slightly tilted from the vertical. That part of the material which is kept molten always sticks to the low side of the circle so that there is no total movement in the direction of rotation of the annulus.

Strips of silver sheet cooled below the melting point of the material are positioned in the bottom half of the annulus, alternating at equal intervals. The lower temperature of the inner strips causes the material to freeze on the inner side of the annulus forming a solid mound of crystalline substance. As the annulus rotates, the front edge of the mound starts melting as it enters warmer regions; growth of the mound continues at the rear edge near the silver strips. The melted material from the front edge flows over the mound and some of it refreezes. As much liquid flows backward as the solid is carried forward. The resulting flow of liquid sweeps the rejected impurities away from the growing surface of the crystals and the impurities flow through the canal-like passage between the mounds and are withdrawn. After repeated freezing and melting the pure material is removed [*Chem. Engng News*, **43** (39) (1965), 48].

Synthesis of furan compounds

A simple and efficient method for the synthesis of furan compounds starting from α,β-unsaturated γ-lactones has been reported. A solution of $Al(alkyl)_2H$ or $Al(isobutyl)_3$ in tetrahydrofuran is added dropwise to a solution of a suitable α,β-unsaturated γ-lactone in tetrahydrofuran with stirring at −20° to −25°C., in an atmosphere of nitrogen. The stirring is continued at the same temperature for 0·5-1 hr. The mixture is acidified with 10 per cent H_2SO_4 and the product extracted with pentane. The pentane extract is washed well with aqueous $NaHCO_3$ and water, dried over Na_2SO_4 and evaporated. The residue is separated by chromatography on neutral alumina (activity II) to obtain the corresponding furan in 60-70 per cent yield [*Chem. & Ind.*, (1965), 899].

Direct construction of benzene rings on existing molecules

A simple and direct method of constructing a benzene ring on the base of an existing molecule has been developed at Princeton University, USA. The method makes possible the synthesis of a variety of aromatic compounds and is particularly suitable for the preparation of unsymmetrical biphenyls. The synthesis is based on the addition of *trans*, *trans*-1,4-diacetoxybutadiene to dienophiles resulting in the formation of Diels-Alder adducts which readily undergo elimination of acetic acid to afford aromatic products. Dienophiles used successfully include quinones, β-nitrostyrenes, chalcones and acetylenes. The yields vary considerably depending upon the dienophile but are usually of the order of 30 per cent. A typical build-up of benzene ring on an acetylene derivative is described below.

A mixture of 1,4-diacetoxybutadiene (0·89 g.), dimethyl acetylenedicarboxylate (0·71 g.) and hydroquinone (0·01 g.) is heated in a sealed tube at 120° for 84 hr. The reaction mixture is taken up in a 10 per cent potassium hydroxide solution in 50 per

cent aqueous ethanol and refluxed for ½ hr. The solution is concentrated to a small volume, acidified with 30 per cent sulphuric acid and extracted with three 50 ml. portions of ether. The ether extracts are dried, decolorized with charcoal, and concentrated to yield 0·45 g. (49 per cent) of pale yellow crystals of 3-hydroxyphthalic acid; m.p. 155-60° [*J. org. Chem.*, **30** (1965), 2414].

High quality protein from coal

A technique for synthesizing high quality protein, developed at the US Bureau of Mines Pittsburgh Coal Research Centre, involves growing the yeast *C. lipolytica*, strain 409, on the Fischer-Tropsch fraction FTW (boiling range >316°C.). About 500 kg. of the yeast can synthesize 1250 kg. of protein per day. The coal-derived materials tested include Fischer-Tropsch synthetic liquid fuel, fractions FTL (boiling range 0-204°C), FTD (boiling range 204-316°) and FTW, hexane-soluble material from Rockdale lignite low temperature tar, and a few paraffin-olefine fractions from the neutral oil of low temperature tar. Of more than 200 cultures of bacteria, yeasts and fungi tested, the yeasts *Candida lipolytica*, strains 409, 409A, 409B, and *Candida tropicalis*, strain 410 were selected as the most promising cultures with respect to total cell yield, ability to utilize diverse substrates and resistance to reasonably high substrate concentrations.

It is concluded that coal-derived material is as satisfactory as petroleum derived material for growing microogranisms for the production of proteins [*Chem. Engng News*, **43** (39) (1965), 69].

Microbe mutants for hydrocarbon oxidations

The use of microbes in organic synthesis has hitherto been restricted to the production of antibiotics, fermentation of carbohydrates and conversion of steroids. Recent research carried out opens a new field of application for microbe mutants, viz. the oxidation of hydrocarbons. It has been found that through mutation, *Corynebacterium* sp. can give reasonably high yields of salicylic acid (3 mg./mg. cells in 5 hr) by the oxidation of naphthalene and there are possibilities of the method being adopted commercially.

N-Methyl-N′-nitro-N-nitrosoguanidine has been used for the mutation of the organism. This chemical produces multiple lesions in the genetic code at extremely low kill rates. Since it is not known which part or parts of the genetic code should be altered to obtain the required mutation, a mutagen which can affect multiple sites is required. To select the right mutant, moist ferric nitrate soaked filter papers were touched on colonies incubated over naphthalene for 1 hr, the characteristic purple colour of ferric salicylate indicating the formation of salicylic acid.

A commercial mutant should have high tolerance for salicylic acid and inability to consume salicylates, besides aiding high salicylic acid production. It may be possible to get such mutants by employing improved selection techniques [*Chem. Engng News*, **43** (39) (1965), 64].

Identification of bacteria by gas chromatography

Methods employed to identify bacteria, which include morphology, serology, fermentation, nutritional needs, pigmentation, staining reactions and production of certain organic compounds, are time consuming. A gas chromatographic technique which can characterize microorganisms more rapidly than is possible in the conventional methods, has been developed by Dr W. Garner and R. N. Gennaro of New Mexico University. They showed that gas chromatography of volatiles, obtained by vacuum-pyro-distilling whole micro-organisms, gave reproducible chromatograms and that widely differing bacteria yielded characteristically different chromatograms.

The microorganisms selected for the analysis belonging to the gram-negative intestinal group, Enterobacteriace, have been grown both in nutrient broth and buffered glucose-glutamic acid solution. Pyrolysis was carried out in a closed system. The chromatograph used was an F & M 609 flame ionization unit. Samples of pyrolyzate were injected into a 100 ft (0·01 in. i.d.) stainless steel column coated with polypropylene oxide. With the injection port at 335°C., column pressure was 30-60 p.s.i.g. Column temperature was controlled from 35° to 225°C. at 9° per minute. The chromatograms of the bacteria obtained showed distinct differences in the number of peaks and peak heights. The chromatograms displayed a high degree of reproducibility of peak retention time and peak height data. Within the range of species tested the chromatogram of each species gives enough data to constitute a unique finger print.

This technique can find use where rapid and continuous data are needed, such as in monitoring bacterial changes in fermentation tanks. This technique can resolve volatile compounds to a higher degree of separation using a smaller amount of sample than other chromatographic methods [*Chem. Engng News*, **43** (39) (1965), 69].

Manganese dioxide as a remedy for suffocation disease of rice

Suffocation disease of rice, characterized by a reddish-brown discolouration of older leaves, stunted growth, root rot and low yield, has been attributed to excessive reduction of soil. Of the retardants of reduction (potassium chlorate, potassium perchlorate, sodium nitrate, manganese dioxide and 4-chloro-3,5-xylenol) employed, manganese dioxide at a concentration of 0·4 per cent by weight of the dry soil retards soil reduction, corrects the physiological disorder and improves the growth of rice. The effect is not due to the micronutrient effect of manganese or to impurities of manganese dioxide because: (i) all soils had adequate concentration of water-soluble manganese, (ii) manganese (25 p.p.m.) as manganous chloride applied to soils produced no response, and (iii) manganese dioxide prepared in the laboratory from chemically pure potassium permanganate gave a better response than commercial manganese dioxide. High redox potential, lower concentrations of ferrous iron and organic reduction products in the soil

solution of manganese dioxide treated soil then in control suggest that the effects are associated with retardation of soil reduction. Release of carbon dioxide as the sparingly soluble manganous carbonate is an additional benefit.

As manganese dioxide (i) undergoes reversible oxidation-reduction when rice soils are alternately drained and flooded, (ii) is not likely to suffer appreciable losses in poorly drained soils, and (iii) is relatively inexpensive, its use as a remedy for physiological diseases caused by soil reduction and as an ammendment for acid lowland rice soils merits attention [*Nature, Lond.*, **207** (1965), 1103].

Lactation value — A new index for protein evaluation

The most commonly employed methods to evaluate the nutritive value of food proteins are the growth promoting and nitrogen balance methods. The parameter used in the former method is the gain in weight per gram of protein consumed and for the latter is the nitrogen balance established with a specific protein ration. A new standardized index, 'lactation value', has been described for the evaluation of food proteins. The method depends upon three simple measurements, viz. (1) change in weight in the lactating mother, (2) gain in body weight of litter during the first 14 days after the birth and (3) amount of protein consumed by the adult female during this period. The algebraic addition of the body weight changes in mother and litter expressed as per gram of protein consumed yields the lactation value of protein. The protein value evaluated by this technique in 10 varieties of food are very much comparable to protein values obtained by conventional methods.

The determination of lactation value index of food proteins is relatively rapid and can easily be performed in a nutrition laboratory, which maintains a good breeding colony. This standardized technique is of particular importance in providing specific information as to the value of protein food for the very important function of milk production and mother litter maintenance and the development during the preweaning period [*J. Nutr.*, **85** (1) (1965), 52].

Progress Reports

Regional Research Laboratory, Hyderabad

The annual report of the laboratory for the year 1964-65 presents an account of the main achievements of the various research departments and the developmental activities during the year.

It has been demonstrated that single cells derived from liver of adult animals can recognize their own kind both *in vitro* and *in vivo*. The material between the cells in the higher animals has been shown to contain ribonucleic acid, which has so far been considered to occur only inside the cell. This gives a strong support to frame the hypothesis that in tissue of higher animals the presence of intercellular cement (which contains RNA) and cell contact are factors important in determining the permeability of the cell membrane. A new method, based on difference in the precipitability of the two types of RNA with zinc ions has been developed, by which small molecular weight RNA can be separated from large molecular weight RNA in one step. Specific and simple methods based on thin-layer chromatography have been developed for rapid detection of adulteration of vegetable oils. Another thin-layer chromatographic method has been worked out for the separation and quantitative estimation of alpha, beta, gamma and delta tocopherols.

Many new organic compounds belonging to the groups benzylamines, β-phenylethylamines, 1,2-diphenylethylamines, benzhydrylamines, etc., have been synthesized through different routes and these are being screened for their pharmacological activity.

Two methods for the synthesis of 1,5-benzoxazepine systems with substituents in the benzene ring and also in hetero ring have been developed. Conditions for the production of benzoyl chloride from benzotrichloride have been worked out to yield 85 per cent of the purified benzoyl chloride. This improvement eliminates the two-stage operation, i.e. first solation of benzoic acid and then reacting it with benzotrichloride.

A new method for continuous chlorination of toluene to produce benzyl chloride free from nuclear chlorinated or higher chlorinated products has been developed. A screw pressing process for the production of cotton seed flour, conforming to the international specification for a protein-rich material, has been developed.

A number of processes developed in the laboratory have been released for commerical exploitation. These include processes for the manufacture of (1) anhydrous calcium sulphate, (2) bleaching earths from Korvi fullers' earth, (3) phenylacetic acid and phenylacetamide, (4) *m*-aminophenol, (5) Lounginin (a flavouring agent), and (6) Citicide (a potent insecticide). The following processes are ready for exploitation: (1) preparation of industrial lecithins from the sludges of solvent extracted groundnut oils to yield light coloured products in both plastic and powder form, (2) production of high protein cotton seed flour, (3) recovery of fatty acids from cotton seed soap stock, and (4) manufacture of benzyl esters, benzaldehyde, benzoic acid and benzoyl chloride.

Beside the Hykol 'X' prototype plant to produce activated carbons based on coal, other units designed and fabricated by this laboratory are: an extrusion press for preparing test pieces of microwave ferrite rods; high pressure oil injector for tar hydrogenation plant; die for making test pieces of silicon nitride; dies for pressing microwave ferrite test pieces of different shapes; groundnut slicing unit, stainless steel reactor for air activation of active carbons; and a phase-separator of 300-litre capacity for the tar acids extraction plant.

New Periodicals

Palynological Bulletin

This annual publication is intended to serve as one of the official organs of the recently formed Palynological Society of India. Some of the articles published in the first number issued

during August 1965 are: Palynological Society of India; Prof. Birbal Sahni's contribution to palynology; Geological sporology and palynology — Past and present; Role of tapetum in pollen development; Taxonomy of fossil (Palaezoic) sporae dispersae; Normal and abnormal pollen grains in *Abies pindrow* (Royle) Spach.; Studies on pollen storage of lemon and loquat; Pollen grains of *Rauvolfia*; Pollen for physiological studies; Palynological studies in subtropical fruit trees: Mango (*Mangifera indica* L.), grapes (*Vitis* spp.) and phalsa (*Grewia asiatica* L.); Pollen grains of *Artocarpus* Forst.; Pollen morphological studies of *Eriocaulon* Linn. from India; On classification of pollen grains and spores; Palynological studies in Indian Azioaceae (Ficoideae, Molluginaceae); Pollen morphology of Himalayan daphnes; A new record of *Pediastrum delicatites* from W. India; Pollen morphotypes in the family Compositae from parts of Western Ghats (India); and Male gametophyte and pollen structure in *Furcraea gigantea* Vent. It also carries section on Reports, Notes and News, and Book Comments. The bulletin is priced at Rs 7 per copy (Rs 10.00 foreign). Further details can be had from the General Secretary-Treasurer, Palynological Society of India, National Botanic Gardens, Lucknow.

Metrologia

This new quarterly journal has been started by the International Committee of Weights and Measures. The journal publishes the results of original researches directed towards the improvement of fundamental measurements in any field of physics. It also carries review articles on various fields of measurement, reports of the activities, decisions and recommendations of the International Conference of Weights and Measures, the International Committee of Weights and Measures and its advisory committees and of the International Bureau of Weights and Measures at Sèvres.

The annual subscription for the journal is $ 8.50. Orders may be placed with Springer-Verlag, New York Inc., 175 Fifth Avenue, New York, NY 10010. Communications regarding publication of papers should be addressed to the Editor, *Metrologia*, Division of Applied Physics, National Research Council, Ottawa 2, Ontario, Canada.

Experimental Brain Research

This new periodical, published by Springer-Verlag, Berlin, started appearing towards the end of 1965. The journal is intended to cover the entire field of experimental brain research, as represented by the International Brain Research Organization, extending over neurophysiology, neuroanatomy, neurochemistry, neuropharmacology, neuroendocrinology, cybernetics, neurocommunication and higher nervous functions, including behavioural and conditioning studies. One or two volumes of the journal (each volume comprising 4 numbers) are expected to be issued annually. The subscription for the journal is DM 72 or $ 18.00 per volume.

FORTHCOMING INTERNATIONAL SCIENTIFIC CONFERENCES

Date	*Conference*	*Place*
5-14 June	International Fluid Power Exhibition and Conference	Lecture
6-18 June	Sixth World Forestry Congress	Madrid
8-18 June	Twenty-first International Conference on Large Electric Systems	Paris
12-18 June	Tenth International Ceramic Congress	Stockholm
14-16 June	Third International Materials Symposium	Berkeley (Calif.)
15-17 June	Second International Communications Conference	Philadelphia
17-26 June	International Building Congress	Essen (Germany, FR)
20-23 June	International Symposium on Induced Mutations and Their Utilization	Gatersleben (Germany, DR)
20-24 June	International Clay Conference	Jerusalem
20-24 June	International Conference on Crystal Growth	Boston
Summer 1966	Tenth International Conference on Low Temperature Physics	Tiflis or Zürich
Summer 1966	Second International Symposium on Magnetohydrodynamic Electrical Power Generation	Salzburg
26 June to 2 July	Seventh International Congress of Gerontology	Vienna
26 June to 2 July	Third International Congress of Radiation Research	Cortina d'Ampezzo (Italy)
26 June to 2 July	Fourth International Symposium on the Chemistry of Natural Products	Stockholm
27-30 June	Sixth International Food Congress	Copenhagen
June	Thirteenth International Symposium on Microscopy	Chicago
4-8 July	Seventeenth International Dairy Congress	Munich
4-8 July	Fifth International Symposium on Rarefied Gas Dynamics	Oxford
11-16 July	International Symposium on Reaction Mechanisms of Inorganic Solids	Aberdeen (UK)
11-16 July	International Symposium on Statistical Mechanics and Thermodynamics	Copenhagen
12-19 July	General Assembly and Seventh International Congress of the International Union of Crystallography	Moscow
19-22 July	International Symposium on the Alkali Metals	Nottingham
24-30 July	Ninth International Congress of Microbiology	Moscow
24-30 July	Third International Pharmacological Congress	Sao Paulo
26-30 July	Sixth International Congress on Clinical Chemistry	Munich
July 1966	International Colloquium on Intense Magnetic Fields, Their Production and Their Applications	Grenoble
July 1966	International Colloquium on New Spectroscopic Methods	Bellevue (France)
July 1966	International Congress of Microbiological Standardization	Moscow

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