THE ECONOMIC PROSPECTS OF CHEMICAL INDUSTRIES IN INDIA

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BY

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PREFACE

MY main object in writing this book has been to meet a longfelt demand by universities, chemical engineers, technicians, industrialists and businessmen for a clear, concise, yet comprehensive survey of Indian industries in general and Chemical industries in particular, giving adequate and authoritative up-to-date statistics.

An attempt has been made to describe in detail, the scope for the expansion of chemical industries and for the indigenous manufacture of chemicals, which are, at present being imported from abroad. I have laid special emphasis on the economic aspect, as expansion of the chemical industry is, ultimately, related to the expansion of all other industries.

Details are given of the imports and exports, as also of production figures of a large number of mineral and agricultural products, heavy and fine chemicals and for most of the industries existing in India. The effects of the partition of the country on 15th August, 1947, have been analysed and illustrated with relevant figures showing industrial and economic re-allocation thereafter.

I trust that Industrialists, students and economists in India, anxious to extend their interest in Indian industries, particularly the chemical side of it, will find this book quite useful, inasmuch as it provides a detailed picture, not only of the present state of Indian industries, but also of their future prospects in relation to availability of raw materials and other resources of the country.

A. K. MADAN.

1st November, 1949.

Dedicated to

The Memory of My Dear Father

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CHAPTER I

INTRODUCTION

THE main object of this publication is to throw light on some of the industrial developments in the chemical field in India, during the last ten years. Special reference has been made to the country's resources in respect of her mineral, and agricultural wealth, including availability of power, fuel and energy. Truthfully speaking, this is a shabby approach to jot down some of the facts in a brief manner. It will have to be admitted that for a vast country like India, with her unlimited material resources including manpower, this book has not many details.

Much is spoken about India and her civilisation in the past but the pages of history have failed to give the correct position about India in the primitive ages and before. The references about the period 5000 B.C. are, no doubt, available and some facts are narrated from the books of *Ramayana* and *Mahabharatha* but all such achievements appear to be buried.

India had a name among first rate nations of the world in the past. The art and civilisation of those days is exhibited from the archæological excavations from the various historical towns and such findings clearly speak of advancement in scientific work made by the Indians.

The standard of Indian alchemy was well recognised by other countries of the world and it is, however, established that the knowledge of chemistry and chemical processes was fully understood by the Indian alchemists. The use of herbs and roots for curing diseases was already known with correct significance. Most of the products are today termed as biological preparations like drugs, serums, syrups and tinctures, etc. and are obtained from the botanical and other natural sources.

The ancient archæological excavations speak of the standard of industrial advancement made by the people at that time. The metal castings and huge metallic pillars show that the science of metallurgy was well known to the people in the past and they had fair idea about the iron and steel industry and other important alloys. Some of the primitive samples and specimens of olden ages show the finest workmanship of the type of writings and idol engravings on some of the stupas, pillars, etc. Such specimens of iron and steel and other alloys have been found to be rust-proof and resistant to atmospheric corrosion, having very high compression and tensile strength which is, sometimes, much more than the most modern high quality structural pillars manufactured by modern methods. The art of pottery making, spinning, and weaving cotton and woollen fabrics were known. The use of wines and beers and other processes of fermentation were also in the knowledge.

The extinction of bright historical civilisation was due to certain destructive events and happenings during the dark period. Most of the facts from history are missing and it is but to be admitted that our history is incomplete. It needs sufficient efforts to investigate and do research work to trace facts about Indian culture.

Apart from the fact that the geographical position of India, with its originally combined dominions like Burma, Ceylon and Pakistan, India's boundary line was believed to be remarkably grand. India of today which has been under foreign domination for a considerable period is much different from the original country.

The industrial developments in India, as we call them, have really matured in the Twentieth Century whereas other nations of the world had been directing their attention towards the industrial and scientific aspects for the last 200 years. The introduction of modern means of communications and transport and developments in the electrification and irrigation projects have been encouraged by the English who happened to rule India for nearly more than 150 years. The textile and sugar industries were started just after the World War I but, prior to that, all the requirements of the country were obtained from abroad.

It has, lately, been realised that India has vast resources of raw materials, both mineral and agricultural. Most of these raw materials had been exported in large quantity and, in return, finished goods were brought back. The political movements in the country had sufficiently awakened the people of India and had made them conscious of the motive of foreign rulers. The industrial supremacy of the foreign nations was also realised only during war days.

Strictly speaking, the intermediate period during the two world wars, was a period of agitation for Indians to secure freedom from the foreign rule and the World War II accelerated the achievements. It goes without saying that these wars have been really the chemical warfares and the advancement in chemical field has been marvellous in all the countries. The Atomic Bomb, being the latest and deadliest weapon, so far produced, has further altered the standard of wars and warfare materials. The advancement towards political freedom has been fructified and it is on the 15th August, 1947, that two Dominions known as Pakistan and Indian Union came into existence as a result of relaxation of the British rule in India.

The Dominion of India comprises the provinces of East Punjab, United Provinces, Bihar, West Bengal, Central Provinces, Bombay, Madras, Assam and Orissa, and Chief Commissioners' provinces like Delhi, Ajmer Merwara, Coorg, and the Andaman Islands and more than 500 States including Hyderabad which have acceded to the Indian Union, and as a result of reorganisation of States Unions, several new provincial territories are created, *i.e.*, Rajasthan, Saurashtra, Madhya Bharat, Vindhya Pradesh, Himachal Pradesh, etc.

The Pakistan Dominion, however, comprises the provinces of Sind, North-Western Frontier Province, West Punjab, East Bengal including district of Sylhet of Assam, and Baluchistan. Some of the important States which acceded to Pakistan are Bahawalpur, Khairpur, Kalat, Chitral, Dir and Swat.

The Government of India is today in the hands of peoples' representatives and the destiny of India's political, economic and industrial existence rests with them. It has been fully realised that maximum efforts have to be made to step up industrial production, thereby avoiding the economic crisis. The country has been in crisis and still the critical hours are hanging on. We have to fight starvation and economic depression which our countrymen are facing. The present difficulties of food shortage must be overcome and we must rebuild our economic structure.

The establishment of Scientific and Industrial Research Board during the war has really been a remarkable step which was taken by the Government of India in the year 1940. Besides the research and industrial developments, it has also served the purpose of promoting industrial and technical knowledge in the country.

The scope of this book is more or less limited. It briefly illustrates the various minerals available in the country stating their industrial uses. Rough estimates of cost and production figures of minerals are given, indicating the utility of these products in India and their scope for export. The agricultural products, *i.e.*, food grain cereals and industrial crops like cotton, jute, sugar-cane, tea, tobacco, coffee and oil seeds, are mentioned with reference to the shortage of foodgrains in the past period. The aspects of fuel, power and energy have also been dealt with. In the case of heavy chemicals, statistics of the local production and domestic consumption are given and are supplemented by annual import figures of such products. The manufacturing processes have also been touched, indicating the scope of utilisation of by-products. Further chapters deal with the subject of certain chemicals for the particular industries like that of electroplating chemicals, photographic chemicals, fine chemicals, solvents, coal tar distillation products, dye-stuffs, mordant and textile auxiliaries and explosive chemicals. A list of chemicals used in the various industries, like textiles, sugar, glass, match, ceramics, cements, potteries, plastic, soap, paper, metallurgy, rubber, leather tanning, toilet and cosmetics, writing and printing inks, disinfectants and insecticides and breweries and distilleries, etc., are given in the appendix.

In the end, references have been made about the materials of construction and the labour welfare in the chemicals industries. Statistics of imports, exports and production of various chemicals and chemical products are also given in the appendix.

CHAPTER II

GENERAL INDUSTRIAL SURVEY

A CRITICAL review of India's present industrial position indicates some doubtful and unbalanced state of affairs. The expanded and newly started industries were the outcome of war, partly to meet the war requirements and partly, due to the shortage caused by dwindled imports. A large number of companies were floated with limited liabilities and private enterprises also came into existence.

None so far disagrees that India has her large agricultural and mineral resources in addition to manpower. The population of India is growing rapidly and for want of forward policy to develop her resources, the country is placed in imminent peril. Both agriculture and manufacturing industries are necessary for the welfare of the country but they should be proportionate and balanced in a manner which may really be beneficial.

Post-War reconstruction committees have been appointed by the Government of India which are working enthusiastically. Their main function has been to look for the possibilities of keeping the expanded and newly started industries in existence and save them from facing ruination and, thereby, save the country from the ill-effects of the post-war depression. There had been a good many tell-tales, about the stabilisation of the existence of manufacturing units during the future period. A large number of mushroom like concerns came into existence with temporary money-making plans, but some of them have already met their end with the improved conditions of imports and cut-throat competitions.

The question arises about the industrial potentialities of the country. Presently, the industry in India is in such a disorganised state of individuality that it is difficult to speak of the potentialities of the country. The first and the foremost task of the planners is to develop the various resources of the country by giving due importance to both mineral as well as agricultural products. India is sufficiently rich in these products and one can claim to plan soundly the post-war India into an Industrial India. There is no dearth of minerals in India and there is ample scope for developing various industries from them. Most of the resources of States have still remained unexplored. In fact, there is need of a team of geologists to expose the hidden treasures of the earth for the industrial purposes.

The various industries that can be developed in the country are, for example, the manufacture of mineral acids; fertilisers; heavy chemicals, B. P. and fine chemicals; drugs; paints and varnishes; electroplating chemicals; photographic chemicals; dyes and colours; synthetic resins; oils, fats and wax; various qualities of cement; etc. The success of the above industries can only depend upon sound planning. The present day industries of automobiles, aeronautics, ship-building, heavy machinery and engineering need not be ignored when sound planning is in view.

India had no chemical industry in the pre-war days. The shortage of chemicals on account of reduced imports was being felt in the early years of the war. At the top of it, the demand for chemicals for defence purposes was very heavy. The existing manufacturers of chemicals, subsequently, extended their field in expanding their lines and started new projects. There were a few plants for the manufacture of acids. The manufacture of other chemicals and fertilisers was also being carried out on a very small scale before the war. The production of explosives has been one of the biggest war requirements. The production of chemicals needed for the manufacture of explosives was, however, taken up on a large scale, *i.e.*, nitric acid, toluene, glycerine, saltpetre and other chemicals. The manufacture of dichromates of sodium and potassium was also taken up as a result of demand for their use in textile industry and in chrome tanning processes. Scope for the manufacture of fertilisers has all along been considered to increase the agricultural output. The campaign for "GROW MORE FOOD" has also been vigorously followed.

Many small scale producers came into field, in order to supplement the existing production for the execution of Government orders and to meet other demands. The production of analytical reagents and B. P. chemicals had also been taken up by various concerns to satisfy the demand caused by dwindled imports. The manufacture of pharmaceutical chemicals was also started with a keen interest. The various technical aspects as to the capability on the part of the manufacturers to produce the goods of necessary specifications are quite important. Some of the products of a few manufacturing concerns, already existing in the country, have sufficiently been patronised and there is still ample scope for the expansion of this industry.

The manufacture of certain basic chemicals was rapidly taken up by a few producers immediately after the war had started. The coal tar distillation was also encouraged by the Government at centres like Calcutta in the absence of imported stocks of such products. A bright future could be anticipated in these lines. The vegetable ghee industry also developed a good deal during war. Industries like soaps, paper, silk and art silk fabric manufacture brought a prospective turnover. The producers of non-ferrous metals had a boom period. Other small scale and cottage industries developed with a doubtful future. The manufacture of other special compositions like waterproofing cements, rust preventive compositions, soft soaps, bronzing compositions, anti-gas creams, anti-gas varnishes, anti-gas fabrics were taken up entirely for defence purposes.

Various industries like sugar, cement and textile were the outcome of the last great war and these industries were established in India in such a fashion that no post-war period could bring them down either by a way of production or through competition. Their stage of production at one time had touched the level of saturation which made the manufacturers to think of export facilities. The cement industry, however, got a big advancement in the year 1938 when about half a dozen new plants were set up by an industrialist at various centres in India. Just before the war, the sugar industry was not working with fair results on account of over-production, but now the conditions in the industry are very much different. The leather industry had also expanded during war period but there had been shortage of goods for the general civil requirements on account of commitments for war supplies. The trend of market prices was upward and had, thereby, given impetus to the development of indigenous production. The production of non-ferrous metals, high grade steel, and surgical appliances was also taken up vigorously during that period. The paper industry was in its stage of infancy, just after the last war. During the intermittent period of peace between the two wars, a few paper manufacturing plants were started in India. The production of various qualities of writing and printing paper was taken up by them, but the newsprint manufacture has all along been considered to be a big problem. Some experiments have been tried at the Dehra Dun Forest Research Institute for producing a good composition of newsprint and they have been fairly successful at certain stages. The special quality of wood needed for the production of wood-pulp is, however, not available in appreciable quantities which can encourage the production of newsprints in India. The production of several qualities of paper board, including duplex and triplex, has also been attempted at certain centres. It may take considerable time to fully develop these lines.

It is believed that the production capacity of a particular unit is one of the major factors which determine the cost of production of a particular article; the bigger the production unit, the lower the cost of production. There is no doubt that the introduction of machines has been very helpful in mass production of certain articles and hand abour in most of the industries has proved to be very uneconomic. This rapid replacement of hand labour by machines has sufficiently cut down the cost of production.

The mission of temporarily making money has so far been the chief aim of certain manufacturers. Those who were successful in getting themselves established during war period had hardly tried to think of means of cutting down their cost of production. There is no doubt that the cost of raw materials has particularly gone very high and the labour charges have also been increased due to high cost of living, while certain other factors are equally dominating the production economy of the article. Several industries are dependent on each other in one way or the other, as the control over the production of one is bound to affect the other dependent industry. There can be fair chances of stabilisation if the industries create their own subsidiary units. In the case of sugar industry, it may be desirable on the part of the manufacturers to develop their own sugar-cane farms which would yield superior qualities of cane, with high percentage of sucrose and ultimately offering a better yield of sugar. The textile industry would prefer to have high grade cotton for the production of good qualities of yarn and fabrics. The developments of cotton fields should be the responsibility of textile millowners. It is absolutely essential to have better resources of raw materials for the economic production of finished articles, but the economy of production is primarily based on the integration and economy of subsidiary processes.

The fertility of Indian soil is an unquestioned element and it offers fine chances for developing suitable agricultural production centres. Scientific production can offer scope for more efficient and healthy results. The industrial and commercial future of the country depends upon its resources. It is widely known that India is sufficiently rich in agricultural and mineral wealth. There should be a thorough planning to utilise these resources properly and chances should be created for the non-stop supply of raw materials. The control of industry may be handled efficiently by dividing the country into various industrial zones. Strictly speaking, these zones may not be water-tight compartments but they may offer suitable facilities either for production or for marketing or for both. These zones should be comparable to the various centres as textile industry in Bombay Presidency, sugar industry in United Provinces and Bihar and the jute industry in Bengal.

A technical mission from the United Kingdom surveyed the country, during the year 1944, to determine the possibilities of fertiliser industry in India and for locating suitable manufacturing centres. The latest concurred plans for the manufacture of synthetic ammonia and, subsequently, ammonium sulphate will bring forth a prosperous future for India, if they are successfully put into practice.

The extensive and growing mineral industry in India is responsible for providing basic raw materials for good many industries and, thereby, form their foundations. Developments in the process of mining have rather been slow, so far. A large number of minerals ranging from precious varieties to the mineral of cheap siliceous nature are found. The minerals of Indian origin like mica, ilmenite, monazite and manganese ore have proved beneficial to various industries of international importance. Exports of these minerals are being made on a very large scale. Thoria and ceria are extracted from Indian monazite by the foreign manufacturers whereas the same task of extraction could be carried out in India and the refined chemicals could be exported later. Mica possesses high insulating properties and its importance is very much recognised in the electrical industry which is greatly expanding. With further developments in the science of electronics, the utility of mica would increase. Manganese ore is finding use in the steel industry for the production of ferromanganese alloys and other manganese steels. Manganese is also used in batteries and electroplating jobs. Thousands of tons of these minerals are annually exported out of India.

Vast resources of iron ore are increasingly consumed by the local iron and steel industry. Iron ore is found plentiful in India and, if required, it can also find export market. India may one day lead other countries in the production of aluminium metal, as bauxite, the aluminium ore, is found in large quantities. Its by-products like titanium oxide and vanadium oxide can also be extracted in considerable quantities. The vast deposits of gypsum of West Punjab (Pakistan) could act as the most important source for sulphur and sulphuric acid, but the area is excluded from Indian territory by the partition of the country. Gypsum is used in the manufacture of cement and plaster of paris and is also used as filler.

The cement industry made marked progress just before the World War II as the production was enhanced with the start of more factories, ultimately, resulting in the fall in prices. Little achievements have so far been made in the production of coloured and white cements. The plentiful supplies of limestone also offer extensive chances for the production of lime. The use of lime can be encouraged for chemical purposes for the production of bleaching powder, calcium carbide and cyanamide. The resources for the production of indigenous talc are seriously being developed on account of its demand as refractory materials and for the building of acid resisting tanks. The finely pulverised talc powder is finding an important use in the cosmetic industry. Talc powders are also finding good use as fillers and as polishing agents and are being exported in thousands of tons every year. Excellent qualities of South Indian magnesite can, however, offer suitable source for the production of metal magnesium. High class refractories are produced out of magnesite. It can also be used as a flux in the metallurgical operations. The expansion in the paint industry has definitely given an impetus to the development of mineral pigments. The improvement in the quality of these pigments would make the paint industry an asset for the country. The coal industry has not received proper attention so far. There is a great scope for the better utilisation of coal and innumerable products, vital to the developments of other industries, can be produced from this.

CHAPTER III

RESOURCES OF INDIA

INDIA is sufficiently rich in minerals and ores. A large variety of minerals is found from various mine centres spread all over India. Innumerable agricultural products are obtained from different parts of the country and such agricultural products mainly depend on the variations in the climatic conditions of different geographical and physical zones and regions, created by the natural boundaries.

Details of various products are given in sub-sections of this chapter, *i.e.* (*a*) minerals and ores, (*b*) agricultural products, (*c*) fuel, power and energy.

A. MINERALS AND ORES :

There is a wide scope for exploring the mineral resources of the country, as much of the useful information is available from the geological reports issued by the Government of India. Matters have been keenly pursued and vigorously investigated, with a view to promote and materialise natural assets.

It is observed that unlimited vast mineral deposits of all types are located at different centres, and it is further anticipated, that there are ample chances of finding lot of latent mineral wealth.

Minerals can be grouped under the following major heads and are classified according to their availability, firstly, minerals which are plentifully available and can find export market, *i.e.*, iron ore, mica, maganese ore, bauxite, etc.; secondly, minerals which may be just sufficient for the requirements of the country, *i.e.*, limestone, marble, slate, sodium salts, aluminium ore, felspar, barytes, etc.; thirdly, mineral products which are scarce and are imported, *i.e.*, petroleum, sulphur, lead, zinc, tin, molybdenum, platinum, nickel, mercury, silver, etc. A brief survey of some of the important minerals and ores is given below.

ABRASIVES : Abrasives are very important group of industrial products which have their mineral origin in natural form and are also manufactured artificially. Abrasives serve a wide range of industries and are mainly agents for the purpose of cutting, drilling and polishing external surfaces of materials made of metal, wood, leather and other miscellaneous surfaces like that of rubber and plastics.

Abrasives play an important role in various industries. Some of these are metalware and electroplating industries which include automobile industry, surgical instruments, hospital equipments, presentation articles and novelties, where surfaces are polished with the help of specially prepared polishing compositions. Building stone and tiles production involves the use of abrasives for preparing suitable smooth surfaces. Diamond drills which are essentially high class abrasives are very useful for the petroleum industry. In glass industry, the job of cutting, grinding, polishing is done with the help of abrasives. A large number of commercial polishing and grinding agents like grinding wheels, mops, polishing compositions, polishing soap, polishing liquids, polishing powders and sand-papers and sand cloth, emery-paper and emery cloth, basically function on the principle of abrasive action. Abrasives can be classified under different categories. The valuable natural high grade varieties are diamond, corundum (including emery and impure corundum) and garnet. Other grades of siliceous abrasives are grinding stone, mill-stone, grinding pebbles, silica and rubbing and polishing powders. These also include a wide variety of rocks and minerals.

Diamonds are the hardest variety of abrasives. Apart from their use for the production of diamond drills which find important application in the petroleum industry, cutting tools and wire drawing dies are also produced from diamonds. Diamond dust is used for polishing and grinding work. Corundum powder is used in loose form and is also bonded into grinding wheels. Emery and garnet powders are also made into coated paper and cloth, for rubbing metal, leather and hardwood surfaces.

NATURAL HIGH GRADE

	Abrasives	*Occurrences*
1.	Diamonds	Kurnool district in South India. Vindhyan rocks of Central India.
2.	Corundum	Assam : Khasi and Jainti Hills. Bihar : Hazaribagh, Singhbhum and Manbhum districts. Madras : Sittampundi in Salem district. C. P. : Pohra and Bhandara district. Several places in Orissa, Mysore State and Rewah States.
3.	Garnet	Bihar : Hazaribagh district, Singhbhum district. Orissa : Mahanadi river at Cuttack. Madras : Nellore, Kistna and Bezwada. Several places in Hyderabad State, Mysore State and Rajputana.
4.	Emery	No definite deposits. Crude corundum is preferably classified as emery.

NATURAL SILICEOUS ABRASIVES

	Abrasives	*Occurrences*
1.	Flint	Several places in Bihar, Orissa, C. P., Bombay, Madras and U. P.
2.	Quartz	Bihar : Singhbhum and Hazaribagh. Madras : Nellore. Ajmer-Merwara, Kishengarh in Rajputana.
3.	Sandstones	Bihar : Patarghatta, Bhagalpur district. Rajputana : Jaipur and Sawai Madhopur. East Punjab : Jaijon, Hoshiarpur district. U. P. : Dehra Dun district, Loghra and Borgarh near Naini, Allahabad; and in certain places in Kashmir and Baroda States.
4.	Talc	Rajputana : Jaipur, Jodhpur. C. P. : Jubbulpore.

The other cheap and common varieties of abrasives like felspar, limestone, pumice, pebbles, tripoli, rottenstone, granite are obtainable in plenty and are crushed, ground and screened before use and can be graded according to hardness.

Amongst the artificial varieties of abrasives, silicon carbide (carborundum), boron carbide and fused alumina (alundum) are of great importance as their hardness is very high. The manufacture of artificial abrasives has not been taken up so far in India although raw materials and cheap electric energy can be made available quite easily.

India is a typical market for abrasives. The figures of production and consumption are quite vague as they are dependent on irregular prospecting mining and trading in the line.

India definitely stands a very fine chance of developing her resources in the line as the specific minerals for the purpose are found plentiful.

ANTIMONY : Antimony chiefly exists as sulphide known as Stibnite. There is not much utility of the antimony metal but, in the form of alloys, it has numerous uses. Alloyed with copper and tin, it is used as type metal. Antimonial lead finds use in the sharpened bullets and is, similarly, used in the form of battery plates, toys and cables. Antimony compounds find vast application in the rubber industry for the purpose of vulcanisation and also used in the match manufacture. Antimony salts are, however, used as mordants in textile industry and the antimony oxide is used in the enamel works.

Stibnite occurs in small deposits at the Shigree Glacier in Lahul in Kangra district of East Punjab and also at Shagor in Chitral plateau, the latter is apparently cut off due to the partition of the country. There is not much prospecting done of the Lahul deposits but it is estimated that the reserves of the ore are fairly big. Messrs. Star Refinery Works of Bombay have tackled the refining of antimony metal on a commercial scale with their source of raw materials from

Chitral but such existing trade channels have been blocked after the partition. This refinery is in a position to turn out nearly 300 to 400 tons of metal per year and, as such, can satisfy the country's demand in due course. It is, however, earnestly desired that Government must give proper assistance to the existing refinery by way of securing their raw material either from old sources or expedite exploitation of their own resources.

There has been a considerable development in the production of sulphides of antimony and different shades, ranging from golden to crimson, have been manufactured. Such sulphides are very much recommended for the rubber industry, as colouring pigments and as vulcanising agents. The production of antimony sulphide and oxide of antimony must be taken up in hand as soon as possible.

ARSENIC : Arsenic in the form of element has little use but is fairly required for the production of alloys of copper and lead. It also finds minor uses as sulphide but, as oxide, it is fairly in big demand and is largely used for glass industry and, to some extent, for enamel works. The oxide of arsenic is extremely poisonous and is also used as insecticide and as rat poison.

Arsenic ore has recently been located at Sampthar in the Kalimpong area in Darjeeling district where arsenic contents have been assayed above 25 per cent. The Chitral deposits of sulphides are supposed to yield appreciable quantities of ore at nearly six different localities, but this source is presently inaccessible till the time steps are taken to revive old channels of trade.

The imports of oxide of arsenic have been nearly 200 to 250 tons per year before the war. There has been considerable increase in the prices of this chemical during the war period and even today the prices are more than 1½ times the pre-war level, although during war days black market prices went up from 10 to 20 times.

The imports of oxide of arsenic during the past few years are as under :—

IMPORTS OF ARSENIC AND ITS OXIDE

Year		Quantity (Tons)	Rupees (Thousands)
1937-38	...	266.50	117
1938-39	...	281.15	118
1939-40	...	243.25	107
1940-41	...	275.50	128
1941-42	...	298.80	117
1942-43	...	0.50	1
1943-44	...	19.50	4
1944-45	...	26.75	14
1945-46	...	101.70	53
1946-47	...	352.50	44
1947-48	...	820.00	795
1948-49	...	116.95	143

The above figures clearly indicate the extent of demand and it may, therefore, be desired to take up steps to develop the existing resources of the country.

ASBESTOS: Asbestos is found in natural forms, as hydrated magnesium silicate known as Chrysotile and calcium magnesium silicate known as Tremolite. Asbestos mining is done in small quantities in Cuddappah district, Madras, Saraikela, Mysore, Rajputana and Singhbhum district of Bihar. Its uses are mainly based on its high heat insulating properties. The heat resisting compounds like, asbestos magnesia 85 per cent and asbestos hard setting composition, are very much in use for boiler and steam pipe lagging. Long staple fibres mixed with portland cement are largely used for manufacturing corrugated sheets and shingles. Advancement in this line has considerably helped in the house building industry. It has uses in other forms as asbestos textiles, yarn cordage and cloth, in paper and compressed sheets. Other uses of asbestos are in the manufacture of paints, and fire-proofing cement and for filtering fruit juices and acid and is also used as jointing material.

The gradation and evaluation of the qualities of asbestos are based on the fibre length. Indian quality is, however, reported to be of short fibre length and is therefore poorly priced. World's best producing centre is Canada. The varieties are quoted from 20 to 22 cents per lb. depending upon the quality whereas the Indian stuff is sold in local markets from Rs. 70 to Rs. 300 per ton depending on qualities. Total Indian imports of manufactured asbestos goods are estimated to the tune of nearly three million rupees per year. World's other sources are located as U.S.S.R., South Rhodesia, South Africa, Cyprus, U.S.A., Italy, Finland and Czechoslovakia. The world's annual production is about five to six lakhs tons whereas it is difficult to speak of India's production because the prospecting and mining is very poor in India.

BARYTES AND BARIUM MINERALS: Barytes are also known as heavy spars and the chemical composition is barium sulphate. The shades and colours of this mineral vary from deposit to deposit ranging from off colour grey shades to snow white. Barytes are available in India in the Cuddappah, Salem and Kurnool districts of Madras, Ajmer and Rajputana, near Jubbulpore in Central Provinces and Bihar. New deposits are located near Simla in East Punjab and in Alwar and Rewa States. Amongst other main world producers have been Germany and U.S.A., U.K., France, U.S.S.R. The total world annual consumption is estimated nearly a million tons.

The main uses of barytes are in the paint industry. Barytes form nearly 70 per cent of the chemical contents of lithophone which is an item of vital importance in paint and rubber industries. Off colour barytes of fine mesh are largely used by the petroleum companies in the oil fields for weighting mud fluid in rotary drilling. During pre-war days, Italy and Belgium were supplying such requirements but, during war days, Indian production filled this gap. Annually 20,000 to 25,000 tons of barytes were being exported while, on the other hand, the local requirements of the paint industry have been estimated to be more than 20,000 tons every year.

As regards other uses, barytes are used as fillers in the manufacture of rubber tyre and the rubber goods, papers, cloth and linoleum. Barytes are also used in certain types of glass, enamel and glazes. In the chemical industry, barytes are used as a source for the manufacture of the barium salts like sulphide, carbonate, chloride, nitrate.

Further, it may be mentioned that barium is used for ignition equipment in automobile industry where it is used as nickel alloy. Barium nickel alloys give high class thermionic emission and clear last traces of gases from vacuum tubes, showing wonderful results in the radio industry.

Snow white barytes powder of fine mesh are fetching fairly good prices whereas off colour powders are very cheaply available. The mining operations are not tedious and, as such, the mineral is easily available at a nominal cost at the mine pit. The task of grinding to a very fine mesh is really specialised. Usually 300 mesh powders are greatly demanded. The ultimate price of fine powders is dependant on the additional cost of transportation, grinding, packing, etc.

Attempts should be made to produce the various barium salts like carbonate, chloride, sulphide, nitrate, etc. in India which are presently imported from abroad.

BAUXITE : Bauxite, the aluminium ore, has received world-wide importance because the aluminium metal and alloys which are produced from the ore, have rendered high class service during war days. The best use of bauxite is in the extraction of aluminium metal by the electrothermie process. The ore is also used as a filtering material in petroleum refineries. In chemical industry, it is used for the manufacture of alums and other allied compounds required in the dyeing, tanning, printing and other industries. Bauxite is also used in the manufacture of refractories as linings of furnaces, since high alumina content bricks stand very high temperatures. Alundum, the artificial abrasive is, produced out of bauxite.

Bauxite is being raised at Katni in the Jubbulpore district of Central Provinces and Belgaum, Thana and Kaira districts of Bombay and also Ranchi and Singhbhum districts of Bihar. Other deposits are widely available at Bilaspur and Mandla districts and Sirguja and Jashpur State of Central Provinces ; Kolhapur State, Bombay and Jammu and Kashmir State. Huge deposits of laterite which contains bauxite, ferric hydroxide, silica, etc. are located in Deccan.

The present production and consumption figures of bauxite are approximately two to three times the pre-war figures. The maximum pre-war figure of consumption of bauxite in India amounted from 8,000 to 10,000 tons per year. The rates of bauxite at the mine pit ranged from Rs. 2 to Rs. 8 per ton in pre-war days, whereas, with the increased mining cost, it is priced at the mine pit at Rs. 15 to Rs. 20 per ton, these days.

World's other sources of bauxite are France, Hungary, U.S.A., Italy, Yugoslavia, British Guinea, Dutch Guinea, and U.S.S.R. It has also been mined in Germany, Greece, Roumania, Australia, Gold Coast and other parts of Africa.

It may not be out of place to mention that with the developments in aircraft and aviation industry, the demand for aluminium metal and its alloys has increased so considerably that the mining of bauxite and other ores of aluminium like, cryolite (sodium aluminium fluoride) may be calculated in the form of national assets of individual countries.

The production of aluminium metal, on a large scale has been carried out by the Aluminium Corporation of India at Asansol, with an output of 2,400 tons per year which is hardly less than quarter of the pre-war requirements of the country. It is calculated that such demands are bound to go up 5 to 10 times during the next few years. Aluminium should be classified as a general purpose metal, like iron. It is largely used as the material of construction for the purposes of transportation, *i.e.*, vehicles for air, road, rail and water.

The utility of aluminium is also found in the construction of transmission lines for electrical fields and equipments for rail and road transports, and for the production of other light alloys. Aluminium metal, in the form of sheets, circles, foils, tubes, rods, wires and cables for electrical transmission, has good many industrial uses. Aluminium powder is sufficiently consumed by paints and leather industries. It may not be possible to enumerate the various uses, as the details are too many to be included here.

Sound planning is required for the production of aluminium metal and alloys and various other products manufactured out of the ore, including chemicals and refractories, as the bauxite reserves in the country are inexhaustible.

BERYL : Beryl, the ore of metal beryllium, is always found associated with mica and is available in the pegmatite veins. Chemically, it yields about 12 to 14 per cent BeO with minimum contents of nearly 10 per cent. It is a by-product in the mica mining operations. The metal beryllium is extracted from the ore after complex metallurgical processes. The ore is originally silicate of aluminium and beryllium.

Beryllium is largely used in the manufacture of copper beryllium alloy which is, further, utilised in the manufacture of non-sparkling tools and new type of diamond drills. In the ceramic industry beryl finds a little use. Metal beryllium is used for window in X-Ray tube and stands attacks from hydrogen at high temperature. Alloyed with nickel, it is used for structures of high compression strength.

In India beryl is found in Ajmer-Merwara and this was world's only source some times past but, lately, supplies from U.S.A. and Brazil have also come up. Beryl which is mined in India, is entirely finding export market. Beryl is also found in Bihar in the Hazaribagh mica mines and also at Nellore and Udaipur. There is a scope for the exploration of further sources of beryl, but such attempts could only be made in accordance with export demands.

BENTONITE : Bentonite is more of a popular form of the clays which absorb liquids and the degree of absorption depends on quality. Some of the types of such clays are embraced in Fuller's earth series. Chemically, bentonites are hydrated magnesium aluminium silicate.

Bentonites are chiefly used in foundry sand and also in the soap manufacture and in ceramic industry. Other important uses are for filtering and decolourising oils, and for thickening mud in oil well drilling.

India's chief resources of bentonite are Kashmir and Jodhpur, and its rates vary from Rs. 20 to Rs. 25 per ton at the mine. The mining operation cost is very low. Bentonites should be of 200 mesh fineness and should be dried before use.

The present Indian production of bentonite is not properly developed and poor graded material is put in the market as the degree of absorption varies from lot to lot and from source to source. There are no standard processes of activation and reactivation. Low grade materials are produced and marketed.

CHROMITE : Chromite, the chrome ore, is very useful mineral product as it has a marked utility in the manufacture of chrome steels. It also acts as a source of metal chromium and other chemical compounds. The popularity of chrome plating is quite established in the automobile industry and other electroplating jobs. Chromite is also being used for the manufacture of refractory bricks for furnace lining. The chromates and bichromates of alkali metals are being manufactured from chromite and these chemicals are finding vast uses in the dyeing, calico printing, tanning and pigment industry and in other operations where oxidation processes are involved. Chrome alloys are found very useful as they can stand high temperature. These alloys possess high electrical resistance, provide for higher tensile strength and increased resistivity. Nichrome wires which are produced out of nickel chromium alloys are used as high class heating elements. Thermocuples for the measurement of high temperature are produced out of chrome alloys. The chrome steels are also used for arm plates and other high speed tools.

Chromite is mined in India in Shimoga, Hassan and Mysore district of Mysore State and west of Chaibasa, Singhbhum district of Bihar. Baluchistan, now in the Pakistan territory, is another good production centre of high quality chromite. Small deposits are known in Seraikela (Eastern States) and Ratnagiri (Bombay).

Chromite ore is evalued on its $Cr_2 O_3$ contents and the best grade ore yields more than 48 per cent whereas the second grade is about 44-48 per cent and the third is below 44 per cent. Different grades are marketed at different prices. The best quality ore is priced at Rs. 25 to Rs. 40 per ton, whereas surface chromite which is associated with other mineral is disposed off at Rs. 5 to Rs. 15 per ton, depending on quality.

Indian chromite is finding a good export market; the local consumption, of course, is not very high. The Baluchistan source is practically shut off with the partition of the country. The figures of production were about 50,000 to 60,000 tons before the war period and nearly 25 per cent of this production was being retained for local consumption, the rest was exported. During the war period and after, the production figures ranged from 40,000 to 50,000 tons and, after partition, about 50 per cent of production has gone to the share of Pakistan.

CLAYS: The term "Clay" is very vague. Mostly clays are classified as hydrated silicates of alumina with different types of impurities. Further gradation as ordinary clay (silt dug out of water beds of wells, ponds, lakes and rivers), china clay, fire clay, etc., is based on their physical properties like plasticity, fineness, appearance, thermal resistance and shrinkage.

Clays find use in the manufacture of bricks for building and other constructional work and the fire clay variety is utilised for the production of fire bricks and other refractory materials. Clays are used in considerable quantity in the manufacture of portland cement. The white variety of clay, more particularly known as china clay, is largely used for the pottery manufacture, earthenware, and other items like tiles, glazed earthenware, and pipes and sanitary fittings, telegraph insulators, domestic crockery and ornamental wares, etc. Fine powdered china clay is largely used as filler in paper, textile and rubber industries. It is also used in paints and soap. Finer variety of china clay known as Kaolin finds medicinal uses both for internal use and for external applications in the form of plasters, *i.e.*, anti-phlogistine, etc.

Clays are abundantly available all over the country, but the grades vary from place to place. The qualities produced are not properly standardised. This is due to the fact that miners have no facilities to refine the crude siliceous clays. The installation of pug mills, settlers, elutriators and lavigation equipment is very essential but the mine-owners do not care to make use of such refining units. That is the reason why most of the clays are always gritty and objections are often raised by the consumers like textile, paper and rubber industries.

Clay mining is not very expensive. Cost was hardly from Re. 1 to Rs. 2 per ton at the pit before the war whereas the present conditions of labour are much different. The present mining labour costs three to four times. Fire clay could be got at Rs. 4 to Rs. 8 per ton at the pit before war, whereas the present charges vary from Rs. 15 to Rs. 20 per ton. First quality china clay used to cost Rs. 20 to Rs. 30 per ton at the pit in pre-war days, whereas it varies from Rs. 30 to Rs. 80 per ton in these days. The lower grades can be made available at much cheaper prices.

Muddy clays which are used for the manufacture of bricks are used at random and, in certain cases, bricks start dusting out red powder after a period of one or two years and the structures are weakened. The basic defect may be due to the improper firing, but the composition of the clay also plays an important part in this. Silt and muddy soils are found everywhere but white clays are only available at certain selected spots, and the quantities produced are not sufficient. Every year several thousand tons of good quality clays are imported in India.

Chaibasa in Singhbhum district of Bihar, Jubbulpore in Central Provinces and Mehruli near Delhi, are good centres of china clay. On the other hand, fire clay is plentifully available in different places.

COAL: Coal mining is India's most important mineral industry as the production of the same is an index to the country's industrial assets. Apart from the uses of coal as fuel for power generation, huge quantities of the same are converted into coke for metallurgical operations. The production of coal tar and producer gases for further industrial exploitation are additional uses of coal. Innumerable dyes have been derived out of coal tar distillates. It is estimated that 90 per cent of the total Indian production of coal is employed directly as fuel, including metallurgical operations. Indian railways are, however, consuming the best variety of coal and take away about 33 per cent of the total production whereas iron and steel industry, including engineering workshops, deprive of the other 25 per cent production. The rest of the quantity finds miscellaneous uses.

The word "coal" applies to different varieties like anthracite, coking coals, non-coking coals, lignite, and bituminous types. This gradation is based on its analysis and is indicated by the percentage of water, volatile matter, fixed carbon and ash contents and also percentage of sulphur and phosphorus, including reports about the calorific value of the particular variety of coal.

Coal is mined on a large scale in Bihar and West Bengal. The main centres of the coal-fields are Jharia, Raniganj, Bokaro, and Giridhi and Karanpura. Besides these places, small scale mining is being carried out at various centres like Pench valley of Central Provinces in the Korea and Telchir States of Eastern Agency and Kothagudium and Tandur in Hyderabad State.

Further, prospects of coal mining in India can be visualised from the fact that 30 million tons of coal is annually mined in India. India comes ninth on the list of the world coal producing countries and contributes 2 per cent of the total production. So far as the future of the coal industry is concerned, the prospects appear to be unfavourable. With the present resources and the rate at which the wastage is going on, there is a possibility of reaching a stage, when coal stocks would be exhausted. The mining cost of coal is fairly low and it is due to the fact that the standard of maintenance of collieries is very poor. In fact the labour position in coal mines in India is far from satisfactory. The collieries engaged in raising surface coal have inadequate equipment and those reaching the deeper seams are hardly keen to attend to the safety of the workers.

Coal prices, in India, are very much below the rates prevailing in other countries. The surface coal of low quality could be made available at Re. 1 to Rs. 2 per ton at the pit and better varieties cost from Rs. 3 to Rs. 4 per ton before the war, but during war and after that period, prices have been ranging from Rs. 8 to Rs. 10 per ton for medium quality and better varieties cost from Rs. 15 to Rs. 20 per ton. The cost of transport is pretty high in India. Consumers who are located at centres away from the collieries are obliged to pay heavy freights. In fact, it is earnestly desired that freight schedules for an item like coal must be revised for giving benefit to the various coal consuming industries.

COBALT : Cobalt ore is mainly found associated with copper and nickel, which usually exist as complex sulphides. Cobalt ore has been worked out at Rajputana and Nepal, but the production in India is not adequate. World's other resources are Canada, Northern Rhodesia, Belgian Congo, French Morocco and Burma. The world's annual production figures are about 3,000 tons.

The extraction of cobalt metal from ore has not been attempted in India as the quantities of ore mined are not much to take care of. Cobalt has sufficiently been used in the manufacture of special steels of high magnetic permeability, in cutting steel tools and for the production of cobalt tungsten carbide. Cobalt plating has been attempted on experimental scale, but with little success. It may require further investigations for making it a commercial problem. Cobalt salts are used in paints and varnishes and, as oxide, cobalt finds use in glass and ceramic industry. A few of the cobalt pigments and enamels for jewellery are very popular.

COLUMBITE AND TANTALITE : Columbite and tantalite are the natural ores of metal niobium and tantalum and are generally found together in small veins associated with other oxides of iron and manganese. Their main use have been found in the manufacture of special alloys.

As regards availability in India, these minerals are found in Madura, Nellore, Salem and Trichinopoly districts of Madras and also in Mysore, in Bihar mica belt and in Kashmir State. World's other resources are very meagre and very little mining of this mineral is done. Nigeria produces a good supply of columbite whereas tantalite is obtained from Western Australia in large quantities. Together these are found in Belgian Congo and, besides these, little production comes out of U.S.A. and South Rhodesia.

Production of these minerals is not very much encouraged in India because of little demand and for want of further researches in the country regarding utility of the same.

COMMON SALT AND ALLIED SODIUM COMPOUNDS : Common salt, chemically known as sodium chloride, is an indispensable item of human consumption and is produced in large quantities in India, the principal sources of salt being rock salt deposits, and sea water. Khewra salt mines in West Punjab, now falling in the Pakistan territory are one of the prominent deposits in the world and the purity of the stuff obtained is remarkable. Salt recovered from sea brine or inland lakes is somewhat impure and is found to contain soluble compounds like chlorides and sulphates of potassium and magnesium. The process of elimination of these impurities is fairly a tedious one. The production of salt, is effected from the Sambhar Lake of Rajputana and from the sea water along the Indian coastal line including the Rann of Kutch and Coromondal coast.

The process of production of salt from sea water is quite simple and is carried out by the Solar evaporation of brine in shallow evaporating pans. Further refining for industrial purposes is carried out by the vacuum evaporators.

Besides its uses as food material, common salt is largely used for the manufacture of heavy chemicals, like soda ash by the Solvay Ammonia Process and Leblanc Process and also electrolytic production of caustic soda, where chlorine gas is obtained as by-product. The production of liquid chlorine, bleaching powder and hydrochloric acid is also carried out from salt. The utility of these heavy chemicals in industries like textiles, rayon, cellulose, paper, soap, rubber, petroleum, etc., may be indirectly due to the common salt which forms a key point. Salt is also used for salting hides and skins and also for preserving fish. The electrolytic decomposition of salt solution yields gaseous chlorine and hydrogen, which can act as cheap source of synthetic hydrochloric acid. Salt is also used in the manufacture of ammonium chloride from sulphate of ammonia by a process of double decomposition. It is also used for preparing freezing mixtures on account of its high solubility in water. In the soap manufacture, salt is also directly used in salting out process for the separation of soap from spent lye. Most of the chlorides of all the elements on the periodic table owe their formation and production to common salt. There are innumerable chemical reactions both organic and inorganic where the molecules of sodium or chlorine enter into the composition of the products, directly or indirectly, from sodium chloride.

Salt industry had no pleasant past in India. The fact is that salt production has so far been considered as an instrument for revenue collection in the form of salt tax. The production and distribution was carried out under the direct supervision of Central Salt and Excise Department of Government of India. Salt tax was, however, introduced with the advent of the British rule in India.

In spite of the fact that the cost of production of salt has been low and has only been to the extent of As. 3 to 4 per maund (82 lbs.), the retail prices have been from 6 to 9 pies per lb. before the war, as against the rates before the year 1947 which were As. 2 to 3 per lb. Prices of salt were then controlled by the Excise Department. Total Indian production of salt is nearly estimated to one and half million tons and such production was responsible for an aggregate sum of 9 to 10 crores of rupees in the form of salt taxation.

The salt duty has been varying from time to time. From the years 1888-1903, the duty was Rs. 2-8 per maund of 82 lbs. In 1903 it was reduced to Rs. 2 and in 1905 to Rs. 1-8, in 1907 to Re. 1 and in 1916 it was raised to Rs. 1-4. In 1923 the duty was again raised to Rs. 2-8, in 1924 it was reduced to Rs. 1-4 which continued till 29th September, 1931, which was later enhanced to Rs. 1-9.

It was in the year 1930 that Mahatma Gandhi took up the matter with the Government for the abolition of salt tax, under the plea that salt is a commodity of consumption for poor people and the common man should be exempted from such taxation and must have the right to produce salt individually. He, therefore, carried out demonstrations in the form of *Satyagraha* and started the Civil Disobedience Movement in India but the movement was suppressed and resulted in Gandhi-Irwin Pact.

With the political changes in India, it was possible to abolish the salt tax with effect from 1st April, 1947. The Government of India are deprived of revenue of salt taxation to the tune of over 10 crores of rupees. The protest against salt taxation has, so far, been on sentimental grounds whereas basic reasons of free trading in salt have been ignored. It is, however, estimated that the requirements of salt for human consumption in the world are only 4-5 per cent of the production, the rest 95-96 per cent are needed for vital industries and, as such, taxation on salt has so far been a hindrance in the way of industries in the country.

With a view to industrialise the country properly, Government should assist people for the procurement of salt at cheap rates. This aim can be achieved by encouraging more production of salt and by giving facilities for transportation. Besides the local production of salts, imports of salt from Egypt and Aden have also been made whereas it is possible to satisfy the local demands if production is increased. It is estimated that the total world's production of salt is to the extent of 30 to 40 million tons which is mostly from sea water.

Other salts of sodium which occur in natural form are sulphate of soda and carbonate of soda, containing certain quantities of bicarbonate of soda. They are largely used in important industries like glass, soap, dyes, paper pulp, textiles and heavy chemicals. Reh or sajji, the natural form of soda ash, is available in the alkaline soils of Bihar, United Provinces, Mysore and Bombay and also in Lonar Lakes of Berar. The natural sources of reh or sajji are of minor importance, because of large scale production of soda ash carried out from sodium chloride. The sulphate deposits are located in Bihar where the Khari salt yields 70 to 80 per cent sodium sulphate and its commercial uses are in sulphite process for producing paper pulp. The Jodhpur deposits of sodium sulphate are located at Didwana and are of considerable importance.

COPPER : Copper minerals are of great commercial and industrial value because of high class utility of metal copper. Its importance can be judged from the fact that the copper wires are indispensable in electric installations. The demand for copper is increasing every day because of electrification projects advanced by all the countries of the world. Millions of tons of wire are laid down over the entire globe for the purpose of conducting electricity from one place to another. Besides the important uses of copper wire, other forms of metal like pipes, conduits, sheets, etc. are finding valuable uses for the manufacture of engineering appliances, machinery parts and are also used as materials of constructions for good many industries. The manufacture of chemical salts of copper like sulphate, chloride, nitrate, carbonate, oxide, etc. is another important line. Other chemicals of copper like copper-plating salts, single and double cyanides, sulphites, are the minor products.

Chief consumers of copper metal are the electrical industry, automobile industry, telephones and telegraphs. It is used for railway equipments, building project and ship-building industry and is also used in other miscellaneous engineering works. The popularity that the copper metal enjoys, is mainly attributed to its high thermal and electrical conductive power and high tensile strength and ductility. It also stands atmospheric corrosion quite satisfactorily. Apart from the uses of the copper metal, its alloy like brass and bronze, which are copper zinc and copper tin alloys, are extremely popular. Copper, brass and bronze are invariably used for kitchen utensils in country like India. Amongst other alloys like monel metal, the nickel copper alloy, has proved the finest material of construction for the chemical industry.

Copper minerals mainly exist as sulphides, chalcopyrite and chalcocite with copper contents of 1 to 4 per cent, depending on the associated impurities. Copper ore mining and smelting is being done at Mosaboni and at Manbhander in Singhbhum district in Bihar by the Indian Copper Corporation. Other popular mine centres of copper in Bihar are Rakha mines and Dhobani. Deposits have been located in Assam, Bengal and various parts of Bihar, Central Indian States, Central Provinces, Garhwal and Almora, Kashmir and Jammu, Madras, Mysore, Rajputana and Sikkim, but the quantities are not much to encourage economic mining. Ore is also obtainable in Kumaon and Kangra valley in Himalayas. The total world production of copper metal has been up to 1.5 to 2 million tons before the war, but it has increased from two to three times during the war. The local production is ranging from 5,000 to 8,000 tons of copper metal and, on the other hand, the consumption figures are up to 40,000 tons per year. Largest supplies of copper are obtained from Chile (South America). Deposits in small quantities are obtainable in all countries.

The process of extraction of metal from the ore is quite tedious. The cost of mining and ore dressing is fairly high as compared to the cost of melting and smelting. Attempts must be made to curtail the mining cost. Ore of 2 to 8 per cent copper contents has to be concentrated. This concentration process is implemented by a process of floatation. Approximate annual yield of 6,000 tons of metal at Singhbhum is calculated with an average copper contents of 2.5 per cent. There are fine prospects of exploring the possibility and setting up smelting units at the Sikkim and Khetri deposits. Production of electrolytic copper is also a problem of vital interest.

The cost of production of the locally produced metal has been worked out at about Rs. 500 to Rs. 600 per ton before the war but, with increased labour cost, the cost is gone as high as Rs. 1,000 per ton.

It may not be difficult to imagine that the copper reserves are getting exhausted in the country and it is high time for the Government to entrust the task of exploration to a team of geologists for locating further reserves. This goes without saying that India is decidedly dependent on foreign sources, so far as her requirements in copper metal are concerned. In the Indian market, copper finds use in the form of alloys like bronze and brass and, on this score, market demand is ever increasing. The copper scrap can, however, be consumed to produce copper salts. In spite of the fact that the prospects of increased production are very meagre, the requirements of the country are bound to go up considerably both for copper metal and its alloys and also for electrolytic copper. It may not be difficult to find out the exact figure of imports of copper metal but it is difficult to estimate the quantities of copper made electrical equipments, machinery and other articles of industrial and commercial interest.

DIAMONDS, RUBIES AND STONES : The gradation and classification of diamonds and precious stones is mainly based on the external appearance, lustre, colour shade, refraction power, hardness and specific gravity. There are good many varieties of such stones and are named differently, *i.e.*, diamonds, rubies, sapphires, emeralds gem, gems jade, rock crystals, opals, turquoize, lapiz lazuli, etc.

Precious stones mining is carried out all over the world. Usually they are obtained associated with other stones like garnet, quartz and rocks of identical geological structures. Mining of such stones is not very popular in India. Accidental discoveries are quite usual. The regular availability of such stones may be viewed from table below :

Qualities	*Occurrences*
Diamond Stones	Anantpur, Cuddappah district of Madras and also Chanda and Sambhalpur districts.
Rubies & Sapphires	Kashmir.
Rock Crystals	Santal Parganas and C. P. and Kathiawar.

Collections of precious stones from water-beds are not very uncommon as they are usually washed away by river streams from the rocks. The historical findings of diamond Kohinoor from the river Godavari is quite well known. The availability of pearls in sea beds is also a line of similar interest. The formation of pearls is a result of marine biology whereas the precious stones formation is entirely based on geology and on the principal of rock formation. The evaluation of gems and precious stones is also a specialised task and is really beyond the scope of laymen. As regards chemical composition, diamonds are crystalline form of carbon whereas the other stones are mainly certain complex silicates.

Diamonds and precious stones are mainly the items of jewellery and have ornamental value but, besides this, the industrial uses of diamonds are many more than considered. Diamonds have great industrial value because of their extreme hardness. Inferior varieties of diamonds are largely used for producing machine for the purpose of rock drilling and for high speed cutting tools and also as abrasives for grinding, cutting and polishing.

There are no good prospects of diamond and precious stone mining in India, unless some serious efforts are made in this direction to locate better centres and, as such, the industry is quite insignificant as compared to world's other producers like South Africa, Gold Coast, Brazil and South-West Africa which are known for diamonds whereas rubies, sapphires, emeralds have been found in Burma, Ceylon and other good many countries.

FELSPAR : A popular variety of this mineral is silicate of potassium and aluminium known as "Orthoclase" whereas other type is sodium, calcium, alumina silicate named as "Palgroclase." A similar mineral, high in soda contents, is styled as "Napheline Syenite." These minerals are finding uses in ceramic and glass industries. It is also a soft type of abrasive.

In India felspar is mined from Ajmer and Merwara and also in Mysore State. Deposits have been located at several other places but the prospecting is not yet done. Present annual production of felspar amounts to a few thousand tons and the same is meeting the domestic demand. With progressive mining projects, export contacts are possible to build, provided attempts are made to mine high potash and soda contents felspar. The world production figures are worked out to be about half a million tons and major portion of it is produced in U.S.A. and the rest from the other countries of the continent.

For the purpose of evaluations felspars are sold in the market on the potash and soda contents with a minimum of iron oxide contents as the presence of iron is not desirable. The cost of mining of crude felspar was nearly Rs. 8 to Rs. 10 per ton before the war but now its cost ranges from Rs. 10 to Rs. 20 per ton at the pit whereas fine powder of 200 mesh, properly packed, finds market up to Rs. 100 to Rs. 150 per ton.

FLUORITE : Fluorite is more popularly known as fluorspar and is chemically known as fluoride of calcium, and exists in natural deposits associated with other impurities.

Its deposits have been located in India at Khairgarh and Nandgaon States but mining has not been taken up in right earnest. Other world's centres of production of this mineral are U.S.A., Germany, U.S.S.R., U. K., and France. Small deposits are obtainable in almost all other countries of the world.

The chief uses of fluorite are as flux in the metallurgical operations, especially steel where it is used to the extent of 0.2 to 0.3 per cent of the basic steel produced. It is used to certain extent as a source for fluorine and hydrofluoric acid and also as a source for artificial cryolite (sodium aluminium fluoride) used in the aluminium metallurgy. In the glass and enamel industry fluorite finds a little use. It is also used in the production of calcium carbide, calcium cyanamide and carbon electrodes and also as a source for the extraction of potash. It is also used in paint industry and also as an abrasive.

The mining cost of this mineral comes to about Rs. 2 to Rs. 8 per ton depending on the depth it has to be worked at. Further, process of treatments and concentration bring the price to the level of Rs. 15 to Rs. 25 per ton. Market prices for the same, in finely powdered and properly graded form, range from Rs. 20 to Rs. 25 per cwt. The imported quality of fluorite is also sold up to Rs. 20 to Rs. 30 per cwt. The Indian quality is far from normal specifications and does not find good market and even there is no regular production of this mineral.

FULLER'S EARTH : It is a specific variety of clay, which is non-plastic in character, does not disintegrate in water and absorbs colouring matter from oils. These clays are similar in activity to the bentonites, but are of non-swelling type. Further gradation is carried out after testing them for their volatile contents, density, acidity and particle size, etc.

Fuller's Earth is obtained in India from Bikaner, Jodhpur, Jubbulpore, Jaisalmer, Mysore and Jaipur. World's biggest producing country for this item is U.S.A. It is estimated that total production amounts to nearly a million ton per year whereas Indian production is only a few thousand tons.

As regards the work of refining and activation of crude earth, it is observed that very little efforts are made to produce proper grades of the same. Occasionally, the local stuff in the markets are found adulterated and are much inferior in quality. Oil hydrogenation industry which has gained much importance in India, during war days, constantly requires superior stuff. Fuller's Earth is being imported in fairly good quantities. Fuller's Earth also finds use in the manufacture of perfumed talcum powders for body perspiration as its effects are soothing.

GOLD: Gold, being a precious metal, has a peculiar value. Gold reserves of any country are calculated more or less as standards of its wealth. In each and every country of the world, gold has found use as a medium for currency and is a standard for barter exchanges. Inhabitants of country like India which holds the mark of Oriental civilisation, have got a specific hobby of keeping gold as personal belongings in the form of ornaments. Apart from the uses of gold as ornaments and as medium for national exchange wealth of the country, it is also used in small quantities for making gold leaves which are often used to be taken for human consumption and also for decorative purposes. Gold also goes into the manufacture of certain chemicals like chlorides and cyanides. Liquid gold is used in the glass bangle industry.

Gold is, in fact, very widely distributed but in minor quantities. Gold is also recovered from certain river sands and, even in mines, gold is found associated with quartzite. Gold mining and extraction is known to Indians since ages. Regular working of mines was taken up in the year 1880 at Kolar Gold Fields in South India. There are few mine centres associated with Kolar fields, *i.e.*, Mysore, Nundydroog, Champion Reef and Ooregaum. Gold has also been worked out in the Dharwar district of Bombay and Anantpur districts of Wynaad (Nilgiris) of Madras and in Hutti mines of Hyderabad (Deccan). Small amounts are obtained from Bihar and other scattered parts of the country. It is, however, observed that the gold production figures vary considerably, as in the year 1938 it was 321,138 ounces, whereas in 1947 production fell down to 171,704 ounces. The total world production is estimated nearly 40 million ounces. Transvaal Gold Mines of South Africa contribute about one-third of the total production whereas other countries like U.S.S.R., Canada, U.S.A., and Australia produce nearly 50 per cent of the production. Small quantities are obtained from almost all countries of the world.

Crude ore from the mine veins costs very little and it may vary from Rs. 10 to Rs. 20 per ton, but further cost of grinding, crushing and milling the ore is considerably high. Process of mechanical concentration gives reasonable results. The final process of extractions may differ from place to place. The formation of mercury amalgams with mercury, assists in recovering the metal and is later separated by the process of distillation. Further extraction of metal from tailings is facilitated by cyanide process. Leaching of gold from fine 200 mesh powder is successfully carried out by the potash cyanide solution. The addition of zinc metal powder to the solution precipitates gold which, on separation, indicates purity of nearly 95 per cent. Gold refining is also carried out by melting with fluxes like borax, etc. Electrolytic refining can also be carried out to attain highest degree of purity.

The prices of gold ruling in India are far from expectation as compared to the prices valid about 20 years back. Gold prices have had a speculative trend all along and it is most surprising to note that the rates of gold before 1930 were nearly Rs. 50 to Rs. 60 per ounce, whereas the present rates are in the vicinity of Rs. 250 per ounce. It may not be difficult to imagine the ill effects of such a tremendous rise of prices of the basic wealth of the country. It, however, reflects on the inflationary trends and its effects on the economic conditions of the country. It is, however, believed that the old prices of gold in India are not going to be revived in any case, although some of the countries of the world have been quite successful in keeping down the price of gold to a reasonable limit.

GRAPHITE : Graphite is a natural form of carbon and exists both in amorphous and crystalline forms. Its chief uses are in the manufacture of crucibles which stand high temperature and are suitable for high class metallurgical operations. It is also used in foundry moulds. Graphite also finds use in paints industry and forms an important ingredient of black lead pencils. Graphite has been found useful as a lubricant. Carbon electrodes for electric furnaces, for electric arc lamp and for batteries and elctrolytic cells; in the form of rods and plates, are made out of graphite. Carbon brushes in the dynamos are also made of graphite.

Graphite deposits in India have been located in the Eastern Ghats, Central Provinces, Travancore, Ajmer-Merwara and Kolar. The other nearest and important source for high quality graphite is Ceylon. Other centres of world are Korea, Austria, Germany, Czechoslovakia, Madagascar, U.S.A., U.S.S.R., and the total production is ranging from 100,000 to 150,000 tons per year. The present Indian production is not very much encouraged because of the poor standard of the mineral mined and also that the finished products from graphite are mainly imported from abroad and, as such, raw graphite is finding little market in the local circles.

The process of grading and refining is very poor, and production of 20 to 30 per cent purity may be mined at the cost of Rs. 4 to Rs. 10 per ton at the pit. Further concentration to grade of 35 and 40 per cent, may cost 2 or 3 times the original cost. Presently graphite from Ceylon deposits is finding good market in India and is even of 90 per cent purity. Prices to mineowners are paid from Rs. 50 to Rs. 100 per ton depending on quality whereas fine grades, free from grit, fetch prices from Rs. 800 to Rs. 1,000 per ton.

GYPSUM : Chemically, gypsum is hydrated, calcium sulphate which gets partially dehydrated at temperature of 120-170°C and is completely dehydrated above 200°C. Other natural crystalline varieties are silenite, gypsite and alabaster. The peculiar properties of re-absorbing the water of hydration and exhibiting different physical and chemical properties have made this mineral all the same very popular in the building engineering works. Gypsum forms an important ingredient of the portland cement and plays a prominent role in regulating setting time.

The partially dehydrated gypsum is known as Plaster of Paris and is largely used in clay modelling for making moulds for pottery industry and rubber industry. In the science of surgery, bone fractures are set with the help of plaster of paris powder and bandages are prepared out of it. In metallurgy, gypsum is used as flux; and in paint industry, it is used as a filler. As a cheaply obtainable mineral for combined sulphur, gypsum has opened avenues for the production of sulphuric acid, ammonium sulphate and fertilisers and other chemical like calcium sulphide, etc. from it, although processes of manufacture have not been commercialised, so far, in India.

Gypsum is plentifully obtainable in India at places like Trichinopoly, Jodhpur, Bikaner, Jaisalmer, Garhwal and Kashmir. Sind and West Punjab, the territories of Pakistan, were also yielding considerable production. As regards world's other centres of gypsum production, all the countries are catering their own requirements through local productions. Total world's production may approximately be 10 million tons per year. It may not be possible to ascertain the extent of local production as figures of consumption can roughly be based on the extent of requirements of gypsum in cement industry. It is understood that nearly 2 to 3 per cent of gypsum is required in the composition of cement. The cost of mining gypsum was Rs. 2 to Rs. 10 per ton depending on quality at the pit before the war, but presently, it ranges from Rs. 15 to Rs. 20 per ton on account of changed labour conditions.

The West Punjab deposits of gypsum which carried a great value have been cut off by the partition of the country and the original plan to use West Punjab gypsum for the fertiliser factory at Sindhri has got to be altered. Those reserves are now inaccessible and arrangement for procuring the same are to be made or more reserves in India have got to be explored. It is felt that the gypsum requirements of cement industry are sufficiently big and the existing deposits of gypsum will have to be carefully used.

IRON : Iron ores are plentifully available in all parts of the country. The various ores are found as oxides and sulphides. Magnetite, hematite and pyrites are the popular varieties of iron ores. High grade iron ore containing above 60 per cent iron has been located in the Singhbhum district of Bihar and Eastern States of the neighbouring localities where deposits are estimated to the extent of nearly 3,000 million tons. Other deposits are obtainable in the Bastar State and in the Chanda and Drug States of Central Provinces and Bababudan Hills in Mysore. India ranks in the foremost iron ore producing countries of the world. Iron smelting in India is comparatively on a very small scale. Mining is, at present, being carried out on large scales at Singhbhum, Keonjhar, Mayurbhanj States. The presence of limestone and coal near the iron ore deposits, has encouraged the installation of iron and steel smelting works at those places. Ore containing above 60 per cent iron has been more suitably used, with the introduction of the modern methods of iron smelting.

Messrs. Tata Iron & Steel Co., Ltd., undertook smelting work at Jamshedpur since 1911-12. Later, Indian Iron & Steel Co., Ltd., had started production at Asansol in 1921 and, lately, an attempt was made by Mysore Iron & Steel Works at Bhadravati. Smelting on small scale is being carried out at various places. Tata mines are consuming 62 per cent ore on an average but ore up to 70 per cent is also in production.

The cost of iron ore mining is fairly cheap in India. The ore may cost from Rs. 3 to Rs. 4 per ton at the pit whereas in pre-war days its cost ranged from 8 annas to Rs. 2 per ton, depending on the depth of the ore it has to be mined. Ore is crushed and sent with coke and limestone to the blast furnace for smelting purposes. The molten metal, known as pig iron, settles down to the base of the furnace whereas the slags which are a complex silicate of calcium, aluminium and magnesium are tapped out from above. The presence of small impurities like sulphur, phosphorus, manganese, cobalt, nickel, chromium, considerably alter the properties of pig iron. Ore is necessarily assayed for the presence of such impurities. The various varieties of steels that are obtained out of pig iron and other elements, exhibit remarkable changes in physical property of the basic metal, *i.e.*, tensile strength, compression strength, tenacity, permeability, elasticity, malleability, magnetic properties, etc. It is understood that nearly 75 per cent of the production of pig iron is directly taken over to the production of steels like manganese steels, cobalt steels, nickel steels, chrome steels, stainless steels, ferromanganese alloys, ferrochrome alloys, etc., and all such varieties have offered scope of their utility in various fields of industry, building construction work, railways, ship-building industry, locomotives, and other miscellaneous projects.

The cost of production of pig iron ranges nearly from Rs. 70 to Rs. 100 per ton whereas steels cost usually about 1½ to 2 times the cost of pig iron, depending on the quality. The local production of iron and steel is nearly up to 2 million tons. The figures of demand are increasing every day because of huge expansion projects by railways and ever increasing demand for heavy machinery, and also for other constructional purposes. The popularity of ferroconcrete has further enhanced the figures of consumption.

Iron and steel have numerous uses. It may be difficult to give an exhaustive review of the same. Railways are the chief consumers. They have got a network of lines running all over the country with prospects of massive expansion. The locomotives, coaches, heavy machinery for big industries like textile, cement, sugar, paper, jute, foundaries, etc. are all being imported in large quantities. The requirements of the country in iron and steel in the form of billets, bars, plates, sheets, structural sections and rails and the finished machinery, both light and heavy, are also being satisfied through imports. Innumerable items are imported under the heading of hardwares which are, further, branched into different categories, *i.e.*, structural hardwares, domestic hardwares, outdoor and indoor furnishing hardwares, etc.

As regards the prospects of the iron and steel industry in India, it is believed that the coal reserves of the country are very meagre and expansion of this industry is mainly based on the easy and cheap procurement of coke. Coke is presently serving two-sided purpose, firstly to heat the ore up to melting temperature and secondly as a chemical reducing agent. Attempts have to be made to minimise the use of coke. It is estimated that the iron ore is much in excess to the available coal reserves and, as and when opportunity permits, possibility of exports have to be explored ; but before considering this aspect of export, it may be equally important to set up plants for the local production of iron and steel. The introduction of electrothermic and electrometallurgical processes have, decidedly, opened up new fields of interest. The electric furnaces have, almost, replaced the crucible methods for the steel manufacture. The latest technique of manufacturing ferro-alloys like stainless steel, nickel, chromium, vanadium and tungsten steels of the type, high speed steel and cutting steel have quite well developed with the introduction of electrothermic furnaces. Such furnaces have definite improvements over the cupolas and blast furnaces for producing steel. The availability of cheap electric energy through hydro-electric sources might, partly, assist in curtailing coke demand and afford chances for speeding up production with the available resources of raw materials.

KYANITE, SILLIMANITE AND ANDALUSITE: Chemically, all these minerals are classified as silicate of aluminium with different molecular formulæ. Another mineral of similar series, with little amount of boron, is known as dumortierite. These minerals find use as lining for the high temperature furnace and are used in the manufacture of refractory bricks. High quality porcelain products like spark plugs are also produced out of these.

Kyanite deposits are found in India in Kharsawan State. These deposits are the largest of its kind. At places, sillimanite and dumortierite are also found. Analytical reports show that good quality kyanite contains 60 per cent of alumina and about 36 per cent of silica with limited amount of iron oxide upto 1.5 per cent and free silica up to 2 per cent. It is observed that the Indian quality of kyanite is quite superior.

The cost of mining of the surface deposits of kyanite is very cheap whereas the cost increases considerably if it is required to get deeper. It used to cost Rs. 3 to Rs. 4 per ton before the war but presently cost has gone up nearly 3 to 4 times. The figures of local consumption are very little as compared to the export trade. Shipments could be affected at price ranging from Rs. 20 to Rs. 40 per ton before the war whereas present quotations are from Rs. 100 to Rs. 150 per ton for superior stuff.

Indian kyanite is obtained in quite pure form and little efforts are needed to procure refined material. Hand picking sufficiently affords the availability of desired grades. Kyanite on calcination at a temperature of about 1,500°C. gives product known as mullite. Mullite is very much used in producing high grade refractory bricks known as " Mullite Bricks." These bricks, specially, stand very high temperature. Use of kyanite in glass factories in India needs encourages ment as such refractory materials are locally available. There are nearly 200 glass works including bangle factorie- in India, and the use of these minerals can be very advantageously recommended for such purposes. Its use can also be made in ceramics, potteries and enamels industries.

LEAD: Lead minerals are generally obtainable as complex natural compounds but the most common one is sulphide known as Galena. There are innumerable uses of metal lead and its alloys. It finds use as an important material of construction in the sulphuric acid plants, for erecting reaction chambers and storage tanks, because of its resistance to acids. Lead is, exclusively, used in the form of sheets, pipes, pumping sets and tank lining. Some of the important lead paints and pigments are white lead paint, litharge, red lead and other pigments, like lead chromates in variety of shades. Chemicals like lead acetate and basic acetate of lead are also items of great interest. Lead plates are largely used in storage batteries. Lead ore which is chemically a complex sulphide of antimony and lead, finds extensive use as blackening for eyes known as *Surma.* Lead metal is very soft, malleable and ductile but harder type of alloys are obtained by introducing certain amount of antimony.

India is very poor in her resources of lead. Scattered deposits of the ore have been located at various parts of the country, especially in Bihar but no effective production has been raised. The Zawar deposits of lead zinc ore in Mewar, Rajputana have recently been prospected and it is anticipated that it might act as a regular production source for metal lead in due course. Small deposits are known at Hazaribagh and Manbhum districts in Bihar, Drug districts of Central Provinces and Datia and Gwalior States in Central India.

Lead is not being smelted in India on commercial scale at present. Local demands are presently satisfied through imports. Lead zinc ore is found to contain a little amount of silver which is supposed to be produced as by-product. The ore originally contains combined zinc and lead up to 18 to 25 per cent. The ore concentration process also gives effective results. Starting with ore contents of 8 per cent lead and 10 per cent zinc with 4 per cent silver, on concentration, may give product assaying up to 75 per cent lead and about 4 per cent zinc.

The extraction of metal lead is not a difficult task but elimination of other metals like zinc and tin is fairly important. The process of ore smelting is carried out by roasting the concentrated ore where sulphur is burnt out leaving sintered ore which is further reduced in the furnace and final part of process involves in refining the metal. A smelter was operated in Bihar with an irregular production figure of 100 tons of lead during war days. The present imports of metal, however, range from 7,500 to 10,000 tons per year. It is anticipated that the figure of consumption might go up 2 to 3 times soon, as the industrial progress of the country is bound to command for more supplies of lead in the form of sheets, pipes and accumulators. Prices of lead metal were controlled and even the releases were also restricted during war period. Lead metal is in short supply in the country and steps must be taken immediately for setting up a few more smelters to ensure higher production and efforts must be made to exploit the existing resources.

LIMESTONE : Limestone is a natural form of calcium carbonate existing as stone. Chemically, it may yield 75 to 95 per cent $CaCO_3$ with varied impurities like silica, magnesia and alumina and iron oxide. Calite and marble stones are finer varieties of calcium carbonate.

Limestone is the cheapest building stone and has innumerable uses. Besides its utility as constructional stone, it is largely used in the manufacture of lime and portland cements which are items of basic importance in the modern building science. In metallurgy, it is used as flux. It goes into the composition of glass and also for the production of bleaching powder and calcium carbide. A softer variety of limestone, known as whiting, is largely used as filler in paint industry and in the rubber factories.

The importance of limestone in cement industry can be well judged from the fact that it is required to the extent of 70 to 75 per cent of cement produced, besides other raw materials. After burning the slurry mixture of cement in the rotary kiln, it is converted into complex silicates of calcium and alumina with other constituents, like iron oxide. Presently, there are about 18 cement factories in India and all of them are located on the limestone quarries. Cement could be made available at Rs. 35 to Rs. 40 per ton before the war whereas the cost of limestone at the quarry was near Rs. 1-8 to Rs. 2 per ton. Today the prices of cement are nearly Rs. 70 to Rs. 100 per ton ; on the other hand, the cost of limestone has increased from Rs. 4 to Rs. 5 per ton at the quarries pit on account of high labour charges.

The production of lime from the stone is quite an important industry. The efficiency of a lime kiln is generally dependent on various factors, *viz.*, temperature of kiln, composition of limestone, degree of decomposition, etc. A good quality lime is consistently in demand in the country but usually materials of poor specifications are available. Good quality lime fetched Rs. 15 to Rs. 20 per ton before the war whereas present cost has gone as high as Rs. 40 to Rs. 50 per ton, while market retail prices even go up to Rs. 200 to Rs. 250 per ton.

As regards availability of limestone, almost all the provinces have developed quarries to produce high class limestone. The best varieties of limestone are mined in Bihar in the Shahabad district and Japla ; and in Lakheri at Rajputana; Jodhpur; Porbandar in Kathiawar; Coimbatore in South India; Katni, Jubbulpore, Bilaspore in Central Provinces ; in Patiala and Jind States. It may be difficult to lay hand on the Indian production of limestone but one can easily say it to be a few million tons per year. Every country in the world is meeting her own requirements of limestone.

LITHIUM : The three ores of lithium are commercially obtained as spodumene, lepidolite and amblygonite ; the first one is lithium alumina silicate, the second is lithia mica and third is lithium alumina fluor-phosphate containing about 2 to 4 per cent of lithia.

World's production of lithia is very meagre and is to the extent of a few thousand tons. Chief producing countries are U.S.A., South-West Africa, Argentina. Besides this, other countries are yielding minor production. Lepidolite occurs in Bastar State in India but it is not mined because of its little demand. The process of extraction of lithium metal is fairly complex.

Metal lithium has been used in producing metal alloys. It contributes to the increase of hardness, toughness and tensile strength of the metals. Lithium salts are used in glass manufacture. Lithium chloride, is used in air-conditioning industry and, as flux, in welding workshops.

MAGNESITE : Natural magnesite mineral is really the carbonate of magnesium and exists in free deposits but when found associated with calcium carbonate, it is named as dolomite. In India magnesite is available in Mysore and Madras and deposits have also been located in the Idar State. The local annual production of magnesite is several thousand tons. It exceeds 40,000 tons annually and nearly 40 per cent of this production finds export market. The Salem magnesite deposits yield a high quality product with 97 to 98 per cent magnesium carbonate contents and are estimated at several thousand million tons.

The chief uses of magnesite have been as refractory material both for the manufacture of bricks and as furnace lining for metallurgical operations. Magnesite gives magnesia on calcination and the same, when mixed with asbestos, yields high class heat insulator for lagging steam boilers, steam pipes, furnaces and for having light furnace tops. In the chemical industry, magnesite is used to produce magnesium sulphate which is more popularly known as epsom salt and is a product of great interest to the medical profession and is also used for other technical and industrial purposes. The production of metal magnesium can be successfully carried out from magnesite, but the processes are not, so far, commercialised, in India.

In paint and rubber industries, magnesium compounds find use as fillers. Magnesium metal has its value due to its lightness. When alloyed with aluminium and zinc, it is found very useful in the aircraft industry. Magnesium alloys are used for engine parts and other miscellaneous equipments like landing wheels, interior fittings, petrol and oil tanks and also for the forged screw. Most of the parts of road transport vehicles can be constructed out of magnesium alloys. Other commercial and electrical equipments like machine tools, printing and textile machinery, electric motor casings, air-conditioning plants, telephone switch parts, optical instruments and busbars can be suitably made out of its alloys. Magnesium powder and wire ribbons find use in the explosives and also for flashlight powders and several other fireworks products.

Magnesite is calcined at a temperature of 1,600°C. and then ground to fine powder and later moulded into bricks with the help of caustic magnesia (bonding agent) which is specially produced at a temperature of 1,700°C. and with a little amount of iron oxide for the purpose of using as refractory. The bricks are then carefully fired. The cost of production of magnesite was nearly Rs. 6 to Rs. 8 per ton at the pit before the war, whereas it has now gone as high as Rs. 12 to Rs. 15 per ton.

The prospects of production of magnesium metal from magnesite have yet to be explored as thermal reduction of calcined magnesite with suitable reducing agent, is not yet quite popular. This is carried out in vacuum and then redistilled in a retort which yields crystalline metal. The production of magnesium metal can be carried out from the sea bittern where the salt works already exist, *i.e.*, Kharagoda on the outskirts of Rann of Cutch and at Okhamandal and, secondly, from the magnesite deposits at Salem. The production capacity of such plants must be based on the local requirements which are increasing every day. The consumption of the metal was very little in the pre-war days whereas magnesium metal and its alloys have been in big demand during the war period.

MANGANESE : Manganese ore is one of those minerals of Indian origin which finds international market. The popular ore of manganese is oxide, known as " pyrolusite." The gradation of the ore is based in its manganese contents. First grade ore contains above 48 per cent manganese; second grade may yield between 45 to 48 per cent and the third grade may indicate between 40 to 45 per cent contents. The manganese dioxide contents of the ore may be reported above 90 per cent and also between 80 to 85 per cent and below 80 per cent, respectively.

Manganese ore is in big demand in the iron and steel metallurgy and for the production of various ferromanganese alloys. About 95 per cent of the world manganese production is being used in the manufacture of steel and rest goes for miscellaneous purposes. Manganese dioxide of the quality 80 to 85 per cent free from iron is also largely used in the ceramics and glass industry. Cheaper grades are also used in the match industry and it is mainly due to its being a cheap oxidising agent. Manganese dioxide is largely used in the manufacture of dry batteries. It is also used in the paint industry. As regards chemical industry, manganese dioxide is used for manufacture of potassium permanganate which is largely used in the medical line because of powerful antiseptic and oxidising properties. Other chemicals like manganese chloride and sulphate are of minor importance. In the electroplating field, manganese plating has been tried on experimental scale and in due course it might gain importance on commercial lines.

The principal areas in which manganese ore is mined in India are the Balaghat, Nagpur and Bhandara district in the Central Provinces, Sandur State and Bellary, Vizagapatam district in Madras, the Panch Mahal district in Bombay, Singhbhum district in Bihar and in the Keonjhar and Bonai States. The total world production figures are ranging from 3 to 6 million tons depending on the iron and steel industry requirements whereas the Indian production is between 60,000 to 100,000 tons of ore. The export market is absorbing major portion of the Indian ore production.

The cost of production of the ore was nearly Rs. 5 per ton at the pit and the f.o.b. deliveries at the Indian ports have been given below Rs. 20 per ton before the war. The basic rise in the cost of mining due to alteration in working condition, is nearly about two to three times. The ore is generally exported in lump form but for its use in chemical processes, ceramics and glass industry, it is crushed and ground to fine powder and is sold at varying prices depending on the percentage purity of ore. With further expansion in the iron and steel industry in India, domestic demand is bound to increase and also with the expansion in the dry cell manufacturing industry its demand can go up. Attempts should, however, been made to further implement the scope of production of manganese alloys on commercial scale in India.

MICA : Mica the complex silicate of potassium, aluminium and magnesium occurs in different natural forms named as "Muscovite", "Phlogopite", Vermiculite, etc. The first two varieties are largely used in the electrical industry because of the high insulating properties. The developments in the wireless industry for the production of condensers and radio tubes, are entirely based on the utility of mica. Mica splittings after binding with bonding agents like shellac are made into insulating materials like micanite board, micanite cloth and micanite paper. Finely powdered mica scrap is also used in the manufacture of roofing, wall papers, automobile tyres, moulded insulators, rubber goods and as lubricant.

Vermiculite is a high class heat insulator and has specific properties of expanding remarkably on heating. Uniful, another product of similar composition and properties, also expands on heating. These varieties find good use in the construction of furnace roofs as their expansion is nearly 10 times and is very light to be used as furnace tops especially in glass tank furnaces.

India ranks in the first rate countries of the world in mica mining. In fact, world's 80 per cent demand of sheet mica is covered from the Indian product. The best deposits are obtained from Hazaribagh district of Bihar and Nellore district of Madras and small deposits are located in Rajputana and Nilgiris. The mica belt of Bihar runs in east and west direction along the line of Gaya, Hazaribagh and Monghyr districts and is about 60 miles long with variable width of 12 to 14 miles. Mica occurs as pegmatite, associated with other minerals like felspar and quartz. Beryl, the beryllium ore, is obtained as a by-product in the mica mining industry from surface deposits. The crude minerals is cut into slabs of quarter inch thickness and the blocks are then properly sorted out and defective portions are eliminated. Most of these blocks are exported abroad in the same condition. Further splitting is also carried out, if required, from 0.08 to 0.12 inch but, for condenser films, it is up to a thickness of .001 to .003 inch. Split sizes of uniform thickness are bundled into packages and are marketed as such.

The cost of mining mica varies considerably from deposit to deposit and crude ore mining may cost nearly Rs. 15 to Rs. 20 per ton, and further crude ore dressing into blocks may bring up the cost from Rs. 50 to Rs. 100 per cwt. The chief centres of marketing are Kodarma and Giridih in Bihar and Madras in South India where the traders have direct export contacts with foreign countries and the import houses. A good deal of variations in mica prices have been observed as first variety of superfine transparent quality blocks are quoted nearly up to Rs. 75 per lb., whereas moderately processed stuff is charged up to annas 6 to annas 8 per lb. and, at the same time, mica scrap is obtained at Rs. 50 to Rs. 100 per ton. The figures of production and consumption of mica are mainly dependent on export market and nearly 7,000 to 10,000 tons of mica sheets are exported annually and this covers nearly 75 per cent of the world's requirements. The mica scrap has not received much importance in India. Mica exports afford a big trading problem for a country like India where her own industries have not yet developed and the utilisation of local reserves of this mineral is a matter of great problem. The export of this important mineral is today creating a trade balance of a 10 million rupees per year to the credit of the country.

MONAZITE : Monazite, the thorium ore, generally contains 8 to 10 per cent thoria and is obtained as a by-product during the concentration process of ilmenite. The production of monazite is being mainly carried out from the sands of Travancore in India. The production is to an average of 3,000 to 4,000 tons per annum. Practically, the world requirements are being fulfilled from the Indian ore and the producers export the mineral directly.

Monazite is used to manufacture thorium nitrate out of the thoria extracted. Thorium nitrate is largely used in the incandescent gas mantles along with minute quantities of ceria. Further, thoria is also used as catalyst in the manufacturing process for synthetic benzine. Cerium is also extracted from this ore as a by-product. Cerium finds uses in the pyrophoric alloys and also in the pocket lighters.

The ore prices are, comparatively, cheap where the prices of chemicals produced out of it are fairly high. The process of extraction of thoria and ceria are fairly tedious and the ore requires a good deal of pre-treatments before the extraction is actually affected. The ore prices before the war were nearly on an average of Rs. 50 per ton whereas presently it is more than Rs. 100.

The war time ruling prices of nitrate of thorium were nearly Rs. 10 per lb. There can be a good scope for taking up the manufacture of the same here in India. The prospects of extraction of thoria and ceria in India are fairly bright and it is reasonable problem as the finished chemicals, in the form of nitrates, can be easily exported.

NICKEL : Nickel minerals generally exist as complex sulphides or as silicates which are found in the form of veins. Nickel ore deposits are not much known in India but small quantities of nickel are being recovered during the copper ore smelting, carried out by the Indian Copper Corporation. In small quantities it is located in the copper deposits of Rajputana and Khetri mines of Jaipur. Nickel availability is also reported from Nepal in the snow bound regions of Himalayas.

World's main supplies of nickel come from Canada and nearly three-fourths of demands are covered from there. Other producing centres are New Caledonia, Finland and U.S.S.R., Norway, Burma, Greece, Germany and Netherlands East Indies. The annual figures of world production are nearly 100,000 tons.

Nickel metal is really amongst the most important metals as its principal uses are in the manufacture of steel alloys, *i.e.*, stainless steel, chrome nickel steel and monel metal, etc. These alloys have proved extremely useful as materials of construction to the chemical industry. The commercial uses of stainless steel and monel metal are too numerous to be recorded here. Apart from their use in the materials of construction for equipments in important industries, these alloys are used for containers and utensils for domestic use. Cutlery and surgical instruments, manufactured out of stainless steel, are quite popular. Nickel is also sufficiently used in the electroplating industry as nickel metal and nickel salts like sulphate, double sulphate, carbonate and chloride and other patent electroplating salts are in big demand. The popularity of nickel plating is due to the fact that a fine layer of nickel electrolytically deposited, gives rust-proof surface. Articles made of iron, copper, and brass, which are constantly exposed to the action of atmospheric moisture and air are less resistant to corrosion and can be easily protected by nickel plating. Nickel is also used as a catalyst in the hydrogenation process of fats and oils. With the increase in the production of hydrogenated products in the country, the consumption of nickel has also gone up considerably.

The process of extraction of nickel is more or less similar to that of copper but with little modification. The metal obtained is later refined electrolytically and purity above 99.9 per cent can be attained.

As regards further prospects of the nickel ore mining in India, efforts have yet to be made to locate reserves of better grade ore and also elucidate better processing for adequate recovery.

Nickel metal is exclusively imported and the supplies are mainly obtained from U. K. Prices of nickel anodes and other electroplating accessories were controlled by the Directorate of Munitions and Production, under the Defence Ministry, during war days but such controls were relaxed after the war. Releases of these materials were, however, restricted. The price fluctuations of nickel anodes have been more prominent in India after excessive imports made during the year 1946-47, and even now. the trend of prices is found downward.

OCHRES AND MINERAL PIGMENTS : Ochres and mineral pigments which are available in different grades and shades are classified as coloured clays or earths. They generally owe their colour to the presence of oxides of iron in the anhydrous or hydrated form. There are no rigid classifications for these minerals as they are graded according to their shades like yellow ochre, red ochre, red oxide of iron, umbers, siennas, etc. These minerals are invariably formed as a result of weathering, surface alterations and decompositions of natural rocks. These pigments find large use in the paint industry where uniformity of shade and fineness are the major factors of consideration. These minerals are also used as fillers and cheap colouring agents in the rubber and card board industries. Some of these are largely used in the production of special cements, *i.e.*, coloured cements and laterite cements. Different shades can, however, be attained by regulating the temperature of calcination of the cements. In India, these ochres were also used in the coloured pottery in the past, but such uses are out of date on account of the advancement in the modern white pottery.

The various shades like yellow (light, medium, dark) ; green (light, medium, dark) ; dull and bright red, brown, chocolate of the cheap paints are due to these natural ochres. Blue and orange colours in different shades, are obtained artificially by proper grading, mixing and making combinations. The paint industry, however, requires all these mineral pigments provided they are very finely pulverised and are free from grit and are also of uniform shades. The natural ochres and pigment colours are so plentifully and cheaply available in each and every province of the country that it is not worthwhile to estimate the extent of production and consumption figures. The use of artificial pigments produced by precipitating organic colours on finely powdered inert materials, has dominated the importance of natural pigments.

The mining cost of these materials is quite nominal as they belong to softer varieties of minerals like clays. These are raised very cheaply from the surface and the cost may range from Rs. 2 to Rs. 5 per ton at the pit but such grades are rather inferior and cheap. Deposits which are obtained a little deeper, cost from Rs. 10 to Rs. 15 per ton. The inferior grades, however, need washing and lavigation for eliminating grit and other undesirable impurities and the process of refining may cost extra. Fine powders of these ochres and mineral pigments suitable for the manufacture of paints and distempers are marketed at Rs. 75 to Rs. 300 per ton depending on the quality, colours and shades of the stuff. If a little care is taken in refining and grading, it may be possible to export these mineral pigments in huge quantities. Persian Gulf red oxide of iron, a refined variety of these minerals is sold from Rs. 60 to Rs. 80 per cwt.

As regards further prospects of mining of such minerals, it is observed that the paint industry is expanding a good deal as all the desired raw materials for this industry are available in abundance in the country. Therefore, the imports of paints which can be easily produced in the country, must be stopped. The local production can be made to meet domestic demand and, at a future date, India can be a big exporter of paints, although small quantities of paints and other materials are already being exported.

PETROLEUM: Petroleum and its allied mineral products are the items of international importance and world-wide searches for these are made by all the countries. Petroleum products are equally evalued like coal and electricity, where problems of fuel and energy have to be tackled. The modern means of transport owe their developments to the petroleum, kerosene and other middle oils, which are good for lighting and fuel purpose. Diesel oils and crude oils have similar industrial importance. Paraffin wax and other waxes are very largely demanded for candle manufacture and are consumed by industries like rubber, textiles and chemicals. Greases and lubricants have their birth from the petroleum products and it may not be difficult to imagine that the technique of lubrication and lubricants has really added on to the efficiency and working of mechanical equipments and has considerably assisted in the industrial achievements.

The formation of mineral oils under the rocks is a matter of geological gestures where good many theories are propounded to explain the existence of natural oil wells and is, invariably, indicated by the evolution of natural gases. Dry distillation of coal under certain conditions of temperature and pressure, yields various distillates of specific range of boiling points and similar products are obtained from the fields and oil bearing strata under the rock structure, thus proving the mineral origin of petroleum. Besides this, there are also organic theories for its existence. The fractional distillation of crude oil, however, yields light oils, medium oils and heavy oils, which fall in the category of motor spirit, kerosene and lubricating oils, etc. The residues are mainly of the series of waxes and asphaltic bases. By the process of cracking (heat treatment under pressure) of crude oil, it is further possible to obtain motor spirit and aviation spirit, which form the key points of automobile and aircraft industries. India's resources of petroleum are quite limited. Oil fields are located in Assam and such deposits of petroleum are concentrated at Cachar and Lakhimpur and the oil refining is carried out at Digboi.

So far as rough estimates are concerned, the production of crude petroleum is to the extent of nearly 66 million gallons per annum. Production from the oil fields of Khaur and Dhulia in Attock district of Western Pakistan are nearly 22 million gallons.

India's own requirements in petroleum products are not fulfilled from the local production and these products are imported a good deal and, as such, India is not well placed to satisfy her local demands. Other centres of petroleum production in the world are Iran, Roumania, Netherlands East Indies, Mexico, Iraq, Columbia, Peru, Argentina and Burma.

PHOSPHATES : Phosphates are classified according to the source of origin. Phosphates are obtainable in two forms, *i.e.*, rock or mineral phosphates and animal phosphates with the tricalcium phosphate as the main constituent. Phosphates have their best use as fertilisers preferably in the form of superphosphates. These are also largely used for the metallurgical operations. Natural phosphates also act as source for various chemicals like phosphoric acid and other chemical phosphates. Element phosphorus is recovered from these phosphates and other compounds like pentaoxide and pentachloride are also manufactured out of the same.

There are very small deposits of rock phosphates in Madras and in Singhbhum district of Bihar but the same have not been much developed. In fact, the occurrence of mineral phosphate is attributed to the accumulated deposits of calcium phosphates in the sea-beds under marine conditions, and later, those deposits appear as geological beds in any of the surface layers as the result of metamorphic changes, which take place in the earth's planet. Natural phosphates, on analysis, yield 35 to 90 per cent tricalcium phosphate. The cost of production is, however, varying much depending on the depth to which it has to be worked at.

Normally, the rock phosphates are the refuse of birds deposits found through ages and are obtained at certain places as veins and nodules. The cost of mining of phosphates varies from Rs. 10 to Rs. 25 per ton depending on quality. Animal phosphates are produced out of bone meal which is obtained after crushing and treating bone powders.

RADIUM AND URANIUM : Radium and uranium are the radio-active elements. The real importance of the radio-active elements has recently been realised with the discovery of atomic bombs. These elements had much of theoretical importance, and had instructive and educational value, so far. The practical utility of alpha, beta, gama and cosmic rays which are emitted from these radio-active elements could not be realised on a commercial scale.

Rays emitted from radium are found useful in the medical treatments of cancer. Uranium, in the form of its oxide, imparts golden glaze on pottery and yellow and orange colours to glass. Metallic uranium and its salts have many uses. As carbide, it is employed as the sparkling medium of automatic cigar lighter. Enclosed in quartz globe and surrounded by an inert atmosphere, uranium electrodes emit rays rich in ultra-violet band. Uranium salts are also used as colouring agents in the manufacture of glass, yielding opalescent yellow colour. In ceramics, yellow and orange glaze is produced by the yellow oxide and green oxide of uranium and the colour variations of glaze can be attained from yellow and orange to brown and dark olive green. For silk and wool, uranium salts are supposed to act as mordants. In the synthetic ammonia produced from nitrogen and hydrogen, uranium salts act as catalyst. In photography, uranium nitrate is used as sensitizing agent. Besides these, there are good many small and minor uses of the metal and its allied chemicals.

The various natural minerals of uranium are pitch blende or "Uranimite" which is primarily the uranium oxide and "Carnotile", the vanadate of uranium and potassium and "Antunite", the anhydrous phosphate of calcium and uranium. Process of extraction of uranium is rather tedious.

Uranium is, practically, an element of highest atomic weight and occupies 92nd position in the periodic tables.

The developments in atomic research and successful production of atomic bombs from an atom of uranium has seriously changed the outlook of scientists and has, decidedly, opened avenues for pursuing the same from different angles. The war time researches carried out in this direction in various countries like Germany, U.S.A., U.K., U.S.S.R., made the people understand that the atomic bomb is the most dreadful war weapon. Attempts are being made by all the nations of the world to keep a joint control over the atomic research. These steps are being proposed to safeguard the interests of each nation and also with a view to save the globe from further annihilation. It is well realised that atomic energy can also be harnessed for useful and constructive purposes and every possible attempt has to be made to give it a practical shape.

All the nations of the world are, however, busily hunting for uranium resources. The deposits are in any case located in Canada, Czechoslovakia, Portugal, Belgian Congo, U.S.A. and U.S.S.R. In India, the mineral occurs at the Singar Mica mines of the Gaya district and in Travancore State. The task of prospecting these mineral deposits has been taken up in right earnest as, very recently, the Government of India have set up an Atomic Research Control Board.

Further scope regarding the exploitation of the country's resources of uranium and radium, entirely depends on the interest that the Government shows. The pursuit of researches in the radio-active elements falls under the heading of atomic research and the same must seriously and sincerely be encouraged by the Government. With proper facilities and adequate financial aid afforded by the State, it is quite possible to build up defence resources of the country.

SALTPETRE AND POTASSIUM SALTS : Saltpetre is chemically known as nitrate of potash and was once one of the principal mineral products of India. The biggest centre of production has been in West Punjab which is now a separate territory and is included in Pakistan. It is mainly extracted from the surface soil in certain tracts of land which are unfit for agricultural production. Such sites are also located in the United Provinces, Bihar and Orissa. The districts of Gaya, Tirhut, Saran and Champaran are quite popular centres of production in Bihar and the districts of Allahabad, Banaras, Kanpur, Ghazipur in the United Provinces and Coimbatore, Kistna, Madura, Salem, Trichinopoly and Vellore in Madras, Bhind and Jawahargarh in Central India. The quality of saltpetre produced in West Punjab is very superior to the quality produced in the various centres in India.

The process of extraction of saltpetre is quite simple. Heaps of soil and earth are collected and leached with water and the extract is dried in beds under sunshine, thus crude saltpetre is obtained. It is further purified. The main impurities associated with saltpetre are sodium chloride and potassium chloride. High grade saltpetre must be free from chloride contents. Commercial grades are 90 to 95 per cent pure, whereas the purest varieties contain 98 to 99 per cent. Higher qualities are graded according to the chloride contents, *i.e.*, 1, 0.5 and 0.25 per cent.

Saltpetre has good many uses and the most important use is in the manufacture of explosives. The use of saltpetre is being made in the sulphuric acid manufacture. Sulphur dioxide is oxidised to trioxide of sulphur and this reaction is promoted by the oxides of nitrogen which are liberated from the nitrates. Chilean saltpetre, although available at cheaper price, was sufficiently replaced by local saltpetre production during war days. Saltpetre is also used for the manufacture of nitric acid. Ammonium nitrate which is produced from the purest qualities of saltpetre, has also an important use in explosives. Saltpetre is used in the manufacture of potash salts like carbonate, permanganate, hydroxide, etc. and also for the use in glass and ceramic industry. Saltpetre has proved a very useful type of fertiliser and supplies nitrogen and potash to the crops.

Rough estimates of production of saltpetre of the undivided country, are to the tune of 15,000 tons per year.

Saltpetre industry received a great setback after the World War I and had, practically, got extinct as the imports of sodium nitrate (Chilean saltpetre) had always been made at competitive prices. Immediately after the World War II had started, saltpetre was greatly demanded for the manufacture of chemicals and explosives. The pre-war low prices which once were below Rs. 100 per ton went up with the sudden demand from Rs. 500 to Rs. 800 per ton. The situation is still worsened, as the West Punjab reserves of saltpetre have now been eliminated and there being a great demand of this item, the prices are soaring very high.

It may be desired that further efforts may be made to exploit the possibility of increasing the production and creating chances to produce purer stuff from the existing sources of Bihar, United Provinces and Madras.

Other potash salts are the chloride and sulphate of potash which are also available from natural sources. Potassium chloride is usually found associated with rock salt and is also extracted during the process of saltpetre refining. From the sea salt, it is also removed as complex double chloride of magnesium and potassium and is known as carnalite. By the process of fractional crystallisation at controlled temperature and vapour pressure, they are separated on commercial scale into individual chlorides. Sulphate of potassium and magnesium are also found in complex form, commercially known as Kainite.

There is no appreciable production of potash salts in India whereas sufficient quantities of muriate of potash are imported into the country as potash fertilisers.

SILVER: Silver being a precious metal is fairly important element and, like gold, is a metal for coinage. In India, silver is produced from the Kolar Gold Fields, Mysore, to the extent of 20,000 to 25,000 ounces against the total world production of nearly 250 million ounces. Silver is generally produced as by-product from gold and copper refineries as it is usually found associated with ores of lead, copper and gold, etc. In natural forms, it is also found as sulphide. Chief silver producing countries of the world are Mexico, U.S.A., Canada, Peru and Australia. Small quantities are obtained from almost all other countries of the world.

Silver metal is largely used for ornamental purposes which include household silverwares and other ornaments of personal wearing. Coins made out of silver have, lately, been replaced by cheap nickel alloys. Silver bromide has vast application in the photography whereas nitrate of silver has good many commercial uses including silvering of mirrors and for medical purposes, and also, for silver plating from the silver cyanide baths.

The process of extraction of silver is quite simple but the process of refining is very delicate. The prices of metal silver have been showing an upward trend since the last 20 years especially after gold had gone off the standard since 1931. The prices have gone up from 10 to 12 annas to Rs. 4 to Rs. 5 per ounce. The inflationary conditions have very badly effected the price level of silver and there are remote chances for the recovery of the old standard.

SILICA (QUARTZ AND SAND) QUARTZ STONE, OR QUARTZITE are the natural forms of silica and are available in plenty in all parts of the world. Quartzite occurs mainly as rocks whereas sand is usually found at river beds, sea beds and practically everywhere. Chemically, silica is known as silicon dioxide. Silicon is one of the most important elements and is found in great abundance in the natural form of silica and as complex silicates.

Ordinary sands are largely consumed for building and constructional purposes. Other grades of sand have utility as moulding sands in foundries. Silica is also refractory material and is used for steel smelting furnaces. White sand, free from iron, is largely used in glass industry, pottery and in ceramics. Sands are also used as abrasives.

Various qualities of sands are graded differently depending on the uses to which they are put in. Sands must be properly washed and must be free from mud and silt for their use as building materials and for constructional purposes; but for other industrial purposes, sands have different features—

Grades of Sand	Important Index
1. Building and Constructional Sands	Clear sharp angular sand, free from silt and mud.
2. Moulding Sands	Cohesiveness, refractory, moulds sufficiently permeable to permit the escape of gas.
3. Filter Sands	Free from clay and organic matter, evenly sized grain.
4. Abrasive Sands	Grain may be round or angular but size must be uniform.
5. Glass and Ceramics Sands	Grain uniform size; white, and free from iron (limit for colourless batch up to 0.02 per cent iron).

Ordinary sands are found in abundance in India but the glass-maker's sands are not much available. A few centres of white sand are in the United Provinces and Jaipur State and at places near Naini in the vicinity of Allahabad, Lodhara, Ferozabad, Nagina, etc. Small quantities of white sand are obtained at Jaijon in East Punjab.

Sands are sold at different prices according to qualities. The building sand may be available at Rs. 2 to Rs. 5 per ton whereas the white sand may cost Rs. 20 to Rs. 30 per ton. Quartz is largely used for the manufacture of stoneware, pottery and refractory bricks. Quartz costs Rs. 5 to Rs. 10 per ton at the mine pit whereas the prices of the powdered quartz are comparatively high. It is very difficult to give any idea about the figures of production and consumption of sand and silica as such statistics are not available. The development of glass and glass bangle industry in United Provinces is mainly due to the cheap availability of white sands in that locality.

SLATES: Slates are hard clayey rocks and are often very dark in colour on account of the presence of carbonaceous matter. Slates are graded according to their colour, hardness, density, porosity, absorption strength, electrical resistance and their properties of resistance to corrosion by acid and alkaline solutions.

Slates are used for roofing and also for flooring, table tops, school slates and slate pencils. Other articles of garden furniture are also made out of slate. In fine powdered form, it is used as abrasive and as a cheap soap additive. It is also used as filler in paint, rubber and linoleum industries.

Millions of tons of slates are quarried every year in all parts of the world. In India, the production of slates is very prominent in Kangra Valley and in Bihar. These are also obtained, associated with hard rocks, in almost all parts of the country.

The cost of production of slates, primarily, depends on the size and design of the finished articles. The cost of quarrying may roughly be nearly Rs. 5 to Rs. 10 per ton, whereas the prices of the finished articles may be abnormally unproportionate. Fine slate powder, however, fetches prices up to Rs. 80 to Rs. 100 per ton, depending on quality. The pre-war prices were, comparatively, very cheap.

The splitting work of slabs is done by hand work in India and the use of mechanical devices is not quite popular.

STRONTIUM : Strontium ores are popularly the sulphate and carbonate, known as Celestite and Strontianite, respectively. The former ore is largely mined in U.K. and the latter in Germany. In India, strontium deposits have been located in certain parts of Madras which are distributed in veinlets in clay beds.

Strontium compounds have several important commercial applications and main uses are in the sugar industry and in pyrotechny. Strontium hydroxide forms insoluble saccharates with sugar which are decomposed by carbon dioxide and yield pure sugar. Strontium salts impart red and crimson colour to the flames in fireworks and the variation in colour shades is affected by the addition of aluminium powder, magnesium powder and other oxidising chemicals like chlorate of potash. Strontium minerals are also used as filler in the paint industry and also find use in metallurgy and medicines.

SOAPSTONE: (TALC, STEATITE): Soapstone or talc or steatite or french chalk are the good many names given to a particular variety of stone which is very soft and has got soapy touch. Chemically, they are known as hydrated magnesium silicates. The various factors for gradation of these stones are colour, hardness, degree of fineness and, also, absence of foreign impurities like silica.

Soapstone has good many uses. Soapstone blocks are used as refractory material for the construction of alkali smelting furnaces, especially of the type for burning black ash in soda recovery plant of paper factory. In powder form, soapstone is used in the textile, paper, rubber and paint industries. In soap industry, this powder is largely used as an adulterant for the purpose of cheapening soaps. It is also used as lubricant and as a soft polishing medium. In the form of slabs, it finds use for the construction of tanks, which are chemically resistant, and in making switchboards. In ceramic industry, it is used for the production of heat resistant products. In toilet industry, 300 mesh fine snow white powder is largely demanded for the manufacture of face powders and other scented and medicated talcum powders. Amongst the other small uses, soapstone powder is also used for producing solid disinfectants and anti-septics like DDT powder. Steatite blocks can be very easily cut, carved, lathed and drilled and, thereby, offer good items for ornamental and decorative materials of construction.

Soapstone is available in plenty, in India, and the local annual production is several thousand tons. Finest deposits are, however, located around Jaipur. Main production is from Rajputana and Madras; but other centres are located in Central Provinces, Bihar, Central India, Eastern States, United Provinces and Mysore. It is estimated that the total world's production is nearly 500,000 tons out of which U.S.A. contributes nearly one-third.

The cost of mining of soapstone is fairly cheap as working is very easy. The working cost at the mine pit may be Rs. 10 to Rs. 20 per ton for good quality stone; whereas in pre-war days, it amounted to nearly Rs. 5 per ton. It is always demanded in terms of its fineness. The finer the powder, the higher the price it fetches. Snow white powder of 300 mesh of cosmetic quality is even priced at Rs. 200 to Rs. 250 per ton; whereas lumps, at the mine pit, may be available at Rs. 20 to Rs. 30 per ton.

India is meeting her requirements of talc through local production and there is also sufficient surplus material for export. The task of pulverising soapstone to the desired fineness is of paramount importance, although very few grinding mills in the country are producing fine material.

SULPHUR, SULPHIDES AND SULPHATES: Sulphur exists in nature, both in free and combined state. Natural deposits of brimstone containing 60 to 70 per cent of sulphur are obtained in free state; whereas in combined state, it exists as copper pyrites which are sulphide ores. Natural sulphates are gypsum and sodium sulphate.

The importance of sulphur is very well recognised in the chemical industry as it is the raw material for sulphuric acid and other allied chemical compounds. Sugar industry consumes sulphur to a great extent for refining purposes in the single and double sulphitation processes. Sulphur is also largely used in the manufacture of explosives. Other uses of sulphur are in industries like rubber, match, insecticide, fertilisers, dyes, food products, oil and varnishes. Some of the important chemicals like thiosulphate, sulphite, bisulphite, metabisulphite, hydrosulphite of soda owe their production to sulphur. In combined form, sulphates of soda, ammonia, calcium, magnesium, copper and iron have innumerable uses and, as such, sulphur may be classified as a key chemical for all industries.

The consistent search for sulphur ores in India had enabled the location of brimstone in Baluchistan which now constitutes a part of Pakistan territory. Refining of these deposits was taken up as a war time project, in the absence of imported sulphur. The project proved a failure on the grounds of economy as the same was very expensive. Sulphur was mainly imported from Japan and Sicily before war, but such supplies were cut off after the World War II had started. The American sulphur was, however, obtained from U.S.A. under the emergency system, but this arrangement was soon discontinued after the war was over. Present supplies of sulphur are being procured from U.S.A., purely on commercial understandings. The various grades of sulphur are roll sulphur, rock sulphur, sulphur powder, sulphur flour and, also, special quality like rubber maker's sulphur. The import of sulphur during the past years are given below :

IMPORTS OF SULPHUR

Year	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	29,407.75	2,612
1938-39	22,284.15	2,174
1939-40	38,788.65	4,545
1940-41	38,853.00	5,054
1941-42	29,459.45	5,401
1942-43	14,732.20	2,849
1943-44	22,202.00	3,025
1944-45	19,501.10	3,573
1945-46	9,972.65	1,688
1946-47	52,369.70	10,574
1947-48	29,851.10	4,433
1948-49	38,331.85	6,116

India is decidedly deficit in her resources of elemental sulphur and such deficiency is bound to be continued, unless the country's resources of combined sulphur, like sulphides and sulphates, are exploited. Presently, the pyrites are found in Kashmir hills, Bihar and in Himalayas near Simla, yielding nearly 40 to 50 per cent of sulphur and attempts must be made to utilise the same for the production of sulphuric acid. At times, traces of selenium and arsenic are detected in pyrites and these impurities are very harmful. Careful examination of raw materials is essential before commercial projects for the manufacture of acid are taken in hand. The roaster gases from the copper smelters, operating in Bihar, can be usefully converted into sulphuric acid and ammonium sulphates as these gases are, primarily, the oxides of sulphur. The gypsum resources of the country which have been located at good many places like Rajputana, Kashmir, Dehra Dun and Madras could be utilised for this purpose. The West Punjab deposits of gypsum are now in Pakistan and are beyond access but they might be available on commercial terms, at a later date. The cement industry is having quite a high demand for gypsum at this moment and it may be considered essential to have imports from Pakistan.

There has been a good deal of variation in the prices of sulphur. Supplies were effected at the rate of Rs. 85 to Rs. 100 per ton before the war ; but during war days, there was a control enforced on the prices and on the distribution of sulphur. Releases were made on preferential basis, but the unofficial market rates rose from Rs. 1,000 to Rs. 2,500 per ton. The controls were lifted after the war, and now the prices have considerably come down after the revival of import channels. Prices are, however, ranging from Rs. 200 to Rs. 300 per ton, depending on quality.

The sulphides and sulphates are much cheaply available and, at the mine pit, the cost is very nominal. It is, therefore, desired that natural sulphides and sulphates may be taken up as the sources of sulphur and process for their utility must be developed at an early date.

TIN : Tin ore which is mainly an oxide, is known as Cassiterite and is not much obtainable in India. Very small deposits have been located in the Archaean Rocks of Hazaribagh district of Bihar and also in Orissa. At Simratri, it occurs in lenticles of granite enclosed in mica schist; near Pihira, in a dyke of lepidolite granite and at Chappatand in a granulite. At Nurunga near Parasnath, a thin layer of cassiterite bearing granulite is recorded. Other tin producing countries of the world are Malaya States, Netherlands East Indies, Bolivia, Siam, China, Belgian Congo, Burma and Australia. The total world's requirements of tin are about 200,000 tons per annum. The annual consumption of tin in India is estimated to 3,000 tons in the form of ingots, bars, slabs, foils, etc. This demand is, however, satisfied through imports.

Tin metal is industrially very useful, as directly, it is largely consumed for the manufacture of tin plates and for the purpose of tinning surface of other metals like iron, copper and brass and, also, for the manufacture of tin alloys like bronze, solder and type metals and white metal. Tin is also used for the manufacture of collapsible tubes, foils, and pipes. A few chemical compounds of tin, like oxide and chloride are fairly known products.

Presently, all the requirements of tin, tin alloys and allied tin chemicals are being satisfied through imports. It is, however, difficult to speak of the existing resources as they are too meagre and are mostly of theoretical importance. The price of tin was controlled during war days and its distribution was also governed by the Non-Ferrous Metal Control Orders.

TITANIUM : Titanium is usually found associated with aluminium, iron and zinc ores. The important minerals which act as sources for titanium are ilmenite and, to a little extent, rutile, the tin ore. Ilmenite is the chief titanium mineral and is obtained in large quantities in India, forming nearly 75 per cent of the total world production. Travancore beach sands are the main source of this ore. Other minor sources are recorded in Bihar. Ilmenite concentrate obtained from Travancore contains 50 to 60 per cent of the ore, the rest are tin, monazite and zircon which are also extracted from it. Huge deposits of titaniferrous magnetite are obtained from Singhbhum and Mayurbhanj district of Bihar. Ilmenite is also located in Rajputana States. The bauxite deposits, obtained from several places in the country, can yield appreciable quantities of titanium in the form of by-product.

Titanium has good many uses in industrial fields. The oxide of titanium is the most important compound which forms one of the most valuable fillers in paint and pigment industry. In fact, this is mainly due to its specific property of having high covering power, perfect whiteness and almost complete inertness towards variable atmospheric conditions. As a pigment, it has important uses in plastics, linoleum coated textiles, rubber, wall paper and printing inks industries. In ceramics, glass and enamel industries, the oxide of titanium has definite uses. Titanium is also used in the production of steel of the type ferrotitanium alloys and makes the steel shock-proof. It is also resistant to abrasion and helps in the elimination of blow holes. In the nickel chrome steel, titanium provides for buffer molecules and, thereby, minimises the interangular corrosion. In arc lamps the titanium compounds along with other elements have proved useful for negative electrodes. As regards the salts of titanium, the tetrachloride possesses properties of producing smoke screens. The sulphate and bichloride of titanium are used as intermediaries in the textile industries.

The cost of production of ilmenite is fairly low as the processes of excavation and concentration from sands are quite simple and are much less laborious. Roughly, it may work out from Rs. 10 to Rs. 20 per ton. It is, however, observed that the entire production of ilmenite is exported abroad and no serious attempts have been made to extract the titanium or manufacture its compounds. The total world's production amounts to nearly 2 to 3 lakhs tons per year. In fact, there are bright prospects for the extraction of titanium and its allied salts and such problems must be taken up on a commercial scale.

TUNGSTEN : Tungsten ores are usually found associated with tin ores. The main ores of tungsten are iron manganese tungstate and calcium tungstates, known as Wolfram and Scheelite, respectively. The chemical composition of these ores vary a good deal and, usually, the tungstate concentrates yield from 60 to 70 per cent of tungsten oxides.

India has not appreciable deposits of tungsten ore; but in Jodhpur State, deposits are obtained at Degana. In Bihar, little deposits of tungsten ore have been located near Tatanagar station in the Singhbhum district. Meagre deposits are found in Central Provinces. Findings of tungsten ore at Chendapathar in the Bankura district are of sufficient interest. The total world production of tungstic concentrates is to the tune of 20,000 tons; the major production, however, comes from China. The other tungsten producing centres in the world are Burma, U.S.A., Portugal, Bolivia, Korea, Malay States and Australia.

Tungsten metal and its alloys are very useful in the steel industry. Ferrotungstic steel alloys find best use for high speed cutting tools. Tungsten imparts additional hardness to steel and, also, there is an increase in tensile strength with limited increase of elasticity. Tungsten carbide is very good for hard cutting tools. Tungsten filaments have, all the same, revolutionised the electrical industry and are largely used in electric bulbs and radio tubes. Chemical compounds of tungsten are useful for pigment industry. Sodium paratungstate is used in fire-proofing of cloth and other fabrics. It is also used as mordant for calico printing and as a weighting agent. Oxide of tungsten is used in ceramic industry for producing yellow colours in glass and porcelain. Sodium tungstate is used for decolourising acetic acid.

The cost of production of tungsten concentrate is quite high and is nearly Rs. 50 to Rs. 100 per ton, depending on the concentration attained. It may be very essential to assess the quantitative resources of the country and, further, locate the possibilities of production of metal tungsten and its useful alloys.

VANADIUM: Vanadium occurs in various natural forms of minerals like "carnotite" (uranyl potassium acetate) "patronite" (greenish coloured sulphide of vanadium) "roscoelite" (vanadated muscovite mica) vanadinite (chloro vanadate of lead). The annual world's production of vanadium is estimated to be 3,000 tons. Main production of vanadium ore comes from Peru, and rest from North Rhodesia, South-West Africa and South Africa, U.S.A., Mexico. Small deposits are located in Australia, U.K., New Zealand, Argentina, Spain, Germany and U.S.S.R.

In India, iron ore deposits in Mayurbhanj State and Singhbhum, in Bihar, are found to bear vanadium and titanium. Little occurrences of vanadium oxides are detected in the Warkalli beds in Travancore, and in the green mica of Bhandara district in Central Provinces. The vanadium contents of the ore are found to the extent of 0.5 to 0.8 per cent. The recovery of the element, however, appears to be difficult, but after the process of titanium extraction, appreciable yield of vanadium can be obtained on further processing.

Vanadium is chiefly used in the production of ferroalloys in the steel industry. Vanadium increases elasticity and tensile strength of steel, without affecting ductility. Copper vanadium alloys are much used in the production of solid copper castings and bronzes, as well as, in the manufacture of certain aluminium alloys. The various salts of this element like chloride of vanadium, find use in photography. Penta-oxide of vanadium is used as colouring material for pottery and glass industry. Writings produced out of vanadium salts solutions, are stable to the action of acid, alkali or chlorine. The vanadium pentaoxide is successfully used as cataclyst in the contact process of sulphuric acid manufacture and has, definitely, revolutionised the process, resulting into curtailment of the manufacturing cost of acids. Minor uses of vanadium salts are in the medicines, in making paint driers, as insecticides, fungicides and fertilisers, in the guilding of pottery and in glass for filtering out ultra-violet rays.

It may be difficult to estimate the extent of the country's resources of vanadium as further investigations, in the process of extraction and commercial uses of element, are not yet very popular in India.

ZINC : Zinc is largely used in the galvanizing industry, both by the mechanical and electrogalvanizing processes. In the former process, the molten zinc bath is employed for dipping the articles and, in the latter process, the deposition of zinc metal is carried out electrolytically from zinc salts. Zinc also goes into the composition of brass which is very important copper zinc alloy. Other uses of metal are in the manufacture of batteries and in the die castings. The oxide of zinc which is universally used in the paint industry, rubber and latex products, is probably the most important chemical compounds of zinc. Lithophone which is, primarily, a product of interest for the paints and rubber industries contains 28 to 30 per cent zinc sulphide.

The local resources of zinc ore, are very poor in India. Lead-zinc deposits have been located at Zawar mines in Mewar. The prospecting and mining task has just been taken in hand. Further, zinc sulphide ore is located near Darabi in Kashmir State. The Bawdwin lead-zinc mines of Burma, from where huge quantities of ores are worked out, may also be employed as a source for the ore, for the local smelting of zinc in India.

The total requirements of the country, in the form of zinc metal and its compounds, had been very large amounting to the extent of nearly 26,000 tons of zinc in the pre-war days. Present requirements for the same may, hereby, be analysed, *i.e.*, 6,000 to 8,000 tons of metal for alloy making and 16,000 to 18,000 tons of zinc metal for galvanizing 3,000 to 4,000 tons as zinc oxide, and about 2,500 to 3,000 tons in the form of zinc chloride. The manufacture of zinc oxide is being carried out at Calcutta, but the production is inadequate to meet the demand which is increasing everyday. The present requirements of zinc and zinc alloys and other allied chemicals are, therefore, being satisfied through imports.

ZIRCON : Zircon, the orthosilicate of metal zirconium, is obtained in India from the ilmenite sand of Travancore. The ore yield is to the extent of 5 to 6 per cent and the ZrO_2

contents of the ore may be up to 33 to 55 per cent. India has been the biggest source of supply of zircon in the world. However, the oxide of zirconium deposits have also been located in Brazil. Amongst other producers of world, are Australia and U.S.A. In India, the ore production is a by-product, hence it is difficult to get exact figures of the extraction of this product. The entire production of zircon in India is, however, exported and it is estimated that value of these annual exports amounts to nearly Rs. 50,000.

The process of extraction of metal is fairly tedious. The complex silicates are, however, decomposed with strong acid treatment at high temperature. Later, zircon is recovered, after the process of fusion with sodium carbonate and borax, at high temperature. The fusion with barium carbonate yields barium zirconate which is converted into zirconium oxychloride with the help of hydrochloric acid and, later, precipitate of metal zirconium is obtained with ammonia.

Zirconium and its salts have good many industrial uses. Pure fused zirconia has a very low co-efficient of expansion and is, therefore, used as high class refractory materials, especially for crucibles and certain high temperature furnaces. It is also used in the ceramic industry for special porcelain and glass and as an opacifier in some enamels. Other uses of zircon are in the radio tubes, ammunition primers and electric welding. The metal zirconium in the element form has little use, although it has been tried as filament for incandescent electric lamps. A little quantity of it is used as ferrozirconium in the steel alloy production. In the manufacture of quartz wares, small quantity of zirconia increases the tensile strength and resistance to the chemicals. Zirconia carbide is also found to be good abrasive and can be used for glass cutting. Other zirconium compounds like oxides, silicates, basic carbonates, phosphates and sulphides are found very suitable pigments and have got high covering power and are non-poisonous. They remain unaffected by sulpherated hydrogen and mix well with paints vehicles.

Zirconium compounds find use in the incandescent glow lamps. Zirconium acetate also finds use for weighting silk.

The cost of mining of zirconium cannot be worked out directly, as it is obtained as a by-product in the ilmenite concentration. The markets abroad are, however, fetching the price from Rs. 75 to Rs. 100 per ton. As regards the prospects of utilisation of this ore in India, research facilities are required to develop extraction and demonstrate application of the various products, obtained from it.

B. AGRICULTURAL PRODUCTS

India is a vast country with agriculture as its premier asset. The variation in the physical and climatic conditions of different parts of the country, commands the growth of innumerable varieties of both cultivated and wild crops. Such peculiarities are due to a large number of factors. Some of the geographic reasons may be attributed to the vastness of the country ; as the area, covered by the natural boundaries, is stretched to correspond with wide range of alterations in temperature and humidity of the atmosphere. A regulated period of rainfall in different regions has, ultimately, led to the creation of different seasonal zones. The effect of monsoons is also very prominent in Indian climatic conditions. The characteristics of Indian soil are also directly connected with the agricultural activities of the country. Physical division into geographical zones is based on soil characters like mountain ranges, valleys, plateaus, plains, coastal lines, etc., which have, further, created agricultural zones and yield specific crops.

Apart from the cultivation of food grain crops in India, there are a large number of other agricultural crops which possess high industrial values. A few of such crops may be grouped as under :

(1) *Food Grain Crops :* Wheat, barley, oats, jowar, millet, maize, rice, pulses, etc.

(2) *Industrial Crops :* Cotton, jute, sugarcane, etc.

(3) *Stimulant Crops :* Tea, coffee, tobacco, etc.

(4) *Forest Crops :* Bamboo, rubber plantation, teak and wood, grasses, etc.

(5) *Oil Crops :* Linseed, castorseed, groundnut, sesamum, rape, mustard, etc.

(6) *Herbal and Essential Oil Crops :* Medicinal herbs, essential oil plants, etc.

(7) *Fruit and Vegetable Crops :* Fresh and dry vegetables, fresh and dry fruits.

(8) *Wild Plantations and Crops:* Flowering and general fencing plants, including wild crops.

The cultivation and growth of all plants is being carried out in different periods of the years, the so-called " seasons." The sowing period, growth period and the periods of maturity are, more or less, specified for each crop ; because the adaptability for growth is dependent on the environments and other atmospheric conditions. Certain factors which help in regulating the periods of growth and maturity, have got to be studied for all the crops.

FOOD GRAIN CROPS : The various foodgrain crops like rice, wheat, barley, millet, pulses, etc., have wide growth in all parts of the country. Rice is chiefly grown in West Bengal, Bihar, Orissa and Madras and is the main item of cultivation in these areas. Moist climate and heavy rainfalls encourage the growth of rice crops. The usual rice crop growth of undivided India was estimated to be nearly 25 to 27 million tons and the area, under cultivation, was about 70 to 80 million acres. With the partition of the country, some of the rice growing areas of Pakistan like East Bengal, Sylhet, Sind and West Punjab, have got a good share of rice crop and it is estimated to be one-third of the total production of the sub-continent of India.

Wheat has a definite growth in the northern parts of India which includes United Provinces, Delhi, and East Punjab. The most prominent wheat producing colonies in Pakistan, are West Punjab, Sind and North-West Frontier Province. In fact, Pakistan has, comparatively, got better share of the total wheat production territories, as compared to the total area allocated to the Indian Union. Cultivation of maize, millet, etc. is also being carried out in almost all parts of the country. Pulses are very commonly grown everywhere in India and they form an important part of human diet.

The food value of some of the cereal crops like wheat, barley, oats, jowar, millet, maize, rice, etc., is well recognised by mankind in general. These cereals are very rich in carbohydrate contents and possess high industrial value for the production of various starches and starch derivatives. Wheat and maize starches are the most popular class of products which are largely used as sizing materials for textile and paper industries. Starches and dextrine also find an important use in the production of adhesives which are sufficiently demanded for industrial purposes. Starches which are, primarily, carbohydrates yield, on decomposition, important products like sucrose and glucose. The production of such sugars and starch derivatives, are carried out in foreign countries, on commercial scale, but this industry has, so far, been a minor one in India. It may be of interest to note that the demand for starches for industrial purposes is fairly high and several thousand tons of dextrine and starches are imported into the country every year.

Starch industry has not been encouraged in the country because of food grain shortage. This shortage is attributed to the low crop yield ; and a very high demand is caused due to the increased population. Constant efforts are being made to introduce modern and efficient methods of agriculture, and use of fertilisers and manures is recommended to step up agricultural production. Starch industry has no bright future, unless sufficient quantities of wheat and maize are made available to produce the same.

Production of starches and other allied products, have been restricted since the resources for raw materials are limited. Similarly, manufacture of glucose and sucrose may not receive encouragement on the same grounds. Liquid glucose is being produced by a few of the starch manufacturers like Messrs. Anil Starch Works Ltd., Ahmedabad; Rampur Maize Products Ltd., Rampur; Bharat Maize and Starch Products, Jagadhari; but the present scale of manufacture is extremely small as compared to the annual imports. Amongst other useful products, wheat straw is used for the manufacture of strawboard and rice husks find use as industrial fillers. The extraction of vitamins and other products of medical interest, can also be considered.

INDUSTRIAL CROPS: Amongst the important industrial crops, cotton, jute and sugar-cane are of great significance. Cotton crop has its prime importance for the textile industry which has developed, in India, on fairly sound lines. Cotton is largely grown in the black soil of Kathiawar, Bombay and Hyderabad. Other cotton producing centres are Central Provinces, Berar and Madras and United Provinces. Sind and West Punjab have, however, been growing a good quality cotton, but such productions are now cut off after partition. Raw cotton is exported to other countries in huge quantities, although nearly 400 cotton textile mills are working in India. Besides the cotton textile production carried out by the mills, hand and powerloom industry has sufficiently gained importance in the country. Apart from its use for spinning, weaving and fabric making, cotton has important uses in chemical field. The production of cellulose and its derivatives like acetates and nitrates is carried out basically from cotton. Celluloid and film industry are also dependent on the same. The rayon and acetate silk industries are consuming cotton on large scale. Lacquers produced out of cellulose derivatives have a firm industrial and commercial value. Some of the cotton derivatives go into the composition of explosives. Cotton, in the form of rags and cloth cuttings, is used in the manufacture of paper pulp and, thereby, forms an important raw material for the paper industry. Cotton seed oil is hydrogenated to produce vegetable ghee, which is an important food product for human consumption. Cotton seed oil has, in fact, innumerable uses. The cotton seed cake, after the oil extraction, is largely used as a manure.

Jute is another crop of great industrial importance. India had been holding world monopoly for the production of raw jute. Considerably large quantities of jute have been exported from India, both in raw form and also in the form of finished goods. Jute cultivation is mainly carried out in Bengal, Assam, Bihar, Orissa and in small quantities in the United Provinces. With the partition of the country into the Dominions of the Indian Union and Pakistan on the 15th August, 1947, the jute trade had been left in a quite unbalanced state. It is understood that the area under jute cultivation of undivided India was nearly 26 lakhs acres, with an annual production of 85 lakhs bales; and, out of such production, 30 per cent of raw jute was finding export market, 65 per cent was for mill consumption for the purpose of fabrication and the rest 5 per cent was put to other miscellaneous uses. The allocation of jute trade, on partition, has been estimated to be 27 to 30 per cent of area under cultivation for the Indian Union with corresponding percentages of production.

Jute cultivation can be most successfully carried out in high temperature regions where soil is of fine texture and is quite deep. Heavy rainfall and regular supply of water is required for the plants to be submerged for specific intervals, so as to get properly ret.

There are more than 100 jute mills in India and all of them now fall in the territory of Indian Union. So far as jute trade is concerned, the uneven distribution of raw jute production in India and Pakistan has placed them on different levels. However, arrangements for exchange between the two Dominions might result into proper settlements.

India is one of the most important sugar-cane growing centres of the world, with more than 4 million acres of land under cultivation. The best sugar-cane grows in the United Provinces and Bihar and Orissa, while cultivation, on small scales, is carried out throughout the country. In several cases, the quality of cultivated sugar-cane is found very poor and the sucrose percentage in the cane are quite low, but under the guidance of the Imperial Sugar-Cane Breeding Station, Coimbatore, and the Institute of Sugar Technology, Kanpur, the average quantity of extraction has been increased.

Sugar industry has considerably been progressing in India although there was imminent danger for foreign competition. In fact, the present strength of the sugar factories which are today more than 150 in number, is entirely based on the protective policy of the Government. The protection afforded through the recommendations of the Indian Tariff Board since the year 1930-31, has really led the sugar industry to exist in the country and expansion on a large scale has also taken place. The imports have a definite threat even today ; but the latest recommendations of the Tariff Board to continue the protective policy which was valid only up to 31st March, 1946, has offered further chances of security to the industry.

Crystal sugar production is carried out by series of processes. Sugar is produced by a regular process of mill cane crushing and, later, purifying the juice by modern methods of defication and filtration. Further refining of cane juice is carried out by the carbonation and sulphitation processes, which are operated in batteries, either in single or double, or combined. Juice is, ultimately, concentrated and crystal sugar is separated out. A huge amount of sugar-cane produced in the country, is extracted for the production of jaggery or crude sugar, known as *gur*, by ordinary crude country methods of open pan heating process. The comparative figures of *gur* production in the country are nearly 3 times that of the refined sugar which is nearly 10 to 13 lakh tons per year. Sugar refining from *gur* is also carried out at certain places. The *Khandsari* variety of sugar is also in production.

Other industries allied to the sugar refining, are the utilisation of molasses and disposal of bagasse and filter cake. Fermentation of molasses has been successfully carried out in few of the distilleries, attached to the sugar factories. Several million gallons of ethyl alcohol are produced in the country. The various uses of alcohol are popularly known. Its use as power alcohol may be considered the most promising one. Alcohol is also a product of interest to the medical profession, as large numbers of pharmaceutical preparations and tinctures are produced from it. There are other innumerable uses of alcohol in the preparation of chemicals, toilets and perfumery. Denatured spirits and methylated spirits have a wide commercial and industrial utility like that in French polishes, solid fuels and other miscellaneous products. Wines and spirits are also weak dilution of ethyl alcohol and are taken for human consumption, whereas prohibition programme, enforced by some of the Provincial Governments, might discourage this. During the process of fermentation of molasses, carbon dioxide gas is evolved as a by-product. Carbon dioxide gas is filled in cylinders for sale on commercial scale. It is felt that the utilisation of molasses in this way, would give a considerable relief to the sugar industry and help in bringing down the basic cost of sugar production. The disposal of bagasse may not be considered on serious lines, as it is finding use as boiler fuel. Attempts have been made to produce straw-board from the waste bagasse but no successful results on commercial scale have been recorded. Filter cakes, however, are sent to cane farms for use as fertilisers. There are other minor products of similar interest but they need not find any reference here.

STIMULANT CROPS : Some of the popular toxicant crops are tea, coffee, tobacco, opium, beetles, etc. The popularity of these crops is mainly due to the fact that some of the principal active ingredients of these crops induce habit forming features.

Tea is mainly grown in Assam and Bengal and a small quantity is cultivated in South India. It is understood that tea plantation in India had its steady progress, during a period of nearly 100 years, and there has been a marked and regular expansion in the line since the year 1940. The present area under tea cultivation is more than 8 lakhs acres with an approximate annual production of nearly 500 to 600 million lbs. The yield of tea per acre in different areas, varies considerably with a maximum figure of nearly 800 lbs. per acre in certain tracts in Assam, and with a minimum of nearly 60 lbs. per acre in United Provinces. Tea is regularly exported from India in large quantities; the figures of export range from 350 to 400 million lbs. every year which form nearly 70 to 75 per cent of the total production.

Coffee production in India is mainly confined to South, covering nearly 2 lakhs acres of total area under cultivation, with an average annual production of nearly 15,000 tons of coffee, although peak production figures upto 25,000 tons have been recorded in the year 1945-46. The main production of coffee is nearly 50 per cent from Mysore, 25 per cent from Madras, and nearly 20 per cent from Coorg. Indian coffee is also finding export market and considerable quantities of the same have been exported during the past years.

India is one of the major tobacco producing countries of the world. Tobacco cultivation is carried out in India on a fairly elaborate scale. The principal growth comes from the provinces of Bengal, Bihar, Bombay and Madras. It is understood that more than 12 lakhs acres of land are under tobacco cultivation in the country, with an approximate annual yield of 4 lakhs tons of tobacco. Tobacco is consumed in different forms. The primitive and crude form of smoking is done in the form of country pipe known as *hooka* in which heavier variety of tobacco is used. Other forms are cheroot, bidis, cigarettes, chewing tobacco, tobacco snuff and cigar, etc. Besides the local production, tobacco is imported in the form of fine varieties of cigarettes in large quantities and such imports are to the tune of several million rupees. Indian tobacco is also finding market abroad and huge quantities of the same are exported. Tobacco cultivation in India has been very much encouraged during the last 20 to 30 years. Serious efforts have, however, been made to improve the quality of tobacco crops.

Opium is another important toxicant product which is more commonly classified as a drug. The cultivation and consumption of opium is very much restricted by the Government and this is an item of very little commercial or industrial interest.

FOREST CROPS: A fairly large acreage in the dominion of Indian Union is covered by forests. The vast forest area, scattered over the length and breadth of the country, gives an infinite variety of forest vegetation which is dependent on various factors, *e.g.*, climatic conditions, the soil character, topographic situation, rainfall, etc. There are different forest zones in the country, based on the above factors ; and such regional peculiarities can be seen from the particular species of plants which grow there. The various types of forests are : (1) tropical forests; (2) sub-tropical forests and temperate forests ; (3) temperate forests ; (4) alpine forests ; (5) beach forests (6) bamboo forests ; and (7) other wild plantations.

There are series of natural advantages which are derived from forests. Besides the natural advantages, forests have huge importance of offering large number of industrial products, *e.g.*, the teak wood forests offer high quality timber woods which find use in constructional and building projects and is an indispensable item of daily requirements.

Bamboo, another product of forest origin, is finding utility in the pulp and paper industry. There are several species of bamboos which grow in the tropical, sub-tropical and temperate zones. The rubber plantations of South India which have wild forest growth, are quite popular and provide very important raw materials, to a number of rubber factories in India and abroad, in the form of raw rubber latex and raw India rubber. Some of the important varieties of wild forest grasses have also been in use in paper factories for the production of pulp. Rosin and turpentine, which are the products of great industrial importance in the paints and varnishes industries, are recovered from the resins of certain forest plants. Some of the natural gums and resins also find important industrial uses.

VEGETABLE OIL CROPS: There are a large number of vegetable oil crops which are widely cultivated in all parts of the country. Some of the important crops are linseed, castor seed, groundnut, cocoanut, cotton seed, sesamum, rape, mustard, mowra, etc. Vegetable oils have great industrial value as these are used in a good number of industries. The soap industry is consuming quite a big portion of the vegetable oils production. Soaps of various kinds, like washing soaps, toilet soaps, shaving soaps, soft soap, are presently being producd in the country on fairly large scale and they mainly consume mowra oil, castor oil, cocoanut oil, groundnut oil, til oil, cotton seed oil, etc. The soap industry affords an important by-product like glycerine which has innumerable industrial and commercial uses. Vegetable oils are also consumed for edible purposes, either directly or indirectly, after treatment. Margerine, a popular butter substitute, is also produced out of oils. Hydrogenation of oils like groundnut oil and cottonseed oil has gained prominence in India, during the war days. This industry was, however, in a stage of infancy just before the World War II, but presently it is quite well established and has, successfully, offered a useful ghee substitute. Oils are also largely used as lubricants for machinery. Some of the drying oils like linseed oil, poppy seed oil are most important raw materials for paint and varnish industry. Oils are also used for the production of cosmetics and hair oil preparations. In fact, uses of oils are too many to be recorded here. The production of stearine and oleic acid from hydrogenated products is also an industrial problem. The residue left after oil extraction, known as oil cake or oil meal, is largely recommended to be used as important manures and is also used as cattle food.

The oil seed production in India is carried out on a huge scale. There is always a big quantity available for export as country's own requirements are not very big. Indian seeds are getting an extremely good foreign market. Even oils are exported in huge quantities. Large quantities of oil cakes have been exported a few years back ; but for the last 3 to 4 years, exports of oil cake have been banned.

Vegetable oils can be grouped according to their uses, *i.e.*, drying oils, semi-drying oils, non-drying oils, edible oils, etc. It may not be possible to give details of the various groups but brief reference about individual crops could be made.

Linseed is grown in India in fairly large quantities and chief areas of cultivation are the provinces of Bihar, Orissa, United Provinces, Central Provinces and Berar, Hyderabad, Bengal, Bombay, Kotah and East Punjab. Huge proportion of linseed production has fallen to the share of West Pakistan. The specific drying properties of linseed oil have brought its use in the manufacture of paints and oil varnishes. It is also used in the production of oil cloth and linoleum, and in the preparation of printing inks and soft soaps. Various grades of treated oil, known as single boiled and double boiled, are put in the market. The linseed cake is found very useful as fertiliser.

Castor plants are prominently grown in Madras, Hyderabad, Bombay, Central Provinces, United Provinces, Bihar and Orissa. Huge quantities of castor oil are exported out of India. Castor oil has many industrial uses. It is largely used as a lubricant. Sulphonated castor oil, known as turkey red oil which is produced in different technical concentration, is largely demanded by the textile industry, cloth printing, dyeing works, leather tanneries and, as an important emulsifier, it has found use in large number of industries. Castor oil is also consumed for the manufacture of soaps. Refined castor oil has medicinal uses and is a popular type of cheap laxative. Minor uses of castor oil are in the cosmetics and toilet preparations. Castor cake also forms an important ingredient of the manures.

India is today one of the largest groundnut producing countries of the world. Chief cultivation centres for groundnut are existing in Madras and Bombay. Some of the important groundnut growing districts of Madras are Arcot, Chingleput, Cauvery valley and, in Bombay, the major production comes from Khandesh, Karnatak, Kolhapur, Sholapur, Poona and Satara. In fact, nuts are also eaten as dry fruit either in fresh or in roasted and fried forms. Groundnut oil is a very important food item as it is found to be a cheap nutritive agent. The hydrogenation of groundnut oil is being carried out in India on an advanced scale since it is found to be replacing ghee and other fats. Groundnut oil is also finding uses in various industries like soap manufacture and other miscellaneous industries.

Cocoanut is mainly a product of South India. Chief producing centres of cocoanut are the Malabar and Coromandel coasts. Other major centres of cocoanut production are the Travancore and Cochin States. Large quantities of cocoanut grow in the province of Madras, Kathiawar, Kanara and Bombay. Cocoanut oil is a very popular type of edible oil, with a peculiar flavour and finds use in the preparation of sweets and other edible products. Cocoanut oil is also finding use in the manufacture of large quantities of toilet soaps. There is a keen demand for cocoanut oil because of its great popularity. Cocoanut meal is largely used for edible purposes. Coir industry has also sufficiently developed in the cocoanut producing centres.

Rape seed cultivation is mainly confined to Northern India which include East Punjab, United Provinces, Bihar, Bengal and Orissa. Rape seed is also produced in some of the important districts of Western Pakistan and, proportionately, large quantities of the same are grown there. Rape seed oil is largely used for culinary purposes and is required for burning and lighting purposes. It also finds use as a lubricant. Rape seed cakes is also an important manure ingredient. Cotton seed oil is plentifully available from the cotton growing centres. Apart from its use as edible fat and in the production of soaps, cotton seed oil has also a good number of industrial uses. Cotton seed cake is largely used as good fertilisers. Mowra trees are largely grown in Bengal, Bihar and Central India and, to a little extent, in South India. Mowra oil is a major constituent of washing soap and is also used for producing cheap toilet soaps.

There are a large number of other vegetable oils like poppy seed oil, sesame oil, soya bean oil, neem oil, til oil, which have specific useful purposes for trade and industry.

HERBAL AND ESSENTIAL OIL CROPS : There is a wide range of herbal and essential oil crops which are artificially cultivated and are also widely obtainable. A large number of herbs and other plants useful for the production of medicines and drugs have been referred to, in the subsequent chapters. The production of essential oils is really a matter of great importance. No doubt, there is a good deal of scope for exploring the possibilities of producing essential oils in India but, in certain cases, the foreign synthetic products which are cheaply marketed, have really discouraged these productions. A few of the important items of interest may be camphor, menthol, thymol, borneol, oil of peppermint, oil of cinnamon, oil of cloves, etc. A large number of other products of allied interest to the perfumery, confectionery, aerated waters, etc., where flavouring agents are demanded in huge quantities, can also be considered under this heading. The oil of geranium, lavender, rosemary, nutmeg, caraway, etc., are some of the products which could be considered along with these. The production of eucalyptus oil and sandalwood oil which is being carried out on fairly large quantities in India, is finding a good export market. In fact, no definite attempts have been made in India to produce menthol, camphor, thymol, etc., for which some of the raw materials could be located. All these products may be conveniently grouped under the heading of fine chemicals.

FRUIT AND VEGETABLE CROPS : The fruit and dry fruit production is carried out in India on a satisfactory scale and there is a definite scope for the expansion of this line. There are not many fruit gardens in the country which are cultivated on a scientific line. It is absolutely essential to increase the fruit cultivation area as the importance of fruits can be very well recognised from the fact that they form a part of a valuable nutritive diet, hence availability of fruits at cheaper prices is essentially demanded. It is observed that major portion of the production of fruit gardens in the country act as food for the pests and birds. Proper use of fertilisers, insecticides and fungicides would, definitely, give healthy results. Efforts must be made to offer transport facilities for fruits, so that they may reach the consumers before decaying. The bad storage of fruits is a very common practice in the Indian markets, with the result that a large portion of fruits are wasted in transit. The fruit canning and fruit preservation industry is rather in a stage of infancy in the country and must be encouraged at all costs. The chief fruit for the purpose of canning that can be considered are mangoes, peaches, apples, pineapples, etc. The various other preserved products of interest are squashes and syrups which may also attract the attention of the manufacturers. The vegetable growth has got to be considered on more serious lines than fruits cultivation. They essentially form a basic part of the daily diet of the common man. The efficiency of vegetable cultivation and specific crop yield is of great importance and successful efforts could be made to follow scientific methods for the purpose.

WILD PLANTATIONS AND CROPS: There are good varieties of wild plantations and crops in the country. Some of these are found to serve the fencing purpose. Other innumerable type of plants do exist which have specific periods of growth and maturity and appear at regular seasonal periods whereas some of the crops have a permanent growth and bear fresh leaves and off-shoots every year. Some of the wild crops bear very good, sweet and useful fruits. There are several species of wild herbs which bear useful fruits. There are also some of parasite plants, like mistletoe, which grow by nature but have no use. Their growth must be stopped. There are also flowering plants which have a definite decorative value and, in some cases, they are affording good flavour and essences from flowers that are found to have specific values.

C. FUEL, POWER AND ENERGY:

The subject of fuel and energy has been receiving very slow and steady attention, from both official and non-official circles in the country. The scientific developments are the best guides and assist to investigate into the various prospects of fuel and' energy. It will have to be admitted that the availability of cheap fuel and energy can help in the advancement of industrial, agricultural and economic conditions of the country.

Cheap fuels and cheap energy are, invariably, the elements of urgent demand. Fuels like coal, petroleum oils and gases are found to serve manifold purposes. India is poor in her resources for coal, petroleum and other combustible fuels, and it is a matter of speculation to correctly give judgment about future prospects. There is a wide scope for further exploitation of all such available reserves of fuels. Apart from the fuel value, these are also utilised for the generation of power and energy. The basic value of fuels for the chemical processes in good many industries like metallurgical furnaces and other smelting operations, cement, glass, etc., is well recognised. The production processes of innumerable chemicals and certain products by the thermal reactions are quite well-known.

Steam and electricity are the main sources of energy and the same have, successfully, been harnessed for numerous industrial and other domestic purposes. Steam is generated from coal and serves the purposes of acting as a heating medium, and for the generation of mechanical energy. The electrical energy is produced from thermal stations and from hydro-electric sources and has gained sufficient importance in everyday industrial, transport projects and several commercial and domestic appliances. There are ample chances of producing electric energy in India, from the natural waterfalls and from the various river dams. There being a large number of streams, rivers and other waterways, considerable attention is required to explore the possibility of harnessing more and more water energy into useful power. It is, however, estimated that present hydro-electric projects are producing only negligible amount of energy as compared to the potential hydro-electric energy lying unexplored. It may not be worthwhile to enumerate the various uses of electricity ; but, at the same time, one may state that the present developments in all scientific and industrial activities of the various countries are entirely due to electricity.

A broad classification of various types of fuels may be referred to as solid, liquid and gaseous fuels and all these types of fuels serve as sources for heating purposes or for the production of steam or the generation of electrical energy. The various types of solid fuels that are having great industrial importance, are coal and coke. A few other solid fuels such as wood, saw mills waste, bagasse and tree barks are also used but they have limited scope.

In India, coal is used for various purposes, *i.e.*, for the generation of electrical energy or is consumed by railways and ship companies. Coal is used in good many industries either for supplying steam energy or for providing steam heat. Major industries like iron and steel smelting which use the coking coal, stand as the biggest consumers of this fuel. Other industries like that of cement, glass, ceramics, potteries require coal in large quantities. Coal has a marked utility in the chemical furnaces, oxidation and reduction operations, reverberatory furnaces and lime kilns. The distillation of coal and coal products also give innumerable series of important chemicals and dyes. Coal is also used for domestic purposes.

It is estimated that nearly 30 to 35 million tons of coal are raised every year and, out of such production, 30 to 35 per cent goes for consumption by the railway and about 25 per cent is taken up by iron and steel industry, including engineering workshops, about 10 per cent for textile, jute and paper industry, and about 5 per cent goes waste and the balance for miscellaneous industries and other purposes. The detailed figures of production and distribution of coal are given below:

PRODUCTION AND DISTRIBUTION OF COAL IN INDIA

Particulars	*1944*	*1945*	*1946*	*1947*	*1948*
			(*Thousand Tons*)		
Coal Raised	26,040	28.776	29.280	31,176	29,820
Coal Despatched	23,160	24,648	25,608	25,872	25,860
Distribution :					
Indian Bunkers and Export .	1,440	1,320	1,512	1,380	1,752
Railways	9,660	9,732	10,944	11,580	9,552
Electric Supply Co.	1,164	1,404	1,416	1,416	1,920
Iron and Steel Works ...	2,664	2,784	2,892	3,156	2,868
Cement	732	876	804	804	672
Cotton Mills	1,416	1,992	1,956	1,908	1,872
Jute Mills	408	456	600	516	636
Engineering	264	264	204	204	228
Paper Mills	312	396	408	312	408
Chemical Industry	84	120	132	144	144
Brick making	108	240	600	444	684
Others...	4,692	4,572	3,852	3,552	3,840

It may not be possible to give a correct idea about the coal reserves of the country but it is a bare fact that the position about proper utilisation of coals is not satisfactory. From the rate of consumption, it may not be beyond estimates to say that in about 50 years time, there might be a serious shortage of coal if new reserves are not brought to light. In view of such calculations, Government must take active steps either for conservation of existing reserves or make efforts to explore more resources. Some of the basic industries like iron and steel smelting which have the major requirements for coking coal, should be given preference by way of allotments and coking coal should not be diverted for any other purpose. Other grades which are suitable for distillation, should not be put to any use other than specified. The various varieties of coal are anthracite, coking coal, non-coking coal, lignite, bituminous, etc. All such varieties must go to their proper consumers. The coal mining, as presently carried out, is on a very poor standard. The process of mining is exceedingly wasteful and there are no provisions made for proper gradation. Much of the high grade stuff goes in waste coal. Further, the mining operations demand planned working. Adequate approach to deeper seams is required. It is, however, felt that permanent steps should be taken to check the various drawbacks in the coal mining industry and the production and distribution must be restricted. Consumers like railways should preferably be run by electrical energy.

The utilisation of powdered coal for industrial purposes has found a beneficial scope, as the high thermal efficiency attained by burning of powdered coal has found preferential use in industries like cement manufacture. Powdered coal is ranked as first-rate fuel, on account of its low cost of operation and maintenance. The old difficulties of finding proper use of powdered coal have been overcome with standing advantages.

Liquid fuels are mainly the petroleum and its allied products which may, further, be classified as light, medium and heavy distillates. The various commercial grades are petrol, kerosene, crude oils and furnace oils, etc. The various advantages of liquid fuels over the use of coal, are in labour saving, low operating cost, and the reduced maintenance and depreciation charges. The importance of liquid fuels has very well been realised during war days, and it is a matter of utmost certainty, that every nation in the world should either be self-sufficient in her natural resources of liquid fuels or must proceed towards seeking artificial methods of producing the same or, otherwise, look for substitutes.

The basic requirements of aviation spirits, motor spirits and lubricants, during war days, for military operations have brought home to the people the importance of liquid fuel. The output of Indian oil fields is really inadequate.

The partition of the country has, further, eliminated the oil fields of West Punjab. The oil fields of Assam are, however, being drained at full speed, and there are no further prospects of more supplies. Most of the requirements in fuel oils have, so far, been fulfilled through imports.

In view of the fact that mineral oil resources of the country are very poor, attempts must be made to produce liquid fuels by artificial methods. A good many processes of converting coal into liquid fuels have been successfully tried in foreign countries, *i.e.*, distillation of coal, hydrogenation of coal tar and also by trying synthetic processes. The utilisation of coal for such purposes should be given immediate attention

There are also other liquid fuels, like alcohol, more popularly termed as " power alcohol." Alcohol is produced in the country in ample quantities and there are very bright prospects for expansion in this line. India is an agricultural country and there are good many agricultural products like sugar molasses and various types of complex carbohydrates which, on fermentation process, can yield specific productions of alcohols. The present strength of sugar factories in India, indicates the extent of production of molasses which are obtained as by-products. The utilisation of molasses has been a big problem for the sugar manufacturers, during the past years. In fact, the utility of molasses in the fermentation process has really given a great inducement to the sugar factories for the installation of distilleries and maintain them as attached units, and is found to be the most beneficial plan. This not only helps in the disposal of molasses, but also for finding out dependable sources for one type of useful liquid fuel. It may be estimated that several million gallons of alcohol can be produced, if the molasses are diverted to fermentation process. Carbon dioxide gas which is a further by-product in the fermentation process can be recovered at a nominal cost and can be easily recommended for producing synthetic hydrocarbons, carbonates and other important compounds. It would be inadvisable to ignore such important problems of national value. The importance of gaseous fuels is limited and has a specific industrial value. The uses of various types of such gaseous fuels like water gas, producer gases, may be too detailed for this chapter. To sum up, it may be sufficient to state that there are no natural resources of gaseous fuels but, presently, artificial methods of production are carried out and they are being operated under limitations.

Although there are various forms of energy, yet the electrical energy is replacing every other form of energy in almost all branches of industry. This fact has fully been realised all over the world. It would require enormous amount of natural fuels for the generation of electric energy, and in order to preserve the fuel resources without retarding the progress of industries, it is absolutely essential to utilise the water energy which is plenty in India.

At the present time, India is striving much for the developments of industries and the demand for cheap power is of utmost importance. The generation of power through hydro-electric sources has, however, been drawing much of the attention of the Government, after the World War I. The steady development of hydro-electric projects in the various provinces and States in India, have given quite satisfactory results.

It may be difficult to correctly speak of power requirements of the country but it must be stated that continued efforts are needed to develop more and more resources of energy, as the electrification schemes require immediate promotion. Railways alone, which are covering several thousands of mileage on coal fuel, need to be run by electric energy. The utility of power for expansion of industry, agriculture, transport communication and other progressive social and domestic purposes is much on the increasing scale.

The latest figures of production of electrical energy are available from the tables, given overleaf, wherein details of distribution are also stated.

Hydro-electric centres, as they exist today, in the various provinces are being operated with beneficial motives as the

ELECTRICITY

Production and Distribution

Particulars	*1939*	*1940*	*1941*	*1942*	*1943*	*1944*	*1945*	*1946*	*1947*	*1948*
					(Million Kilowatt Hours)					
Electricity Generated	2,532	2,808	3,240	3,276	3,576	3,828	4,116	4,032	4,140	4,572
Electricity Sold—										
Domestic Consumption ...	180.0	195.6	208.8	196.8	214.8	235.2	285.6	325.2	355.2	403.2
Commercial Light and Small Power	102.0	106.8	117.6	117.6	128.4	169.2	205.2	214.8	204.0	234.0
Industrial Power	1,382.4	1,566.0	1,873.2	1,941.6	2,137.2	2,246.4	2,329.2	2,161.2	2,187.6	2,392.8
Street Lighting	54.0	57.6	58.8	44.4	36.0	32.4	36.0	49.2	50.4	50.4
Tramways	46.8	46.8	46.8	43.2	44.4	48.0	48.0	42.0	45.6	50.4
Electric Railway	168.0	165.6	186.0	202.8	208.8	216.0	213.6	219.6	222.0	222.0
Irrigation and Agricultural de-watering	64.8	74.4	82.8	69.6	69.6	69.6	93.6	103.2	121.2	118.8
Public Works and Sewage Water Pumping	108.0	115.2	123.6	128.4	140.4	150.0	162.0	168.0	170.4	176.4
Supplies to M.E.S.	13.2	13.2	19.2	25.2	32.4	45.6	66.0	64.8	44.4	94.8
Total sold ...	2,119.2	2,341.2	2,724.0	2,769.6	3,012.0	3,212.4	3,439.2	3,324.0	3,400.8	3,694.8

building of such projects, dams and bunds, definitely implement the irrigation schemes of the country and aids the agricultural production. The various provinces like Bombay, Madras, East Punjab, United Provinces, Bengal and Bihar, Orissa and Central Provinces and Indian States like Mysore, Hyderabad have got very big projects. Notwithstanding the fact that the power production is major issue, the basic factor of cost cannot be ignored. It had been observed that the various thermal units installed by, both private enterprise and the Government, are yielding current supplies at lower rates than from the hydro-electric centres. The reason for this is the high cost of maintenance and the same has a supreme importance.

The industrialisation schemes can only be put into practice if cheap availability of power is assured to the various consuming industries. The chemical industries, however, need power for various electrochemical and electrothermic processes, in addition to the usual work of driving machinery. The manufacture of good many chemicals is being advocated by the electrolytic method. Cheap electric energy is demanded for such purposes. Other electrometallurgical processes which need the development of electrothermic furnace operations can only be encouraged if cheap power is available. The current rates of power supply are very high and are unproportionate to the requirements at some of the centres. The present calculations are from 4 to 6 pies per unit whereas minimum of a pie per unit should be expected for the economic centres. It may be considered possible to stabilise the various industries, especially electrochemical and electrothermic industries, on the basis of such rates.

CHAPTER IV

HEAVY CHEMICALS

HEAVY Chemicals are, probably, the most important set of products which form basic raw materials for almost all industries. It is needless to enumerate the various industries that consume heavy chemicals as the utility of heavy chemicals is, doubtlessly, recognised to be of paramount importance. It is observed that no country in the world can flourish or progress without the heavy chemicals industry.

A large number of industries have been referred to, in the various chapters, *i.e.*, textile industry (cotton, silk, art silk, woollen), sugar refining, paper and pulp industry, glass, ceramics, potteries, enamels, rubber, match, plastics, drugs and medicines, dyestuffs and textile auxiliaries, explosives, chemical cotton and celluloid, portland cements, coloured and white cements, agriculture and fertilisers, adhesive and glues, manufacturing cosmetics and toilets perfumery, food and fruit preservation, beverages, alcohols and spirits, leather tanning, water proofing cloth, oil and leather cloth, paints, varnishes, lacquers enamels, and distempers, pharmaceuticals, soaps and other miscellaneous products. Strictly speaking, such industries are too many to be listed here. Classification of certain important heavy chemicals is done under three broad heads : (*a*) Sulphuric acid and allied products ; (*b*) Alkalis including salts of sodium and potassium ; (*c*) Miscellaneous chemicals.

A. SULPHURIC ACID AND ALLIED PRODUCTS :

SULPHURIC ACID : Sulphuric acid and its allied compounds are playing a magnificent part in the present-day chemical world. Its utility in almost all the industries, directly or indirectly, has been sufficiently recognised. This mineral acid is placed in first and foremost rank of industries of international value. Its importance can be judged from the list of dependant industries, *i.e.*, production of chemicals (hydrochloric acid, nitric acid; sulphates of alumina, ammonia, copper, iron and magnesium; superphosphates, turkey red oil, chlorosulphonic acid, bichromates of soda and potash), fertilisers, metallurgy, explosives, textiles, petroleum refining, electroplating, the storage cells and leather tanning industry. It is estimated that about 55 per cent of the present production of acid is being utilised in the manufacture of allied heavy and fine chemicals, the rest is used for other industries.

Sulphur, the chief raw material for the sulphuric acid manufacture, is not available in India. Italy and Japan were the pre-war sources of supply. These sources were cut off immediately after the World War II had been declared. Emergency arrangements were made with the United States of America for the supply of sulphur, during war days. In the meantime, the local resources of Baluchistan deposits of sulphur, were also attempted for exploitation by the Government of India. The purification of that sulphur ore, did not prove to be of much utility, as the cost of refining was very high. Other minerals which contain chemically combined sulphur, are available in plenty in India, *i.e.*, iron pyrites and gypsum. In Singhbhum district of Bihar, huge supplies of pyrites are found. Simla deposits, however, have given good pyrites of 40 to 45 per cent sulphur contents. No attempt has, so far, been made in India to utilise such sources of combined sulphur. The presence of arsenic as an impurity, is undesirable and has been detected in some of the deposits. Nitrate of soda or Chilean saltpetre is another raw material for the sulphuric acid industry. During war days, the nitrate of soda could not be imported, hence the manufacturers started using saltpetre (potassium nitrate).

There are 41 sulphuric acid plants functioning in the country, out of which 9 plants are worked on " Contact Process," the rest are operating on " Lead Chamber Process." Lead chamber process involves in burning of sulphur to sulphur dioxide and then oxidising the same to sulphur trioxide with the help of oxides of nitrogen that are produced by heating nitre or soda nitrate. The dissolution of trioxide of sulphur in water, is carried out in chambers made out of lead. The weak acid produced by this process is further concentrated by heating. The contact process is, however, a catalytic process ; where sulphur dioxide gas is oxidised to sulphur trioxide by passing over platinised asbestos. The use of vanadium pentoxide has also been introduced successfully. The acid thus produced after dissolution of gases in contact process, is of 98 to 100 per cent concentration and is of 1.840, specific gravity.

The contact process is much superior to the lead chamber process, on account of several reasons. In fact, the contact process is easier to operate than lead chamber process, and it needs less space for installation. The cost of production of acid in the chamber process is approximately one and a half times that of the contact. Such high cost in lead chamber process, is attributed to the fuel consumption for concentration of acid, from specific gravity 1.750 to 1.840 ; whereas, in contact process, the maximum concentration is obtained directly after oxidation. In chamber process the depreciation is also very high.

The prices of sulphur and other raw materials determine the cost of production of sulphuric acid. In the pre-war days, the rock sulphur was available at Rs. 100 to Rs. 150 per ton ; whereas, during the war period, prices of sulphur were so high that manufacturers who got releases from the Government preferred to divert the goods to the black market and the same fetched very fancy prices. Such fantastic price had considerably come down when imports were freely made after the war, and goods became available in the market at fair prices. Chile saltpetre was available at Rs. 60 to Rs. 80 per ton before the war ; but the highest market price, during war, even exceeded Rs. 300 per ton. As already stated, the non-availability of soda nitrate, during war period, compelled the manufacturers to use potash nitrate which is locally available in India and the same fetched prices from Rs. 500 to Rs. 800 per ton, depending on quality ; but, after partition of the country, saltpetre of good quality is available at fairly high prices, as major portion of the production are found in Pakistan.

Government were obliged to enforce control over the prices and distribution of sulphuric acid, during war days. Production was mainly requisitioned for the essential purposes and releases were made, on preferential basis, to those who had undertaken the war contracts of supply. The prices were regulated from region to region and were also specified for the various grades of concentration. The contact plant producers were being directed to release their acid at comparatively cheaper prices. The withdrawal of these controls was affected soon after war was over, as the emergency period had vanished.

The present annual production is estimated to be nearly 80,000 tons whereas the pre-war figures were 25,000 tons. The sulphuric acid industry enjoys natural protection because of the transportation and shipping difficulties. The shipping companies, at the same time, do not undertake transportation as acid is dangerous to handle. Even the freight is fairly high for hazardous items. The imports of sulphuric acid have been made to a very little extent and the same can be visualised from the figures given below :—

IMPORTS OF SULPHURIC ACID

Year	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	132.25	25
1938-39	131.40	29
1939-40	265.00	48
1940-41	111.75	35
1941-42	38.30	13
1942-43	22.90	8
1943-44	0.35	1
1944-45	1.90	13
1945-46	4.65	7
1946-47	4.65	10
1947-48	4.05	13
1948-49	5.20	9

Presently, the imports are practically negligible. The annual rate of production in the following years is as under :

PRODUCTION OF SULPHURIC ACID

Year	*(Thousand Tons)*
1937-38	26.8
1938-39	25.6
1939-40	30.7
1941-42	43.0
1942-43	40.7
1943-44	59.0
1948-49	80.0

From the production point of view, Bengal ranks the first place and the next is Bombay. The production at centres like East Punjab, Bihar and Madras might be expanded at a later date, when the resources of minerals containing sulphur (pyrites and gypsum) would be exploited on a commercial scale.

As regards further prospects of this industry, it will have to be admitted that India is, decidedly, far behind in her industrial advancements. It may not be difficult to imagine, that with the introduction of fertilisers manufacture in the country according to plans, the sulphuric acid production could be five times the present figures during the course of ten years. This, however, accounts for the installation of fertilisers plants, the schemes for which is bound to mature for the promotion of the country's agricultural production.

From the technical point of view, sulphuric acid industry is very much handicapped by way of materials of constructions for the reaction chambers, handling, storage and transportation of the acid. This is a problem of vital importance and is a real worry for a technician. Lead metal sheets, are mainly used for all types of constructions, like Glovers tower lining, reaction chambers, pipes and storage tanks. The concentration of weak acid is, however, done in fused silica equipments, and this arrangement is termed as the Cascade system. Pumping of acid is done by pumps made out of antimonial lead which is a hard variety. The jointing is done with asbestos.

Mild steel tanks are used for the storage of concentrated acid (sp. gr. 1.840). The utility of special alloys like stainless steel and monel metal has been suitably recognised, but the cheap availability of these alloys is difficult. These alloys are not locally produced in India. The Indian manufacturers are definitely at a disadvantage as they have to depend, entirely, on imports for such materials of construction. There was not much difficulty in obtaining the supplies of lead sheets before the war, but acute shortage was felt during the war period. Even today the sources for these products are very much restricted although war has been over since the year 1945. In the event of such dependability, attempts have to be made for the manufacture of equipments and look for opportunities of creating the replacement of parts locally.

As regards by-products from this industry, only nitre cakes or salt cakes are produced, depending on the use of potash or soda nitrate, and such cakes are further utilised for producing potash alum and Glaubers' salt, respectively. The production of A.R. and B.P. quality of sulphuric acid was also attempted successfully by a few manufacturers. Pure qualities of acid are in demand in good quantity by the analytical and pharmaceutical laboratories. At times, there are complaints about the purity of the stuff as, usually, the technique lacks in the production of standard grades.

HYDROCHLORIC ACID : It is one of the important mineral acid like sulphuric acid and has varied uses in good many industries. More important uses of this acid are in textile industry for the decomposition of lime soap, which is formed when cotton tissues are impregnated in fatty matter. It also finds use in galvanizing ; and in the metallurgy of copper, nickel, cadmium, zinc and bismuth ; for dissolving metals in this acid or mixed with nitric acid. The production of zinc chloride and ammonium chloride is also dependant on this acid. Hydrochloric acid is also used in other chemical processes, *i.e.*, for the production of chlorine, chloral hydrate, chloroform, methyl chloride, chloro-benzyl, alizarine, resorcine, salicylic acid, etc. There are other innumerable uses of hydrochloric acid as almost all chemicals of chloride group are prepared with the help of this acid.

The commercial methods for the production of hydrochloric acid, so far adopted in India, is by the reaction of common salt and sulphuric acid which are heated together. The hydrochloric acid gas, evolved as a result of this reaction, is absorbed in pure water. The commercial grades accepted by the market, range from sp. gr. 1.16 to sp. gr. 1.20 with a purity of 29 to 32 per cent.

The annual consumption of hydrochloric acid in pre-war days, was about 400 tons ; whereas the indigenous production was up to 350 tons. Small quantities of this acid have been imported in the past. The imports have, however, been declining and the same can be viewed from the actual figures of imports, mentioned hereunder :

IMPORTS OF HYDROCHLORIC ACID

Year	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	45.05	15
1938-39	37.10	19
1939-40	28.85	15
1940-41	21.45	17
1941-42	3.95	7
1942-43	2.02	3
1943-44	0.55	1
1944-45	2.00	5
1945-46	3.10	5
1946-47	1.20	4
1947-48	8.15	20
1948-49	4.50	14

The present annual production of acid has been 2,500 tons. It is believed by some circles that a state of over-production has arrived, as the high figure of present production was meant to meet certain urgent requirements of war which is now over. But it will never be wise to feel that a state of over-production is attained since the anticipated industrial developments in the country shall make the increased production entirely consumed.

The cost of production in different parts of the country varies considerably, depending on the various factors, *i.e.*, rates of sulphuric acid, salt, and fuel ; the manufacturing and other overhead expenses. The rates of salt and acid differ considerably on account of the elements of freight which vary for place to place. The availability of salt at cheap rate helps in cutting down the cost. The manufacturing and overhead expenses vary, depending on the unit size of manufacture and unit of organisation for production and distribution. With the abolition of salt tax ; the price level, originally maintained by the excise controls, has considerably changed and the availability and prices of salt are now, at the mercy of trade.

Synthetic hydrochloric acid is also produced by the burning of chlorine gas in the atmosphere of hydrogen gas. The acid is obtained at the cheapest cost by this process. Hydrogen and chlorine, both in gaseous form are obtained as by-products in the electrolytic manufacture of caustic soda. The cost of synthetic hydrochloric acid is estimated to be nearly one-fourth of the one, produced by the chemical process. Messrs. Tata Chemicals Ltd., have got fused silica equipments with fairly good production capacity. Other methods of acid production can also be employed but they have little commercial value at the moment.

Almost all the sulphuric acid manufacturers produce hydrochloric acid. As regards the materials of construction *i.e.*, reaction chambers, retorts, condensers and gas absorption containers, handling, storage and transportation of hydrochloric acid one has to face similar difficulties as those of sulphuric acid. The cast iron furnace pots meet high depreciation, if they are not properly looked after. Stoneware pipes and fused silica equipments are usually used for condensing purposes. For the purpose of pumping, hard lead pumps are also essential. The production of acid proof bricks for the lining of storage tanks is desirable. Special alloys and synthetic resins are being introduced as the commercial materials of construction, in other countries. The local production of these materials will greatly help in minimising the constructional and operating difficulties.

The production of chemically pure acid and of B.P. standard, is attempted by certain manufacturers. These pure acids find use in dispensaries and chemical laboratories. Some of the manufacturers have taken up the production of A.R. and C.P. hydrochloric acid. The technique of standardisation of final products must be given due importance.

The salt cake which is mostly a bisulphate of soda, is used for the production of Glaubers' salt. This, however, involves the consumption of soda ash for neutralisation of excess acidity.

NITRIC ACID : Nitric acid is a mineral acid of international importance, as some of the nitrate and nitro derivatives form key chemicals for explosives. Other important items of production from nitric acid are nitro cellulose, azo and diazo dyes and fertilisers. Gold, silver and copper refineries are also the consumers of nitric acid. Besides these uses, nitric acid has a very large number of industries to serve. The commercial qualities of nitric acid which are accepted by the market are of sp. gr. 1.40 to sp. gr. 1.42, with percentage of purity of 68 to 70 per cent.

The commercial method of production, as presently adapted in India, is by heating sulphuric acid and nitrates of sodium or potassium, depending upon the availability. Sodium nitrate is known as Chile saltpetre and is imported from abroad, whereas potassium nitrate is produced in several places in East Punjab, United Provinces and Bihar. The West Punjab share of saltpetre production is fairly large.

The pre-war annual productions of nitric acid was about 500 tons as against the present production which amounts to nearly 2,750 tons. The imports of nitric acid have, however, been on the decline, as is clear from the following figures :

IMPORTS OF NITRIC ACID

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	120.35	41
1938-39	...	...	65.75	27
1939-40	...	...	79.75	30
1940-41	...	...	38.75	21
1941-42	...	...	0.75	2
1942-43	...	...	..	..
1943-44	...	...	0.25	1
1944-45	...	...	1.35	4
1945-46	...	...	2.20	4
1946-47	...	...	2.35	4
1947-48	...	...	2.85	9
1948-49	...	...	4.95	13

There had practically been no imports during war years. It may be very unreasonable to state that a stage of over-production has been reached. In fact, the production will have to be doubled, in a course of 5 years, if the scheme for producing fertilisers and the planning of industries is actually brought into practice.

The cost of production of nitric acid varies considerably and the major reasons for such variations are the widely different rates of sodium nitrate and potassium nitrate. The rates of sodium nitrate range from Rs. 300 to Rs. 400 per ton whereas the rates of good quality of potassium nitrate ranged from Rs. 500 to Rs. 800 per ton which have, further, gone up after the partition. The pre-war prices of soda nitrate have been Rs. 60 to Rs. 80 per ton and that of potash salt up to Rs. 150 per ton, respectively.

The production of synthetic nitric acid by the oxidation of ammonia, has not been commercialised in India, so far. It may be anticipated that synthetic ammonia plants shall find a better field in the country when schemes for the production of fertilisers are matured. The process of fixation of atmospheric nitrogen into nitric acid either through the oxide of nitrogen or through ammonia, might entirely replace the present chemical methods of manufacture.

Nitric acid manufacture is carried out by almost all the sulphuric acid manufacturers. Chemical engineers have, however, been handicapped so far as the handling storage and transportation of nitric acid is concerned. The heating retorts are made of cast iron and the condensors are made out of fused silica. The production of fused silica equipments is a highly technical job and has not been taken up, in India; and for ordinary replacements and repairs, it is desired to look for imported parts. Stoneware jars are used for the storage and handling purposes. The contact of nitric acid with wooden structures must be avoided at all costs. Special alloys and resins, have been introduced as storage and reaction vessels in other countries; but in India, these are not very popular.

The production of B.P., A.R., and fuming nitric acid, has been taken up in India by a few manufacturing units. It is advisable to improve upon the technique of production and maintain the standard of products.

The by-products from the nitric cake is a mixture of bisulphate and sulphate of soda or potash, depending upon the used sodium or potassium nitrate. The soda bisulphate is converted into Glaubers' salt where the bisulphate of potash is directly used for the production of potash alum, without neutralising the excess acidity.

ALUMINIUM SULPHATE : The sulphate of alumina is very largely used for water purification and has definite uses in paper and textile industries. Further, it is used in the manufacture of water proofing agents and for the production of stearate of aluminium which is invariably used in the preparation of greases. Potash alum is formed if potassium sulphate and aluminium sulphate are crystallised, together in molecular proportion. The paper and textile industries prefer sulphate of alumina, free from iron, as the presence of iron does not give desirable shade in coloured paper and the consumption of the dyes is also more. In paper industry, it is actually converted into aluminium rosinate which acts as sizing agent.

Bauxite and sulphuric acid are the chief raw materials required for the manufacture of sulphate of alumina. Bauxite is available in plenty in India especially in Bihar, Central Provinces and Kashmir State. Aluminium sulphate is graded according to the aluminium oxide contents. The common grades are of 14 to 16 per cent alumina contents, while grades up to 18 per cent are also sent to the markets. The production of iron free aluminium sulphate is being carried out only by a few manufacturers. The present production of sulphate of alumina in India is, nearly 14,000 tons a year whereas in pre-war days it was nearly 6,000 tons. Alumina sulphate has also been imported, in India, in considerable quantities in the past year and the figures of import are as under :

IMPORTS OF ALUMINIUM SULPHATE

Year	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	2,387.95	138
1938-39	1,772.55	111
1939-40	2,290.65	198
1940-41	2,383.95	319
1941-42	496.00	51
1942-43	699.60	102
1943-44	2,236.75	323
1944-45	4,499.00	658
1945-46	1,887.95	382
1946-47	580.90	122
1947-48	920.40	290
1948-49	923.35	189

It is felt that the production can be pitched to the country's requirements and the imports can be stopped. The ruling prices of sulphate of alumina are quite competitive, and vary from grade to grade. Further reduction in prices of the same is also possible if the acid prices are reduced.

Sulphate of alumina is produced invariably by sulphuric acid manufacturers. The process of manufacture is very simple and it involves the use of lead lined tanks. The final concentrated liquor is allowed to crystallise in small moulds.

During the war, there was statutory control over the distribution of sulphate of alumina, as it was considered as an item of considerable importance. The control over distribution and prices, then enforced, was later on withdrawn, immediately after the war was over.

POTASH ALUM : The production of potash alum is also carried out universally by the manufacturers of sulphate of alumina. To start with, the nitre cake which is, usually, a mixture of sulphate and bisulphate of potassium is directly taken to the lead lined reaction tanks to which sulphuric acid and bauxite are already added. Chemical reaction is promoted with the help of steam operating in lead coils. The process of crystallisation is carried out in large cask type moulds.

Potash alum is a very important product of industrial value and is always in good demand. The pre-war production of potash alum was nearly 4,500 tons per year, although imports were also being made in heavy quantities. The figures of imports during the past few years are as under :

IMPORTS OF ALUM

Year	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	209.15	30
1938-39	196.15	30
1939-40	521.20	163
1940-41	732.35	565
1941-42	183.75	64
1942-43	152.65	31
1943-44	369.30	96
1944-45	829.10	202
1945-46	158.55	48
1946-47	81.30	27
1947-48	29.05	20
1948-49	6.25	4

The imports are on the decline and the present production can totally meet the country's demand. Potash alum is finding use in various industries like dyeing, tanning, paper industry and is, also, required for water purification.

Presently, potash alum is manufactured in reasonably good quantities in India and the figure of production is nearly double that of pre-war. The ruling prices are quite competitive and are in line with the cost of imported stocks. Prices can be further reduced if cut is made in the cost of sulphuric acid.

SODIUM SULPHATE : The hydrated sodium sulphate is known as Glaubers' salt. It is largely used as mordant in the dyeing process, in textile industry. Sodium sulphate of B.P. qualities is used as a medicine. It is also largely used in paper industry in the soda sulphite process. The natural sources of sulphates of soda, have been located in Bihar where it occurs as Khari salt with 75 to 80 per cent sodium sulphate contents. Deposits of sodium sulphate have also been found in large quantity in brine lakes of Rajputana. Huge stocks have been estimated at Didwana in Jodhpur State where plants for the manufacture of sodium sulphide have been installed. Sodium sulphate gives sodium sulphide, on chemical reduction. Sodium sulphate is also used in glass industry and for the production of sodium silicate.

Sodium sulphate is produced from the salt cake which is obtained from the hydrochloric acid manufacture. It is also produced as by-product in the manufacture of potassium bichromate but it contains about 2 to 3 per cent of mechanically adhered bichromates. The crude stock of sodium sulphate from bichromate factory can directly be utilised for the production of sodium sulphide.

Commercially, there are three varieties of sodium sulphate and are differently used. The sodium sulphate crystals (Glaubers' salt) which contains 43 per cent sodium sulphate and 56 per cent water of crystallisation are used, principally, as a leveller in dyeing wool and silk, for the precipitation of barium sulphate or blancfixe, for neutralising of sulphonated oils, for treating softened boiler feed water and also used for salting skins. The sodium sulphate anhydrous which is 99 per cent pure, does not contain any water of crystallisation. It is used for diluting dry dyestuffs and is also consumed in tanning industry and it serves similar purpose as that of Glaubers' salt. Sodium sulphate technical (salt cake) is used in the manufacture of sulphate pulp in paper and glass industries and in the manufacture of sodium sulphide.

The rate of imports of sodium sulphate during the past years can, however, be viewed from the following figures :

IMPORTS OF SODIUM SULPHATE

Year	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	1,674.45	85
1938-39	1,724.60	95
1939-40	1,717.40	127
1940-41	605.45	74
1941-42	1,120.45	160
1942-43	860.40	135
1943-44	364.00	55
1944-45	51.70	8
1945-46	24.05	7
1946-47	39.00	17
1947-48	8.30	11
1948-49	45.75	29

The present annual output of sodium sulphate is 2,000 tons and is produced mainly as by-product.

The imports of this commodity are gradually vanishing as the present production is quite sufficient for the country's requirements.

IRON SULPHATE (GREEN COPPERAS) : Ferrous sulphate is also known as green vitriol. Its main use is in the ink industry. In mineral khaki dyeing, it is used for the purpose of toning reddish tinge of the dye and is much used in calico printing. In fact, the iron salts of natural gallates are responsible for giving special tints and shades.

The raw materials required for the manufacture of iron sulphate, are scrap iron and sulphuric acid. Its cost of production does not differ much with the different manufacturers, except that proper efficiency has to be attained in the crystallisation process. The present production, however, is in line with the demand. The pre-war production was nearly 500 tons. It is imported in India in small quantities. The figures of import, during the past few years, are as under :

IMPORTS OF FERROUS SULPHATE

Year	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	46.05	8
1938-39	155.80	36
1939-40	59.20	21
1940-41	12.65	4
1941-42	6.50	7
1942-43	7.66	7
1943-44	2.30	3
1944-45	3.65	5
1945-46	9.80	8
1946-47	7.00	9
1947-48	1.20	3
1948-49	32.05	15

The qualities produced by a few manufacturers are very poor and the product is, sometimes, completely oxidised before it reaches the consumers. No special care is being taken to the storage of the commercial quality as there is no regular demand of this product. It leaves the manufacturers at very cheap rates and they do not care to pack it properly. The production of ferrous sulphate (A.R. quality), though a line of minor interest, can be developed on small scale. The production of ferrous ammonium sulphate, a stable salt of ferrous sulphate and ammonium sulphate, can also be attempted on small scale ; but there is limited demand and such articles can only be manufactured if specialised equipments for vacuum crystal drying are made available. There is over-production of this commodity in the country and imports are not at all wanted.

COPPER SULPHATE : Copper sulphate is also known as blue vitriol. It finds use in calico printing and for the production of copper pigments, *i.e.*, lime blue, copper chromate, blue verditer ; in the preparation of copper log-wood ink to prevent rot in timber and for making it fireproof. Its most important use is in the manufacture of fungicide and insecticide, especially for use in tea and rubber estates. It is also used in the electrometallurgical process and for electrolytic refining of copper and, in pure form, it is used as analytical reagent in the laboratories. The diazo colours are made permanent by the use of copper sulphate. It has other varied uses and is used as base for the production of copper electroplating chemicals, like oxide, chloride acetate, nitrate, carbonate and other complexes of cyanides, double cyanides, pink copper salt for the plating baths and, also, for the production of bronzing solutions. In the medical profession its uses are recognised as tonic, astringent and emetic, but in large doses, it is an irritant poison. Its use has been recommended in dysentery, diarrhœa, epilepsy, hysteria, etc.

The copper metal scrap is oxidized by the process of heating in special furnaces and is, later on, converted into sulphate by the action of sulphuric acid. There is deficient supply of copper metal and scrap in India. The production of copper sulphate from copper pyrites has not been properly attempted. On a small scale, certain manufacturers use waste liquor from silver refineries which are, primarily, nitrate solutions and are reacted with sulphuric acid. Nitric acid is obtained as a by-product in this process. The production cost of copper sulphate is practically negligible in this process; as the nitric acid thus produced, compensates for the cost of liquor. This process is, of course, carried out on a small scale operation and cannot be recommended as a commercial one.

There are, at present, more than a dozen manufacturers who are concentrating on the production of this commodity. Production of copper sulphate is being carried out on irregular scales in India, and it is very difficult to lay one's hand on the pre-war figure. It is, however, recorded that 424 tons of copper sulphate were produced in the year 1948. The figures of imports during the past few years are given below :—

IMPORTS OF COPPER SULPHATE

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	1,745.75	554
1938-39	...	...	1,420.75	426
1939-40	...	...	1,906.05	737
1940-41	...	...	980.30	452
1941-42	...	...	1,167.45	634
1942-43	...	...	2,233.80	2,002
1943-44	...	...	1,658.70	1,246
1944-45	...	...	1,606.35	1,208
1945-46	...	...	603.55	398
1946-47	...	...	801.65	534
1947-48	...	...	1,309.70	630
1948-49	...	...	1,276.45	957

The cost of production of copper sulphate is quite competitive and the import prices are, sometimes, prohibitive. The imports may, however, be discouraged and the local manufacturers may be given facilities to maintain the production figures and they must be given assistance to procure the necessary raw materials. The material of construction needed for the production purpose, should be acid resistant. Monel metal containers are generally preferred.

MAGNESIUM SULPHATE (*Epsom Salt*): Hydrated magnesium sulphate, in very pure form, is very well known to the medical profession as " Epsom Salt." It is also used for sizing purposes in textile and paper industries and as an oil draining agent in paint and varnish industry. Attempts have been made to prepare it from natural sources like sea bittern along with magnesium chloride but by this process it is difficult to attain the proper purity.

Epsom salts both in technical and B.P. grades, are being produced in India mostly from magnesite and sulphuric acid. Magnesite is, chemically, magnesium carbonate and is found in sufficiently pure condition. Good quality magnesite is produced in places like Mysore and Madras and Idar State in South India.

The prices of magnesite at the mine pit, are fairly low ; but the freight expenses are comparatively high. Dolomite which is a natural mixture of magnesium carbonate and calcium carbonate is also used as raw material. Dolomite is also available in plenty and can, advantageously, be used in the absence of magnesite as calcium carbonate does not much effect the final product.

The process of manufacture involves the chemical reactions of magnesite with sulphuric acid in lead lined equipments and, later on, other processes of crystallisation and purification are followed. More than two dozen manufacturers are producing this salt in the various centres in the country, on a reasonably big scale.

The present production of Epsom salt in India is about 1,200 to 1,500 tons. Epsom salt has been imported in good quantities, as is evident from the figures of imports of the past few years, but the same have been declining and the present imports are practically nil.

IMPORTS OF MAGNESIUM SULPHATE

Year	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	439.25	53
1938-39	388.35	46
1939-40	185.10	32
1940-41	42.05	25
1941-42	27.60	21
1942-43	16.60	14
1943-44	30.85	28
1944-45	44.20	43
1945-46	17.05	18
1946-47	30.35	26
1947-48	52.10	56
1948-49	0.75	1

Epsom salt B.P. quality is consumed in big quantities in all parts of the country. The stage for self-sufficiency of production and consumption has already been attained and there is a good deal of competition in the local market for this item and trade prices for the same are maintained at a reasonable level. In fact, there are good chances for exporting this commodity.

As regards by-products, carbon dioxide is produced during the chemical reaction but the quantity of gas in this particular operation is not worth considering it as a commercial problem.

B. ALKALIS INCLUDING SALTS OF SODIUM AND POTASSIUM :

CAUSTIC SODA : Caustic soda is one of the popular chemicals which possess first rate importance in the industrial fields. Its value can be judged from the fact that almost all big industries require this chemical for one purpose or the other. It is also an essential raw material for the manufacture of all types of soaps. In addition to this, it is used in paper factories for the production of pulp from different raw materials like wood, bamboo, grass and rags. In textile industry, it finds several uses, *i.e.*, for cotton mercerization in rayon and artificial silk industries, and in cellulose film manufacture. Further, it is used in industries like dyestuff, explosives, metallurgy, ceramics and for other miscellaneous purposes.

Caustic soda is used in rubber reclaiming processes and finds use in the petroleum refining industry. In the production of vegetable oils and in electroplating and litho-printing process, caustic soda is used in good quantities and, to some extent, in the production of adhesive and glues. Other important uses of caustic soda are for the manufacture of cosmetics, toilet preparations and disinfectants. It finds use as a degreasing and cleaning agent in all types of processes and as an insecticide for plantations. Caustic soda is also used as raw material for the manufacture of a large number of fine and heavy chemicals and other miscellaneous products like textile auxiliaries. It has a marked utility in innumerable organic and inorganic processes.

Caustic soda is produced by two different processes, *i.e.*, electrolytic method and the chemical method or the causticization process. The electrolytic method involves in producing caustic soda by electrolysis of common salt solution in special electrolytic cells, with or without diaphragms. There are good many patents obtained for the operation and construction of such plants in foreign countries. The chief raw material in this process is pure common salt, which is chemically sodium chloride. Salt must be free from impurities like sulphate. The graphite anodes which form an important constructional parts of cells, deteriorate at a rapid rate if sulphate contents of salt are found high. These electrolytic cells are mostly the mercury cells. Chlorine and hydrogen gases are released as a result of electrolytic and chemical action. The weak caustic lye obtained from this process, is concentrated in evaporators, where excess salt is, also, separated out, during the process of concentration. Ultimately, strong solution is fused into a solid mass in cast iron pots. In the causticization method, soda ash and lime are used as raw materials. This process is also carried out economically under specific conditions of temperature and concentration.

There are a few caustic soda manufacturers in the country and the prominent ones are: Messrs. Mettur Chemicals and Industrial Corporation Ltd., Mettur Dam; The Alkali and Chemical Corporation of India Ltd., Rishra near Calcutta (a subsidiary company of Messrs. Imperial Chemical Industries (India) Ltd.; The Tata Chemicals Ltd., Mithapur. It is reported that some of the paper mills in India have also small plants of caustic soda and they produce the same for their own requirements.

The Mettur Chemical and Industrial Corporation Ltd., Mettur Dam, started operations of plant in the year 1941, whereas its factory erection was taken up as early as 1937. It is an electrolytic plant, with a production capacity of nearly five tons per day. They have provisions to produce bleaching powder, liquid chlorine and also to recover hydrogen. The Alkali and Chemical Corporation of India Ltd., have got their plant at Rishra and it is also an electrolytic plant. Their factory at Khewra in Jhelum district of Western Pakistan have got a soda ash plant with capacity of 60 tons per day. This plant began operations in the year 1944. They also propose to carry out production by the chemical method. The Tata Chemicals Ltd., Mithapur, have an electrolytic plant of caustic soda with a capacity of 2,000 tons per year and they have provisions for production of 6,000 tons by chemical method, using soda ash as raw material.

It will be worthwhile to note that all these plants are operating under capacity. The total production during the last year has been more than 4,000 tons. On the other hand, the plants attached to the paper factories are producing nearly 14,000 tons of caustic soda.

PRODUCTION OF CAUSTIC SODA

Year	*Quantity (Tons)*
1947	3,314
1948	4,383
1949 (Jan.-March, 3 months) ...	1,528

Caustic soda is being imported in India in a very large quantity, and the local production is comparatively very little. The figures of imports during the past few years are as under:

IMPORTS OF CAUSTIC SODA

Year	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	25,924.25	4,281
1938-39	250,56.70	4,545
1939-40	35,680.65	7,231
1940-41	34,940.90	7,562
1941-42	26,589.60	6,757
1942-43	27,559.00	8,337
1943-44	35,354.90	11,091
1944-45	42,230.55	13,058
1945-46	37,908.50	11,674
1946-47	29,890.75	8,938
1947-48	21,231.05	11,184
1948-49	91,589.80	76,504

The commercial demands of caustic soda which were nearly 30,000 to 40,000 tons per year have presently been stretched up to double. The probable break-up of such requirements has been roughly estimated to the order of soap industry from 30,000 to 35,000 tons per year; in textile industry, 20,000 to 25,000 tons; in paper industry about 25,000 to 30,000 tons and for other miscellaneous purposes from 7,500 to 10,000 tons making a total rough estimate of nearly 80,000 to 100,000 tons during the course of the next five years. Such estimates are a bit on the higher side but scope is being kept for all-round industrial developments, with a view that series of new consumer industries would come into existence.

The Indian Tariff Board examined the case of this industry in July, 1946 and recommended protection to the local producers of caustic soda. The figures of cost production and the landed cost, were compared and the case for the grant of subsidy was forwarded to Government of India with an assumption that the landed cost would be from Rs. 15 to Rs. 16 cwt. It was based on the figures supplied by Messrs. Imperial Chemical Industries (India) Ltd. The cost of production by Messrs. Mettur Chemical and Industrial Corporation Ltd., was examined to be above Rs. 19 per cwt.

The imports position of caustic soda in India was quite satisfactory before war, but during the war period, the situation deteriorated as the foreign supplies were inadequate. Caustic soda was available at Rs. 8 to Rs. 10 per cwt. before the war whereas prices went up nearly to Rs. 20 per cwt. during war period. The monopoly for the supply to India markets had all along been held by Messrs. Imperial Chemical Industries (India) Ltd. Caustic soda was released under the direction of the Chemical Directorate of the Government of India when controls were enforced, during war. The unofficial market prices were very high. Immediately after the war was over, there was further deterioration in the world's supply position of alkalis. Quotations from abroad became very unsteady and the trade position was badly shaken at that time in India. Caustic soda was then very scarce with the result that blackmarket prices went as high as Rs. 150 to Rs. 250 per cwt.

The fluctuation in prices during the year 1947 and trade quotations from foreign countries like U.S.A., U.K., Belgium, indicated that the world's alkali position had gone beyond control. The import position of caustic soda was unsatisfactory till the end of the year 1947 and even the prices were fairly high. Later, in the beginning of the year 1948, imports were allowed more liberally from U.S.A. and, by the middle of the year, more and more licences for imports were issued by the Commerce Ministry to several importers with the results that the imports allowed in this way had practically crossed the stock saturation limit in the markets and prices fell considerably much below the cost. The market position was unsteady till the end of the year 1948 when caustic soda prices sank so low that most of the importers who had to hold the stocks on account of non-availability of the customers were obliged to offer stock at desperately low prices and the price level touched a point ranging from Rs. 20 to Rs. 25 per cwt. There has not been much improvement in the prices till the end of August, 1949, and prospects of recovery of markets are indefinite. It is, however, absolutely necessary that the import position must be regulated till the period Indian production comes up to a level of self-sufficiency, otherwise, such drastic fall in prices in the imported quality would be extremely dangerous to the manufacturers.

The only solution for such odd circumstances is that the local production of the existing plants should be pitched to the maximum quantity and more plants must be set up at almost all the port stations. The country's demand ranges at least from 10 to 15 times the present local production. With reviewed import policy of the Government, it has been considered appropriate to import plants for the manufacture of soda caustic in India. Inexhaustible sources of sea salt are available and attempts can be made to get cheap electrical energy on a large scale.

SODIUM CARBONATE: Sodium carbonate is commercially named as soda ash. This is one of the indispensable chemicals of the present age. There are two varieties of soda ash, *i.e.*, light and heavy. Both the varieties are largely used in almost all the big industries. Amongst important consuming industries are textile industry, where cleaning of fabrics and yarn are done because of its mild alkaline character and detergent properties. Glass industry consumes soda ash on a large scale, as it goes into the chemical composition of glass. Other consumers of soda ash are soap factories, ceramic industries including glass works and enamel works, paper factories, rubber factories and also metallurgy. Besides these uses, the major proportions of soda ash are consumed for washing and cleaning purposes.

Messrs. Imperial Chemical Industries (India) Ltd., have all along been holding a monopoly in this line and have been marketing Crescent Brand Soda Ash (imported from U.K.) and Magadi Brand (imported from Magadi, East Africa). The figures of imports for the past years are as under :

IMPORTS OF SODA ASH

Year			*Quantity* (*Tons*)	*Rupees* (*Thousands*)
1937-38	...	...	74,381.60	5,958
1938-39	...	...	65,426.30	6,088
1939-40	...	...	81,049.20	7,817
1940-41	...	...	83,572.20	9,036
1941-42	...	...	73,604.90	8,080
1942-43	...	...	66,559.45	9,515
1943-44	...	...	50,806.05	7,585
1944-45	...	...	78,877.80	12,282
1945-46	...	...	78,344.35	11,618
1946-47	...	...	57,883.30	8,782
1947-48	...	...	67,948.40	13,275
1948-49	...	...	162,593.60	53,189

It is clear from the figures that imports of soda ash are being made on a fairly large scale and during the year 1948-49, abnormally large quantities have been imported from the various countries like U.S.A., France, Poland, and England. Besides the huge imports of soda ash from abroad, small quantities of the same are also produced here in India.

The Solvay Ammonia Process is chiefly followed for the manufacture of soda ash and the raw materials required for the purpose are sodium chloride, limestone and ammonia which can be made available, in India, in plenty. A couple of plants working on this process, are in operation in India, *i.e.*, Tata Chemicals Ltd., at Mithapur and Dhrangadhra Chemical Works, at Dhrangadhra. The Alkali and Chemical Corporation of India have their plants at Khewra in Jhelum district of Pakistan. In the first two plants sea brine is used whereas the rock salt is used in the third. Inexhaustible sources of limestone of good quality are available at all these places. Lime, which is produced from limestone, finds use in the production of bleaching powder from chlorine, where the caustic soda is produced by the electrolytic decomposition of common salt. Lime is also used in the caustic soda manufacture by the causticization process. The ammonium chloride which is produced as by-product is used in cycle as a source of ammonia. The bicarbonate of soda is formed as primary product which gives sodium carbonate on calcination and the produced carbon dioxide gas is again used in the process. The Leblanc Process is not very economical. This process involves in the reduction of salt cake which is produced as by-product from the hydrochloric acid industry. Salt cake is converted into sodium carbonate by heating with coal and limestone powder on the bed of a reverberatory furnace. It is difficult to encourage production by this method as it is more expensive than the Solvay Process.

The manufacturing cost of the indigenous soda ash is fairly high as compared to the cost of the imported stuff, but during the scarcity period in war days, the manufacturers advanced their production and started finding consumers though at higher prices. It is estimated that about 30,000 to 40,000 tons of soda ash could be locally produced with existing plants but the question of price is unfavourable.

PRODUCTION OF SODA ASH

Year	*Quantity (Tons)*
1947	13,624
1948	28,200
1949 (Jan.-March, 3 months) ...	9,200

The present production of the existing plants is under-capacity as the plants of Messrs. Tata Chemicals Ltd. have not gone in for full operations and the Khewra plants of Messrs. Alkali and Chemicals Corporation of India Ltd., are eliminated as a production source for all practical purposes.

Out of present imports of soda ash, approximately 50 per cent is supposed to be used for the washing and cleaning purposes and the important industries like glass, textile and the paper are each taking up about 12.5 per cent. The remaining 12.5 per cent is used in the manufacture of silicate of soda, bichromates of soda and for miscellaneous chemical purposes. The demand for soda ash might increase on account of its progressive use for industrial purposes, especially when caustic soda need be produced by the causticization process.

Soda ash was sold at Rs. 3 to Rs. 4 per cwt. before the war, but, during the war, prices have been maintained from Rs. 8 to Rs. 10 per cwt. ; though the unofficial market prices went up two to three times. The post-war period has been still worse and prices rose up to Rs. 50 to Rs. 60 per cwt. The markets abroad were also dislocated during the year 1947, and quotation from Rs. 25 to Rs. 30 were received from American and other foreign exporters.

The cost of production of the indigenous soda ash has always been high ; but the manufacturers could easily compete the imported soda ash in prices when higher quotations were being received from abroad after the deterioration of supply position there. During the year

1948, the imports were allowed on liberal scale and the prices went down even below cost and the imported stuff from U.S.A., Poland, France and other countries could hardly find market. The position of soda ash market is similar to that of caustic soda and the reduction of price which started from the middle of 1948, brought the price level below Rs. 20 per cwt. ; and till the end of August, 1949, there has been no improvement. The case for protection to this industry has also been examined by the Indian Tariff Board during the month of July, 1949, and complications arisen out of liberal imports are duly considered.

The future prospects of this industry are very doubtful as the equilibrium of the trade has been badly shaken. To ensure the establishment of such important industries in the country on sound lines, the Government should provide facilities for cheap access to sea salt, ammonium salts and limestone and also offer coal.

Prospects for production of soda ash on large scales at the port stations in India need be considered and it is, however, desired that about half a dozen plants of 10,000 to 15,000 tons capacity may be installed to enable the country to depend on her own production.

SODIUM BICARBONATE: Sodium bicarbonate is the primary product in the manufacturing process of soda ash by soda ammonia process. Refined qualities of sodium bicarbonate of the standard B.P. or U.S.P. specifications, are finding use for medicinal and pharmaceutical purposes. It is also used in the manufacture of foam and soda type fire extinguishers. Sodium bicarbonate is also used in the manufacture of baking powders.

Indian manufacturers who are engaged in the manufacture of soda ash, can also produce this chemical but main attention has to be paid to the cost of manufacture which is not quite favourable as compared to the cost of imported stuff. It is recorded that the production figures of indigenous soda bicarbonate were to the tune of 495 tons during the year 1948.

The country's demand has, previously, been satisfied through imports. The figures of imports in the previous years have been as under :

IMPORTS OF SODIUM BICARBONATE

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	6,208.05	561
1938-39	...	...	4,692.05	484
1939-40	...	...	6,338.70	747
1940-41	...	...	6,312.05	889
1941-42	...	...	5,499.15	848
1942-43	...	...	3,956.25	752
1943-44	...	...	3,423.55	723
1944-45	...	...	4,559.75	1,017
1945-46	...	...	4,661.40	1,100
1946-47	...	...	7,449.55	1,656
1947-48	...	...	5,233.95	1,415
1948-49	...	...	14,200.25	4,689

Messrs. Dhrangadhra Chemical Works have been successful in producing bicarbonate of soda and have given a product of desired standard. Messrs. Tata Chemicals Ltd., have the facilities for the manufacture of the same and their production can help in curtailing the imports. Attempts have yet to be made for improving upon the efficiency of production and also in cutting down the cost of manufacture. As regards prices, the range varies from Rs. 12 to Rs. 20 per cwt. but, lately, the market prices have risen above three to four times, and the pre-war cost of imports ranged from Rs. 5 to Rs. 8 per cwt. A very large amount of bicarbonate of soda has been imported during the year 1948-49 and there is a considerable cut in the prices.

SODIUM SULPHIDE : Sodium sulphide is a chemical of huge significance for various industrial purposes. Its manufacture was taken up in this country only during war days, whereas in the pre-war days all the requirements were fulfilled from imports. It is used in leather tanning industry to remove hair from calf skin and cow hides and from sheep skin from which wool has also been removed. Its utility in the manufacture of, and application of sulphur dyes has been well realised. Other uses of sodium sulphide are in degumming of silk, denitrating of nitro-cellulose rayon, in the preparation of sodium polysulphide solutions, leaching gold ore tailings, dissolving cresol from coal tar oil, boiling out linen and depositing mineral pigments on cotton.

Sulphur colours have proved good substitutes in the absence of vat colours ; and during war days, such applications assisted a lot, thereby creating an increased demand for sodium sulphide. The following figures of imports clearly indicate the extent of demand in the past :

IMPORTS OF SODIUM SULPHIDE

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	3,138.15	328
1938-39	...	...	1,518.65	211
1939-40	...	...	3,673.90	701
1940-41	...	...	2,517.50	595
1941-42	...	...	3,307.40	1,131
1942-43	...	...	1,984.25	800
1943-44	...	...	1,524.30	729
1944-45	...	...	1,975.35	724
1945-46	...	...	2,858.45	1,024
1946-47	...	...	1,500.50	494
1947-48	...	...	1,018.90	771
1948-49	...	...	3,456.60	2,460

The short supplies from abroad during war period could not meet the increasing demand in the country and, at that juncture, the manufacture of sodium sulphide was taken up in India by a few manufacturers.

The process of manufacture is quite simple and involves in the chemical reduction of sodium sulphate into sodium sulphide with the help of coal or other reducing agents and, thereafter, the black mass obtained, is purified and fused. The cost of production works out to be high, as compared to that of the landed cost of imported stuff. The local demand was estimated up to 3,000 tons per year during war days; but with the decreased demand in textile dyeing, the current requirements are being estimated up to 1,500 tons (*i.e.*, textile 600 tons, leather tanning 600 tons, and 300 tons for other miscellaneous uses).

It will have to be admitted that the producers of sodium sulphide in the country hardly cared to send this chemical to the market in the desired form. Heaps of money were collected for black ash, produced by the fusion of sodium sulphate with coal. Fabulous prices were charged for low standard goods. Prices went up as high as Rs. 80 to Rs. 100 per cwt. for black ash whereas 60 to 62 per cent fused sodium sulphide imported from abroad could be marketed up to Rs. 35 per cwt., at a restricted price enforced through the textile controls. In view of the poor quality of product and high cost figures, locally produced sodium sulphide could not be marketed with the result that Indian producers have been now obliged to suspend their production. This industry has really failed to receive any encouragement from the traders as well as from the local manufacturers. Sodium sulphide industry is, however, in a pitiable state of affairs and the manufacturers have to be blamed for their inefficiency and dishonesty.

Plentiful resources of raw material are available in the country. With political changes in the country, the revised import policy of the Government of India have again brightened the prospects for local manufacturers who, in turn, should shoulder the responsibility of producing genuine products at fair prices. The production capacity of some of the erected plants is quite enough to meet the indigenous requirements. Besides these small scale production plants, the Jodhpur plant which was started at the instance of Government is one of the biggest unit of 3,000 tons capacity and has ample raw material resources, around the place. The case for the protection of this industry has duly been considered by the Indian Tariff Board during the year 1946-47.

POTASSIUM HYDROXIDE AND POTASSIUM CARBONATE : The hydroxide and carbonate of potassium are the chemicals of alkali group like that of caustic soda and soda ash series. Potassium hydroxide is mainly used for the production of soft soaps which are largely required for the textile industry. It is also recommended for special soaps like shaving creams and soaps and also for the production of face creams and snow. Further, it is utilised for producing a large number of the potassium salts. Potassium permanganate is produced by fusing caustic potash with manganese dioxide and later the manganate formed is converted into permanganate by passing carbon dioxide in the solution. A good number of potash salts like acetates, citrates and tartarates which are the products of medical interest, are produced with the help of caustic potash. The carbonate of potash is used in glass industry and for the manufacture of potash salts.

The hydroxide and carbonate of potash are imported in India in fairly good quantities. The production of these items is being carried out on small scales, but before the war there was no production. Saltpetre, the nitrate of potash, is used as raw material. The figures of imports of these potash alkalis are not maintained separately and it may be estimated that the consumption of these chemicals amounts to a few hundred tons annually. India can easily produce her own requirements of potash alkalis if nitrate of potash from Western Pakistan is made available. The manufacture of caustic potash is carried out by the usual causticization process and the commercial product obtained after fusion is usually of 85 per cent purity. The standard of products already in production, is quite satisfactory and even the cost of production can be competitive in comparison to the imported stuff if raw materials for the same are made available at reasonably low prices.

SODIUM SILICATE : Sodium silicate is an important chemical for the soap industry. In addition to this, it has also lot of other uses including its use in the paper and textiles industries. The soap makers use silicate of soda because of its detergent properties ; and, at the same time, it imparts weight to the soap. It also hardens the soap and helps in bringing down the cost. Further, it is largely used in the preparation of mortars in building work. Acid proof cements and water proofing compositions are also prepared out of it.

Sodium silicate used by soap makers is known as water glass and contains 40 per cent of sodium silicate by weight and the rest is water. This is manufactured by fusing sand with sodium carbonate at a high temperature. The fused mass is then taken up in water and digested in autoclaves till it gives out semi solid mass. Sodium sulphate is also used as raw material for the silicate manufacture.

There are good many factories in India, producing silicate of soda on a commercial scale. Apart from the local production, sufficient quantities of silicate have annually been imported in the past but, lately, the imports are on the decline :

IMPORTS OF SODIUM SILICATE

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	1,607.15	183
1938-39	...	...	945.15	115
1939-40	...	...	920.75	134
1940-41	...	...	509.15	98
1941-42	...	...	797.60	149
1942-43	...	...	457.35	95
1943-44	...	...	26.15	6
1944-45	...	...	142.65	33
1945-46	...	...	22.80	7
1946-47	...	...	59.30	19
1947-48	...	...	15.45	10
1948-49	...	...	139.90	42

The import figures during the year 1937-38 were above 1,500 tons and, within a period of 10 years, the imports have become negligible, showing that the demand is now being satisfied through local production. Attention has got to be paid to the fact that the use of sodium sulphate must be encouraged in place of soda ash as the former is available in plenty in the country and soda ash is imported from abroad.

Soda silicate was sold at the rate of Rs. 3 to Rs. 4 per cwt. in the pre-war days; whereas during war days, the prices were ranging from Rs. 15 to Rs. 20 but, lately, the prices shot up to a level of Rs. 30 to Rs. 40 per cwt. With the reduction in prices of soda ash due to excessive imports, the prices of silicate of soda have also subsided and such decrease in prices started by the end of the year 1948, and prices went as low as Rs. 10 to Rs. 15 per cwt.; till the end of August, 1949, the price level is now maintained at that point. Efforts must be made to help the manufacturers for procuring raw materials at reasonably low prices. It is an admitted fact that such fluctuations in prices of soda silicate are, primarily, due to the unsteady supply position of soda ash. The prices of soda ash vary considerably and are, more or less, dependant on supply position from abroad or the import policy of the Government. The supply position of soda ash has very much improved during the year 1948 and it has really helped the manufacturer of silicate of soda to reduce the prices.

C. MISCELLANEOUS CHEMICALS:

ACETIC ACID: Acetic acid, a product obtained from wood distillation, is a basic raw material for good many industries. It is largely used in the textile industry for the purpose of dyeing as a weak acid bath. In the rubber latex products like balloons, sanitary goods, surgical gloves, nipples, teats, etc., acetic acid is required in large quantities. Cellulose acetate industry also consumes it considerab' In chemical industry, acetic acid has huge importanc various chemical compounds, like acetates of lead, and calcium, are produced from acetic acid. Bes' chemicals, white lead is also manufactured with the help of acetic acid. Various esters of the type of amyl acetate, butyl acetate and ethyl acetate are a few of the popular thinners required in enormous quantities in the paint industry.

Acetic acid has a utility for other good many purposes, *i.e.*, in the manufacture of fish glue, for pickling foodstuff and stabilising olive oil. In the photographic process, it is used in the hardening and developing solutions and is also used as antichlor. Amongst other minor uses to which acetic acid is put, it may be mentioned that it is used as fungicide and can help to protect seedlings from rotting and saves plant from diseases. It has also disinfectant properties. The weak solution of acetic acid from 5 to 7 per cent is more popularly known as "vinegar" and is prepared by the slow fermentation process of sugar-cane juices. The anhydrous acetic acid of 98 to 99 per cent purity is called glacial acetic acid.

The sources of production for acetic acid are different in different countries. The popular wood distillates, however, yield fairly large quantities of acetic acid which is obtained, associated with other products like methyl alcohol, acetone and naphtha and this commercial distillate is termed as pyroligneous acid. Acetic acid is separated from the pyroligneous acid as calcium acetate and is later liberated with the help of dilute sulphuric acid. The dilute solution is, then, concentrated by the process of distillation. Acetic acid is also produced by the fermentation process, but it is not an economical method. Other popular processes of manufacture of acetic acid are by the oxidation of ethyl alcohol or by the synthetic method of conversion from acetylene.

The country's requirements of acetic acid have all along fulfilled through imports from foreign countries like ˇ S.A., and Canada. Acetic acid is usually packed in rrels or glass carboys, and, sometimes, aluminium drums are also used. The figures of imports during the past few years are as under :

IMPORTS OF ACETIC ACID

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	363.55	174
1938-39	...	...	283.20	141
1939-40	...	...	488.60	465
1940-41	...	...	445.10	538
1941-42	...	...	453.75	728
1942-43	...	...	6,038.00	1,507
1943-44	...	...	506.40	944
1944-45	...	...	8,526.70	1,337
1945-46	...	...	332.85	550
1946-47	...	...	348.65	591
1947-48	...	...	2,039.25	3,232
1948-49	...	...	409.20	768

Production in India has been attempted by the Mysore Iron & Steel Works, Bhadrawati, who have installed a wood distillation plant. They are having a considerably big plant to provide for a 200-ton capacity but it is underworked. They also produce calcium acetate. Plans to instal plants in Hyderabad and Madras, are also being worked out. The indigenous production might flourish in due course.

There have been considerable market fluctuations in the rates of acetic acid and the same vary from time to time, depending upon demand and supply. Serious efforts are required to be made to produce acetic acid, in India, on such a large scale that the entire demand may be fulfilled through local production.

CITRIC ACID : Citric acid is chiefly a constituent of the citrus fruit juices, especially of the lemon type. This is one of the important tribasic acid of aliphatic series and has sufficient importance in the chemical field and, also, as for medical use. Citric acid is largely used in the confectionery manufacture. The citrates of potash and soda also find use in the medicines.

The manufacturing process of citric acid is quite simple but proper technique of purification has not been developed in the country, so far. The lemon juice can be effectively utilised for producing calcium citrate and, later, decomposed with the help of sulphuric acid to produce citric acid in solution form, yielding nearly 50 per cent of the citric acid if calculated on the basis of raw juice. The production method of citrates of potash or soda are also quite simple and involves in the neutralisation of acid with carbonate of potash or soda, respectively. The crystallisation job must be followed properly so as to attain the highest degree of purity corresponding to the B.P. grade.

As regards the country's requirements in citric acid, they are obtained from abroad as, practically, there has been no manufacturing activities of this item in the country. The figures of imports, during the past few years, are as under:

IMPORTS OF CITRIC ACID

Year	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	129.15	139
1938-39	160.50	179
1939-40	194.25	273
1940-41	159.05	279
1941-42	223.95	434
1942-43	21.15	73
1943-44	111.80	281
1944-45	208.15	571
1945-46	206.45	482
1946-47	153.85	285
1947-48	244.35	570
1948-49	290.70	675

The figures of import show a marked increase and thus indicate that the demand has greatly gone up. The problem of considering the scope of local production is very important, when raw materials are plentifully available in the country.

The import prices of foreign product range from Rs. 100 to Rs. 120 per cwt. whereas the cost of manufacture, in India, is just within the limits of reasonable price and, as such, there is fine scope for producing citric acid and its citrates in India, with encouraging results. The main item of consideration is to maintain proper standard of quality and purity.

OXALIC ACID : Oxalic acid, the dibasic organic acid of the aliphatic series, is one of the important member of the group. Its main uses are in the calico printing and in the manufacture of blue ink. The various oxalates of sodium, potassium, and ammonium are largely used in the chemical and medical lines.

The process of manufacture of oxalic acid is quite simple but there is no regular production of this acid in the country. The various organic materials like alcohol, sugar, glycol, starch and cellulose yield oxalic acid, on oxidation with nitric acid. Similarly, these materials, on fusion with caustic soda or caustic potash, also yield oxalate of soda or potash, depending on the alkali used. Calcium oxalate is precipitated from these solutions and, later, breaking is done with dilute sulphuric acid. In commercial practice, wood saw dust is fused with alkali and the yield of oxalic acid is about 50 to 60 per cent of the weight of saw dust. Strictly speaking, the country's requirements were entirely met through imports before the war ; but, during war days, oxalic acid manufacture was also taken up in India. Imports during the past few years are as follows :

IMPORTS OF OXALIC ACID

Year			*Quantity* (*Tons*)	*Rupees* (*Thousands*)
1937-38	...	...	124.95	85
1938-39	...	...	167.75	119
1939-40	...	...	190.70	204
1940-41	...	...	103.95	141
1941-42	...	...	25.80	32
1942-43	...	...	4.90	13
1943-44	...	...	13.70	25
1944-45	...	...	27.05	35
1945-46	...	...	103.60	140
1946-47	...	...	4.70	8
1947-48	...	...	26.70	64
1948-49	...	...	57.85	110

It may be advisable to take up the manufacture of oxalic acid in India keeping in view the extent of requirements which, approximately, range from 150 to 200 tons annually.

The import cost of the acid is less than Rs. 100 per cwt., while it can be taken for granted that the local producers can easily work within these limits of prices with reasonable margins of profit. It is usually reported that the quality of oxalic acid produced by the local manufacturers is inferior to that of the imported one ; hence, it is desired that standard of purity and quality must be maintained.

SALICYLIC ACID : Salicylic acid (or hydroxy-benzoic acid) is usually obtainable in B.P. and commercial grades. It is used in the manufacture of medicines and dyestuff and also as an intermediary in good many synthetic organic processes. It is both antiseptic and antipyretic in character and is also largely used as industrial preservative. It also forms an ingredient of dusting powders and dissolved in collidion, it is employed as solvent for corns and warts.

Salicylic acid manufacture has not been taken up in India so far, and the country's requirements are satisfied through imports. The consumption figure may be nearly a few thousand pounds every year.

The process of manufacture of salicylic acid involves in the carbonation of sodium phenate and the sodium phenyl carbonate obtained is, subsequently, converted into sodium salicylate on heating. Later, the salicylic acid is precipitated out with the help of dilute mineral acid.

The various salicylates like that of sodium, potassium, strontium, ammonium, calcium, lithium, and magnesium are all the products of pharmaceutical interest. The methyl salicylate, though a pharmaceutical product, is also known as " oil of winter green " and is used as flavouring agent in foodstuff and beverages and as odorant in printing inks and insecticides. The phenol salicylate which is commercially known as " salol," is also a medicinal product.

STEARIC ACID : Stearic acid is a waxy product and is more popularly known by its grades, like single pressed, double pressed and triple pressed stearic acids. It invariably contains small proportions of oleic acid and palmitic acid and the quantities vary according to grades. Stearic acid is largely used in the preparation of cosmetics like face cream and face snows and is also used in the manufacture of candles in small quantities. Further, it is used in rubber industry. The various stearates of calcium, sodium, potassium, ammonium, aluminium, magnesium and zinc have good many industrial uses. Calcium stearates are used in plastic industry; and aluminium stearates are used as waterproofing agents and also as lubricants. The stearates of sodium, potassium and ammonium are, however, required in certain textile auxiliaries. The magnesium and zinc stearates are used in rubber industry. Stearic acid is also graded according to melting points as the different grades have different ranges of melting points.

Stearic acid is manufactured from certain oils and fats. The usual raw materials are tallow or the hydrogenated oils, which are saponified with caustic soda. The sodium stearates formed by this process, are later broken with dilute sulphuric acid. The stearic acid, on separation, usually contains a lot of oleic acid and palmitic acid, the presence of which is undesirable. The technique of pressing out the oleic and palmitic acids is rather specialised one and it is required to have adequate equipment for the pressing purposes.

India's requirements for stearic acid were fulfilled entirely through imports, before the war. Messrs. Burmah Shell Company were importing the same in fairly large quantities. There was no manufacture of stearic acid in India before the World War II but some of the war order suppliers took up the manufacture of stearic acid on the initiative of the Government. The following figures of imports would, however, reveal the extent of stearic acid demand in India :

IMPORTS OF STEARIC ACID

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	2,047.85	555
1938-39	...	...	2,259.95	503
1939-40	...	...	544.85	204
1940-41	...	...	404.15	247
1941-42	...	...	342.75	240
1942-43	...	...	525.20	611
1943-44	...	...	114.95	153
1944-45	...	...	148.35	240
1945-46	...	...	457.70	511
1946-47	...	...	37.40	50
1947-48	...	...	41.45	109
1948-49	...	...	75.40	181

Supplies of stearic acid are being obtained from Australia, U.K. and U.S.A. It has been found that the quality of the Indian product is much below the standard. Most of the manufacturers in India have discontinued the production. The chief raw material for this is the Australian mutton tallow. It is found that Indian tallow is marketed in rather impure condition and, as such, it is much inferior in quality, hence the stearic acid ultimately produced is of low grade.

It is observed that the import cost of Australian and English stearic acid was nearly 7 annas to 10 annas per lb., depending on quality, but lately, the American varieties have been imported at a price from Rs. 1-2 to Rs. 2-8 per lb.

It has been estimated that nearly 500 to 600 tons of stearic acid are annually consumed in the country and proper investigations must be carried out to find out the scope for its production in India. The process of refining the Indian tallow should also be developed.

TANNIC ACID, GALLIC ACID AND PYROGALLIC ACID : Tannic acid is one of the principal products obtainable from the natural gall-nuts of the types myrobalans, catechu, sumach and wood bark of the variety of babul bark and tarward bark, etc. Tannic acid is particularly of interest to the leather tanning industry. In medical profession, it is recognised as high quality astringent and is used to produce good many preparations and ointments for external application. Tannic acid is also used in the manufacture of inks and its utility is due to the formation of complex iron tannate. The gallic acid is used in the manufacture of stylographic inks. It is also used in medicines. The pyrogallic acid which is also found associated with these acids is much used in photography.

The gall-nuts of the type Alleppo galls and Chinese galls and the ordinary gall are the basic raw materials. The process of extraction involves in simple percolation operation with the help of water which chiefly yields tannic acid. Extraction with ether water mixture yields gallic and tannic acid, simultaneously. The ethereal solution contains gallic acid and the aqueous one retains tannic acid. The task of separation of the two acids is quite simple. Gallic acid is also separated by fractional crystallisation process from the aqueous solution. The production of pyrogallic acid is carried out merely by dry distillation of gallic acid at a temperature of 100 to 120°F.

The production of tannic acid from wood bark is carried out by the process of percolation and leaching operated in the form of a battery. Such tanning materials which are rich in tannic acid are, sometimes, directly used for tanning purpose and the processes of purification are not pursued. A mixture of gallo-tannic acid is also extracted by processing with a warm water at a temperature of nearly 50°C to 60°C. and is, later, recovered from aqueous extract.

It may be difficult to correctly estimate the requirements of the country in respect of these acids as the figures of import as well as production are not known. The records from trade statistics do not show separate figures for these acids. Rough estimate of consumption may be to the tune of several thousand pounds.

A few pharmaceutical concerns in the country are concentrating on the production of these chemicals and are manufacturing both commercial and B.P. qualities.

The prices of these acids vary considerably. The tannic acid, however, fetches a price of Rs. 2 to Rs. 10 per lb., depending on quality, while the prices of gallic acid and pyrogallic acid vary from Rs. 5 to Rs. 10 per lb. There is no dearth of raw materials in the country. The production figures can easily be regulated according to occasional demands.

TARTARIC ACID: Tartaric acid is an important organic acid. It is used largely for photographic process of printing and developing. It is also used in calico printing and finds use as intermediary in the dyestuff industry. For dyeing wool, it is used in the mordant bath and is required for brightening the colour of silk after dyeing. In the form of tartarates, it finds use for baking powders and, as purgative, in the form of Sidlitz powder. Its other compounds, known as tartar emetic and cream of tartar, are very common products of daily requirements.

The possible sources of production of tartaric acid are the vegetable juices which, usually, contain certain percentage of tartarates of calcium and potassium. The various juices are prepared out of tamarinds, mulberries, pineapples, unripe beet-roots and grapes. Its production can be carried out more scientifically as a side line where wines are produced.

The process of manufacture of tartaric acid is fairly tedious and requires fine technique to produce pure products. The grape juice, on fermentation, usually yields a solid crystalline crust which is known as "Argol" and is rich in tartarates. Argol powder is digested in hydrochloric acid under controlled conditions of temperature and is, later, precipitated with the milk of lime. Further, the calcium tartarate is very carefully decomposed with the help of sulphuric acid to produce tartaric acid in solution, from which fine crystals are obtained by the process of crystallisation. The process of extraction of this acid from green tamarind seeds, is, somewhat, different as it involves in the use of solvents; and the aqueous extracts are, further, precipitated with lime and, later on, tartaric acid is liberated with the mineral acid, and is ultimately crystallised.

Strictly speaking, the process of manufacture of tartaric acid is very complicated, but it is one of those important products which must draw the attention of the Indian manufacturers to make attempts for local production. Presently, the country's requirements are obtained from abroad and figures of imports are appended below:

IMPORTS OF TARTARIC ACID

Year	*Quantity* (*Tons*)	*Rupees* (*Thousands*)
1937-38	73.40	89
1938-39	112.85	153
1939-40	117.00	217
1940-41	42.45	112
1941-42	40.50	217
1942-43	15.25	104
1943-44	28.95	178
1944-45	66.85	396
1945-46	19.65	122
1946-47	167.60	898
1947-48	112.90	485
1948-49	170.85	481

The above figures show that imports have considerably been varying during different years. Both crystalline and powder forms of tartaric acid are fairly in good demand and there is a marked difference in the prices of both the varieties. It may, however, be noted that the ruling prices which range from Rs. 200 to Rs. 300 per cwt., are nearly one and a half times that of pre-war rates.

AMMONIA ANHYDROUS AND AQUEOUS: Ammonia anhydrous is a colourless gas at normal temperature and pressure. It is condensed at high pressure and is liquefied before it is filled in cylinders for sale. It is largely used in the refrigeration industry. In plastic industry, it finds use as condensing agent for phenol formaldehyde resins. In rubber industry, it finds use in vulcanising process and also for neutralising and deodorising rubber goods which are cured with sulphur chloride. In water treatment, ammonia is also used for elimination of excess chlorine and carbon dioxide. Ammonium sulphate is the most important ammonia salts. Other compounds like chloride and carbonates are also very popular salts. Ammonia is used as neutralising agent for petroleum before cracking process. It is also used for nitriding of steel and, as solvent, for good many products. In aqueous form, it is produced in different commercial standards of specific gravity 0.800, 0.888 and 0.910. Apart from the above uses, the aqueous form of ammonia is largely used as preservative for rubber latex. Further in silk industry, it used as degumming agent and for the production of cuprammonium silk and reeling silk. In leather industry, it is used as dehairing agent for hides and, as penetrant, for wetting back crusted tanned leather. It is largely used for general laboratory purposes, both for analytical and research work.

Anhydrous ammonia is produced in India on a very meagre scale. Messrs. Imperial Chemical Industries (India) Ltd., have all along been the chief suppliers of this product; but, during World War II, the production was taken up by one of the manufacturers of Mysore State. Local production is rather very small as compared to the indents. The figures of imports during the past years have been, as mentioned hereunder :

IMPORTS OF AMMONIA ANHYDROUS

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	125.50	283
1938-39	...	...	152.25	201
1939-40	...	...	146.40	218
1940-41	...	...	105.15	205
1941-42	...	...	136.10	299
1942-43	...	...	96.95	224
1943-44	...	...	50.55	146
1944-45	...	...	164.60	468
1945-46	...	...	153.35	394
1946-47	...	...	129.45	326
1947-48	...	...	215.35	603
1948-49	...	...	105.75	345

Ammonia is produced by several processes, and the cheapest one is the recovery of ammonia from the coal distillation products. This process can be easily worked out on a commercial scale in the country ; but little attention has, so far, been paid by any of the interested parties. The synthetic process for the manufacture of ammonia is today the most popular methods of production and serious efforts are required to instal a few plants at certain important centres.

The prices of anhydrous ammonia range from Re. 1 to Rs. 2 per lb. ; whereas, in pre-war days, it could be available even below a rupee. The empty gas cylinders are quite expensive. The manufacturers, dealers and consumers are usually linked with each other by the circulation of empty cylinder and hence prices of cylinders are, usually, additional investments for maintaining extra stocks. The prices of the locally produced stuff have been fairly in line with the cost of the imported product.

Aqueous ammonia is also termed as liquor ammonia. Small scale production is being carried out in almost all the important towns of the country. The usual method of production is by decomposing cheap ammonium salts like sulphate of ammonia, with the help of lime. Reaction is hastened with the addition of alkali and the ammonia gas evolved as a result of reaction, is absorbed in pure water. There are minor imports of aqueous quality in small bottle and carboy packing. The rates of aqueous ammonia usually depend on the concentration of the liquor produced, and are graded according to specific gravity of the liquor offered.

BARIUM COMPOUNDS : The various barium salts of commercial importance are the carbonate, chloride, nitrate and sulphide of barium. Barium sulphide is one of the important chemicals required for leather tanning industry. Barium sulphide is also used for the manufacture of certain pigments like lithophone and other luminescent paints. Hair removing preparations in the form of powders, soap, pastes and lotions are also prepared out of barium sulphide. Barium sulphide acts as source for producing other barium salts. Barium carbonate is, however, a chemical of limited interest. It is a poison and is largely used for making rat poisons. It is greatly consumed by the corporations and municipalities and is supposed to be an item of public health utility. Barium carbonate is also used in the glass industry in large quantities. Barium chloride has minor uses and is required for salt purification process for the elimination of sulphates.

The best commercial source for the manufacture of barium salts are barytes which are available in India, in huge quantities. It is, however, a matter of interest to note that the barium salts are largely imported in the country. Figures of imports are not separately available and even the figures of local production, whatever small quantity it may be, are not known. Barium sulphide and other salts can be easily produced from barytes and the process of manufacture is not difficult. Sulphide can be further used for the production of carbonate and chloride. Barium nitrate is largely consumed for fireworks and pyrotechnic manufacture and is a chemical of sufficient commercial interest. It can be very easily produced in the country along with other barium salts. It is estimated that the imports of barium salts do not exceed more than a few hundred tons every year.

BICHROMATES OF SODIUM AND POTASSIUM : The chromates and bichromates of sodium and potassium are chemicals of vital importance. Bichromates of potassium and sodium find various uses in good many industries and in several chemical processes. The process of chrome tanning has revolutionised the leather industry. Bichromates are used directly in both single and double chrome tanning processes. The manufacture of chrome pigments is another important use to which the chromates are put in. The various pigments like chromates of lead, barium and copper are very useful in the paint industry. Various pigments with shades ranging from pale yellow to deep orange are produced from these chromates. Bichromates are also used for mineral khaki dyeing which had, practically, replaced the vegetable khaki dyeing during the war days. Chrome alum is also used for this purpose. Chromic acid and other chromium salts for electroplating purposes are also manufactured from the bichromates. There are other minor uses of bichromates, *i.e.*, in the manufacture of safety matches, as oxidising agent in the oxidation of anthracene to alizarine, in the manufacture of chrome alum, in the manufacture of aniline violet, in solution with sulphuric acid as bleaching agent for tallow and palm oil and as ammonium salt in photography.

The chief raw materials for the manufacture of bichromates are chromite ore, soda ash, lime, sulphuric acid and chloride of potassium. Fuel is also an important requirement for this industry and furnace oil is preferably used for this purpose. Chromite, lime and sulphuric acid are plentifully available for the production of bichromates. Soda ash requirements are covered through imports as the production of the local manufacturers in India is very small. The potassium chloride which is required for producing the potash bichromate, is also obtainable in India.

The process of manufacture of bichromates is not very difficult. The mixture of chrome ore, soda ash and lime is roasted on the bed of oil fired or coal fired reverberatory furnace. The roasted ore is extracted for soluble chromates by the lixiviation process and the soda chromate liquor, thus obtained, is acidified with the help of sulphuric acid to convert the same into bichromate of soda. The bichromate of potash is produced by the process of double decomposition, using potassium chloride or nitrate.

The bichromate industry, however, does not yield very important by-products. The residue left after the lixiviation of furnace roast, contains about 2 to 5 per cent unreacted ore. A part of this unreacted ore is used in small quantities with the fresh charges of mixture of ore, lime and soda ash and the rest is thrown out of the factory. Sodium sulphate is another by-product which is produced in large quantities. Glauber's salt prepared out of that, finds use in textile, paper, glass and silicate industries and also in the manufacture of sodium sulphide. The bichromates sticking to the sodium sulphate are removed during the purification process.

Bichromates were all along being imported and the figures of import during the past few years are as follows :

IMPORTS OF BICHROMATE OF SODIUM AND POTASSIUM

	Potassium		*Sodium*	
Year	*Quantity (Tons)*	*Rupees (Thousands)*	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38 ...	275.45	144	1,038.10	466
1938-39 ...	198.60	103	719.55	341
1939-40 ...	314.60	442	873.40	1,009
1940-41 ...	349.15	479	3,320.65	3,620
1941-42 ...	79.90	65	2,369.05	1,751
1942-43 ...	5.00	7	1,311.40	1,093
1943-44 ...	..	..	2,392.15	2,234
1944-45 ...	29.05	9	1,136.70	1,107
1945-46 ...	0.05	..	..	..
1946-47 ...	..	..	..	..
1947-48 ...	2.05	3	..	..
1948-49 ...	0.55	1	20.00	7

The maximum war time consumption is recorded to nearly 6,000 tons of bichromates and the approximate rate of consumption in various industries may be, *i.e.*, textile industry 75 to 80 per cent; leather tanning 10 per cent; chrome pigments 10 per cent ; match industry nearly 1 per cent and certain amount for chromic acid production. With the fall in demand for bichromates, the present production has been reduced to half of the wartime output and the actual figures of production for year 1948 are 2,835 tons. The requirements of bichromates for the purpose of khaki dyeing have again been replaced by organic dyes. There was a control enforced by the Government of India during war days and the prices fixed for sodium bichromate were at Rs. 95 per cwt. and that of potassium bichromate were at Rs. 195 per cwt. but the controls were withdrawn soon after the war.

The machinery required for the production of bichromates can be manufactured in the country. The main equipments are crushers, tubes mills, furnace fitted with recuperators and chimney, liquor storage tanks, acidification pans, cooling pans, filter tanks, boiling pans, crystallising pans and hydro-extractors. The fire bricks which are required for the bichromate furnace are produced locally. The pans and tanks are all made of mild steel and can be easily fabricated in India.

Further developments in the field of chrome plating and leather tanning would considerably increase the demand for bichromates. The increase in popularity and use of chrome pigments in the paints industry would further elevate the bichromates requirements. The importance of chromium plating has fully been realised and it may be essential to popularise the technique of chromium plating at this stage.

Calcutta is a centre for the paint industry and offers a suitable place for the concentration of bichromate industry. Kanpur and Madras are well known leather tanning centres. Centralisation of plants at these places can promise good future. Bombay factories which, primarily, had an aim of supplying bichromates to textile mills, have now diverted their products to paint and leather tanning companies.

The question of giving protection to this industry was considered by the Indian Tariff Board in the beginning of the year 1946 and, after careful consideration, Government of India have offered assistance to the industry by way of imposing protective customs duties and have allowed the manufacturers to attain a stage of immunity from foreign competition.

BLEACHING POWDER AND CHLORINE : Bleaching powder is largely used for bleaching purposes of pulp in the paper industry and cotton yarn and cotton fabrics in the textile industry. Strictly speaking, chlorine does the bleaching whereas the lime acts as medium or vehicle for chlorine. Bleaching powder is also used as disinfectant and for other sanitation purposes and is also used in other various chemical processes. Bleaching powder is usually graded in terms of its chlorine content and such percentages of suitable powder should be from 25 to 30 per cent or 30 to 35 per cent. Higher grades are produced according to requirements.

Direct use of chlorine is advocated in most of the industries but handling and transportation difficulties do not permit the same. The extra expenses for the maintenance of heavy gas cylinders and the cost of transportation from one place to another puts a heavy monetary strain on the prices of chlorine. Storage of chlorine is also difficult. These factors prohibit the direct use of chlorine.

Chlorine is largely used for the manufacture of organic solvents and other chloro products. It is also used in textile and paper industries for bleaching purposes. Chlorine is, further, used for disinfectant purposes and for sterilisation of water. Preparation of large number of chemicals like synthetic hydrochloric acid ; the chlorides of iron, zinc and barium; chlorate of potash; carbon tetrachloride; chloroform; chloral hydrate and ethyl chloride are directly or indirectly produced from chlorine.

The relative uses of bleaching powder and chlorine are based on the fact that the powder can be easily transported, but it has its own disadvantages as well. The stability of powder in tropical climate is a matter of speculation and, in practice, it is sometimes found that there is too much of deterioration. In certain chemical reactions, the presence of calcium is not desired and thus direct use of bleaching powder is not made. The handling and transportation difficulties are unfavourable factors in the case of chlorine.

The production of bleaching powder is, primarily, based on the availability of chlorine. Chlorine is produced as by-product in the manufacture of caustic soda by the electrolytic decomposition of common salt solution. The requirements of chlorine and bleaching powder in India for the various industries are estimated to be in big quantities. There were huge imports of these products in the pre-war days prior to the period caustic soda plants had, actually, started operating in India. The figures of import during the past period are given below :

IMPORTS OF BLEACHING POWDER AND LIQUID CHLORINE

	Bleaching Powder		*Liquid Chlorine*	
Year	*Quantity (Tons)*	*Rupees (Thousands)*	*Quantity (Lbs.)*	*Rupees (Thousands)*
1937-38 ...	11,865.15	1,313	668,428	249
1938-39 ...	10,656.65	1,249	682,235	213
1939-40 ...	11,787.75	1,782	519,871	159
1940-41 ...	8,578.80	1,529	49,586	25
1941-42 ...	5,009.75	892	..	..
1942-43 ...	1,311.65	242	1,095	1
1943-44 ...	4,564.55	820	62	..
1944-45 ...	4,065.30	764	..	..
1945-46 ...	7,984.95	1,572	..	..
1946-47 ...	7,316.40	1,675	..	..
1947-48 ...	8,367.20	2,288	..	..
1948-49 ...	11,520.50	3,903	..	..

The total consumption of bleaching powder ranges from 10,000 to 12,000 tons per year. It is, however, believed that nearly 50 per cent of the total quantity is consumed by paper mills, nearly 35 per cent goes to textile industry and the rest of the 15 per cent is required for the manufacture of chemicals, surgical dressings and for other purposes of public health. The productions of bleaching powder is mainly carried out by Messrs. Tata Chemicals Ltd., The Mettur Chemicals and Industrial Corporation Ltd. and Messrs. Rohtas Industries Ltd., Dalmianagar. The annual production capacity of these units is reported to be of the order of nearly 8,000 to 8,500 tons per year. The Alkali and Chemicals Corporation of India Ltd., are, however, producing liquid chlorine at their Rishra plant, having a capacity of nearly 1,600 tons and the total production of Messrs. Mettur Chemicals and Tatas Chemicals Ltd. is nearly 400 tons, making an approximate total of 2,000 tons.

PRODUCTION OF BLEACHING POWDER AND LIQUID CHLORINE

Year	*Bleaching Powder*	*Liquid Chlorine*
	(Quantity :	*Tons)*
1947	2,550	1,706
1948	2,836	1,800
1949 (Jan.-March : 3 months)	748	392

Theoretically, the liberated chlorine is nearly 88 per cent by weight of the total amount of caustic soda, produced by the electrolytic method. With the existing plants of caustic soda in the country, the chlorine production is much in excess of the total requirements. The bleaching powder requirements of nearly 15,000 tons can roughly be satisfied with 5,000 tons of basic chlorine. The demand for 2,000 tons of liquid chlorine can also be satisfied from that production. The programme for caustic soda manufacture which provides for a production to the tune of 80,000 to 100,000 tons would afford very large quantities of chlorine and the problem of disposal of excess chlorine would be quite serious. Complications would arise if production of caustic soda is carried out entirely by the electrolytic method. The synthetic hydrochloric acid, if produced out of chlorine and hydrogen, would spare some of the sulphuric acid share. This saving in sulphuric acid would proportionately minimise the use of sulphur. The programme for the production of D.D.T. in India, can reasonably consume some of the excessive quantities of chlorine. Caustic soda production by the causticization process can eliminate chances for the excessive production of chlorine and save the manufacturers from importing electrolytic plants.

The case for protection to bleaching powder and chlorine industry was simultaneously considered along with that of caustic soda industry by the Indian Tariff Board in July 1946. Data regarding the cost of production of local manufactures of chlorine and bleaching powder was examined. It is observed that the task of maintaining the percentage of chlorine in bleaching powder is, rather, difficult as the quality deteriorates in tropical climate. Attempts must be made to stabilise the locally produced qualities of bleaching powder. The foreign products are definitely of better grade and are well preserved in better packings. Imports can entirely be stopped, if local manufacturers are able to produce bleaching powder of standard concentrations and of stable qualities.

BORAX AND BORIC ACID: Borax is largely used by the glass and enamel industries. In the fusion mixture for precious metals, borax is used as an ingredient. Borax is largely used for other medical purposes, both for external and internal uses. It is an important raw material for the production of boric acid. Borax is also used as an antiseptic. Boric acid has a vital importance in the medical profession, because of its mild antiseptic character and it is largely recommended for all types of dressings and minor ailments of wound healings and is an important item of first aid requisite.

Presently, both borax and boric acid, are imported from abroad in large quantities. The statistics for the imports of borax are available while boric acid import figures are covered under certain other miscellaneous head. The figures of imports of borax, during the past few years, are given below :

IMPORTS OF BORAX

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	1,620.60	362
1938-39	...	...	1,295.30	300
1939-40	...	...	1,670.80	487
1940-41	...	...	1,220.00	469
1941-42	...	...	1,651.30	751
1942-43	...	...	1,964.45	1,014
1943-44	...	...	1,608.20	992
1944-45	...	...	2,692.75	1,613
1945-46	...	...	1,429.15	671
1946-47	...	...	1,397.40	673
1947-48	...	...	9,090.00	4,054
1948-49	...	...	1,431.70	641

Nearly 1,500 to 2,000 tons of borax are imported annually. Borax has been located in the sulphur springs of Ladakh valley and Kashmir and also near the Tibetan frontier, but there are no regular estimates of the existing resources and there is good scope for exploring the same.

CALCIUM CARBIDE: Calcium carbide is largely used for generating acetylene gas which gives illuminating flames on burning. The oxy-acetylene flame is popularly used for welding purposes. Calcium carbide is also used for the fixation of nitrogen for the production of calcium cyanamide which is an important fertiliser. Calcium cyanamide is, further, required in the plastic industry.

The method of manufacture of calcium carbide is a specialised one, and involves in the use of electrothermic furnaces. Chief raw materials for this are coke and lime. Various patents are obtained by certain foreign producers for the various electrothermic furnaces, but no attempts have been made in this direction in India. Supplies of calcium carbide are being obtained from Canada, Norway and Africa and considerable quantities are imported every year. The figures of imports are as under :

IMPORTS OF CALCIUM CARBIDE

Year			Quantity (Tons)	Rupees (Thousands)
1937-38	...	...	2,722.25	594
1938-39	...	...	2,866.40	636
1939-40	...	...	3,535.35	995
1940-41	...	...	2,921.85	1,011
1941-42	...	...	3,266.50	1,599
1942-43	...	...	5,006.20	1,737
1943-44	...	...	3,183.45	1,149
1944-45	...	...	6,295.55	2,287
1945-46	...	...	4,551.40	1,668
1946-47	...	...	3,274.65	1,269
1947-48	...	...	4,284.30	1,892
1948-49	...	...	5,348.35	2,616

The calcium carbide requirements have considerably gone up during the recent years. It is, however, anticipated that in the next few years, the demand would still rise as it would find much use in the production of cyanamides.

Certain schemes to set up a plant in India for the manufacture of carbide are being envisaged by some of the industrial circles. It might take some more time for the maturing of these schemes but it is beyond doubt that the problem is worth consideration.

The Munitions and Production Directorate of Government of India had enforced controls over the distribution of calcium carbide during war days but such controls were relaxed soon after the war. Prices of calcium carbide have been varying a good deal from time to time during different trade periods, and such fluctuations have mainly been regulated by the supply position.

CALCIUM CARBONATE: Calcium carbonate is largely used in good many industries and is consumed in various chemical processes. Calcium carbonate is also used as a useful filler in the rubber industry and, to a great extent, in paint industry. It goes into the composition of various products like that of chalks, crayons, white shoe polishes and in the production of face powders and other innumerable preparations of commercial and medical interest.

Calcium carbonate is obtainable in fine powders of varying density, *i.e.*, heavy, medium and extra light qualities. The commercial varieties of heavy and medium qualities for industrial purposes are prepared by finely grinding snow white calcite or marble stones ; but for specific chemical and medical purposes, pure and precipitated qualities of calcium carbonate are required. The pure quality product is prepared by the chemical process. Various grades of extra light and B.P. standard are, further, prepared from the precipitated chalk.

There is no adequate production of light varieties of calcium carbonate as the plants for the same are not many. The heavy qualities for rubber and paint industries are prepared from calcite and marble minerals.

Figures of imports of calcium carbonate in the country have not been separately shown. The precipitated varieties of calcium carbonate can be prepared in this country on a moderate scale and, as such, imports could be stopped if colour, fineness and standard of purity is acceptable. Heavy chalk powder is very cheaply available in India. The precipitated grades, *i.e.*, medium light and extra light which are usually the imported qualities, are being sold comparatively at fancy prices.

CALCIUM CHLORIDE : Calcium chloride is a chemical, mainly of interest to the refrigeration industry and huge quantities of the same are used in ice plants. In fused condition, it is an important dehydrating agent. It has also miscellaneous uses in the production of chemicals and other products like calcium silicate. Calcium chloride is also found useful in the calcium cyanamide industry and also for the fixation of atmospheric nitrogen.

Calcium chloride is obtained as an intermediate product in the marine water industry. Messrs. Pioneer Magnesia Work Ltd., Kharagoda, started the manufacture of calcium chloride in the year 1941 and, since then, the imports have been on the decline. The figures of production are reported to be nearly 850 to 1,000 tons per year and the actual figures of production recorded, during the year 1948, were 943 tons. The figures of imports are as under :

IMPORTS OF CALCIUM CHLORIDE

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	910.30	72
1938-39	...	...	855.25	80
1939-40	...	...	1,049.05	103
1940-41	...	...	664.10	80
1941-42	...	...	655.80	86
1942-43	...	...	361.15	80
1943-44	...	...	11.60	17
1944-45	...	...	14.05	20
1945-46	...	...	32.35	19
1946-47	...	...	2.35	6
1947-48	...	...	93.05	45
1948-49	...	...	228.55	51

The local production of calcium chloride is quite sufficient to meet the country's requirements. With further developments and setting up of soda ash plants, the calcium chloride production will be in abundance and, as such, this industry shall have to stand on its own merits. The imports are not at all required. The prices of the locally produced material are quite competitive. The present prices of this commodity ranges from Rs. 15 to Rs. 20 per cwt.

CARBON BLACK : Carbon black is essentially the " element carbon " and is obtainable in various grades and shades. Other graded trade names are as carbon black, lamp black, gas carbon, ivory black, etc. Gradation on the basis of hardness and softness is also known. Carbon black is mainly a product of interest to the rubber and paint industries. It is used as black pigment for producing black and grey rubber products like rubber tyres, shoe soles, tubing, various types of pressed and extruded rubber goods including rubber rods and sheets. In paint industry, it forms an important constituent of black paints and enamels and is in big demand. Black printing inks are produced out of carbon black and lamp black. Carbon black is used as a universal black pigment for all purposes and also forms constituent of black moulding and bakelite powders. It is also used for oil cloth, and imitation leather cloth. Mixed with other pigments, carbon black gives other shades ranging from grey to jet black. It is also used for the leather finishes and finds use in the manufacture of stencils and crayons. Black polishes are produced out of it. Electrical conductor and electrodes are made out of pressed carbon and form important products for the electrical industry.

Carbon black is not, so far, manufactured in India. The process of manufacture is not difficult and can be developed if efforts are made in the proper direction. Hydrocarbons and mineral oils and other organic products, on burning in specialised equipments, yield various grades of carbon black under certain controlled conditions.

It is estimated that import figures of carbon black amount to nearly 4,000 tons a year, out of which 3,500 tons are for rubber consumption and balance of 500 tons goes for paint industry. The compressed and uncompressed forms are demanded for different purposes. Some of the popular commercial grades are sold under different trade names like "Kosmos," "Kosmobile," etc.

The trade prices of carbon black have been varying to a considerable extent. The landing cost of certain grades range from annas five to annas ten per lb.; whereas, in pre-war days, the cost was 50 per cent of the above prices.

The manufacture of carbon black should be taken up on a commercial scale in India in order to meet country's requirements in full. With further interest in the expansion of rubber and also paints and enamels industries, the consumption figures are bound to go up and, hence, it must immediately attract the attentions of the manufacturers to encourage new enterprises for this product.

CARBON DIOXIDE : Carbon dioxide has good many industrial and commercial uses. It has a major use in the manufacture of aerated and mineral waters which are the commodities of daily consumption. It is also used in various chemical processes. Solidified carbon dioxide is largely used as refrigerant and is extremely popular because of the low degree temperature that can easily be attained. The gas is also used for obtaining inert atmosphere. The soda acid fire extinguishers work on the principle of quick production of carbon dioxide gas. The manufacture of bicarbonates and carbonates of soda by solvay process is, primarily, based on the carbonation process. Sugar refining industry use considerable quantities of carbon dioxide in the single and double carbonation processes. Potassium permanganate is formed when carbon dioxide gas is passed in the potassium manganate solution.

The commercial methods of manufacture of carbon dioxide are quite simple and even the raw materials like limestone, coke, potash and other carbonates are easily obtainable in the country. Limestone, on burning, yields lime and carbon dioxide gas. Sugar factories which work on carbonation process, have elaborately built lime kilns with arrangements for the collection of gas. Carbon dioxide is also obtained from the fermentation process and is got as by-product from the distilleries and breweries.

The resources of carbon dioxide gas in India are adequate and the production is quite satisfactory. One of the manufacturing company has four to five units, operating in different parts of the country like Bombay, Calcutta, and Delhi in India, and at Rawalpindi and Karachi in Pakistan, with the plants having annual production of four to five million lbs. Other producers who operate on fermentation process have capacity over a couple of million lbs. These factories are spread out in the form of a net work in the country and this arrangement is very economical as the distribution expenses of the gas are maintained at a low level. The price of gas is really affected by heavy transportation expenses from one place to another on gas cylinders which remain in transit from the producers to consumers and *vice versa.* The pre-war prices of gas were within a range of two to three annas per lb.; whereas, with the increased cost of production, during war days, it were about four to five annas per lb. The tendency of prices has rather been upward due to the increased cost of production and prices above eight annas per lb. are quoted.

The consumers who are located at far away distances from the producers, have the disadvantage of paying high rate of freight for the movements of cylinders. A relief in prices can, however, be given to them by allowing the transit of gas cylinders at concessional rates.

CYANIDES OF POTASSIUM AND SODIUM : The cyanides of potassium and sodium are well known chemicals on account of their being the deadliest poisons. They are not much of the industrial importance except that the electroplating industry consumes these salts in large quantity. It is observed that the cyanides and the complex single and double salts of the plating metals have got high degree of ionisation in solution and, with certain controlled conditions of current density and voltage, they exhibit a high throwing power and are, therefore, very much used in the electrodeposition processes. The cyanides of gold and silver are chemicals of commercial interest as the refining of precious metals is carried out with the help of cyanides of potassium and sodium as in the case of electroplating and electrorefining processes, the complex cyanides of metals are formed. These cyanides are also used in certain organic processes and for producing hydrocyanic acid and other cyanogen compounds. Cyanides are not produced in India. The figures of imports in the past few years are as under :

IMPORTS OF SODIUM AND POTASSIUM CYANIDES

Year	*Potassium*		*Sodium*	
	Quantity (Tons)	*Rupees (Thousands)*	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38 ...	23.45	49	254.65	219
1938-39 ...	24.15	46	173.20	150
1939-40 ...	20.00	41	332.25	289
1940-41 ...	26.90	64	143.10	127
1941-42 ...	15.25	45	194.55	183
1942-43 ...	11.90	37	231.35	220
1943-44 ...	21.60	50	187.75	187
1944-45 ...	22.30	51	133.80	136
1945-46 ...	70.90	180	154.65	164
1946-47 ...	30.35	90	66.75	67
1947-48 ...	33.30	106	153.05	156
1948-49 ...	18.10	54	142.65	153

It may not be difficult to undertake the production of cyanide in India as methods of manufacture are simple but, they necessitate in engaging skilled labour and proper handling and in the installation of elaborate equipments.

FORMALDEHYDE : Formaldehyde, in aqueous solution of 35 to 40 per cent concentration, is termed as "Formaline." It has important uses in the various industries like textile, sugar and leather. It is also required for the medical purposes as it is a powerful antiseptic, disinfectant and deodorant. It is, further, used in the various organic processes for producing synthetic compounds and dyestuffs. Its most important use is found in the plastic industry. The plywood industry, however, requires it for preparing casein adhesives. The moulding powders produced from phenol-formaldehyde, urea-formaldehyde and various similar combinations, have rather revolutionised the plastic industry.

The process of manufacture of formaldehyde is quite technical and involves in the oxidation of methyl alcohol which is obtained as a by-product from the wood distillation process. Apart from these oxidation processes, it can also be manufactured by synthetic processes from carbon monoxide and hydrogen. The first method has been attempted in India in the Mysore State with an annual production of 50 to 60 tons but the cost of manufacture is fairly high. The country's requirements in formaldehyde are being obtained from abroad, but during war period, locally manufactured product was meeting partial requirements though its cost was high. It is estimated that the annual consumption is nearly 150 to 200 tons including demand by the plywood industry which alone was about 50 tons in war days. The production of various moulding powders is a problem of great importance and, in such products, formaldehyde forms the basic raw material. It might be considered that the country's requirements in formaldehyde might amount to a few thousand tons and, as such, the developments in the plastic line must provide for formaldehyde production on a large scale.

FORMIC ACID : Formic acid is the monobasic acid of the aliphatic group and is obtainable in 80 to 85 per cent and 90 per cent concentrations of commercial grades. It is largely used in rubber plantation estates and in the textile industry. It is also consumed for the production of formates and other allied compounds.

This is mainly a product of limited interest and has specific utility. Since there is no indigenous production of formic acid, the demands are satisfied entirely through imports. The annual requirements, including those for rubber estates, amount to a few hundred tons per year. The price of this acid has been fluctuating a good deal, and during a course of a couple of years, it has considerably gone up, amounting to double the rates. The prices of formic acid had been ranging nearly from one rupee to three rupees per lb., and the record prices were almost at the highest level in the days of scarcity.

GLYCERINE : Glycerine is the viscous colourless sweet oily liquid and is very largely used in medical profession for the manufacture of pharmaceutical preparations. It is also used in cosmetics. Another important use of glycerine is in the manufacture of explosives. In commercial preparations like tooth pastes, ointments, and plasters, glycerine finds widest applications. It is also consumed by the textile industry for producing softening and finishing auxiliaries. It is largely used for the manufacture of nitroglycerine and other blasting explosives.

Glycerine is obtained as a by-product from the soap industry. The vegetable oils contain long chain of saturated and unsaturated aliphatic acids compounded with glycerine. Glycerine is released as a result of chemical reaction of caustic soda on oils, and is recovered from the spent lye. In the hot method of soap manufacture, where soap is salted out, the spent lye is separated out and the glycerine is recovered from it by the process of distillation. Glycerine is not recovered from the cold process of soap manufacture.

Soap industry is sufficiently on an elaborate scale in India and one can imagine the extent of available sources of production from the fact that the major portions of the imported caustic soda are consumed for the production of soap and the demand for soap is increasing every day. There are remarkable chances for recovering glycerine from soap industry and, that too, on a massive scale. Glycerine is, however, recovered by a few of the leading Indian manufacturers of soap, who are about half a dozen in number, whereas others are either following cold process or they are unable to set up glycerine recovery plants. Actual production of glycerine is in extremely small proportion, as compared with the possible resources at hand. The present production from all such plants is about 2,000 to 3,000 tons per annum against the pre-war figures of production of about 500 tons. The actual production of glycerine during the year 1948 is 2,142 tons and nearly 600 tons of glycerine have been produced during the quarter January to March, 1949. The statistics of imports during the past few years are appended below :

IMPORTS OF GLYCERINE

Year	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	81.40	107
1938-39	209.45	198
1939-40	44.45	43
1940-41	12.15	15
1941-42	0.40	2
1942-43	..	..
1943-44	0.25	1
1944-45	1.35	3
1945-46	1.40	2
1946-47	0.50	2
1947-48	0.05	1
1948-49	0.15	1

Glycerine requirements of the country can be easily met from the local production. There are prospects for exporting glycerine to other countries. It has been exported in certain quantities but exports were later restricted. Glycerine being an item of national importance should not be exported at this stage when the same is largely required for defence purposes, for the production of explosives.

Attempts should also be made to set up more and more plants for recovering glycerine from the spent lye. The individual soap manufacturers who are unable to set up such equipments should pool up their lye and afford a regular source for the recovery of glycerine.

HYDROGEN PEROXIDE: Hydrogen peroxide, as the name indicates, is a powerful oxidising agent. It is obtainable in various grades, *i.e.*, the commercial grades being in 100 volumes and 130 volumes ; and the medical grades in 12 and 20 volumes. The commercial grades are largely used in textile industry especially silk and art silk, as it is required as a mild bleaching agent. The weaker grades of 12 and 20 volumes are largely required by the medical profession. Hydrogen peroxide is an important oxidising agent and is also a useful antiseptic.

The commercial manufacturing process of hydrogen peroxide is simple, but the elaborate equipments for the same are very essential. Barium peroxide, or sodium perborate are used as the main raw materials for the manufacture of hydrogen peroxide. Weaker grades of hydrogen peroxide for medical supplies are manufactured by a few small scale producers but the production of commercial grades has not been attempted.

It is one of the important chemicals which is imported from abroad and the production for the same, on a commercial scale, can be attempted here in India. The manufacture of perborates and peroxides is also an important problem, as these are very powerful oxidising agent and are also used as raw materials for the manufacture of hydrogen peroxide.

LEAD ACETATE: Lead acetate is largely used in the paint industry for producing various grades of pigments of the type as lead chromates. There are innumerable shades of these pigments ranging from light yellow to deep orange, which are produced from the lead chromates. Green shades are obtained by suitable combinations. Lemon chrome, orange chrome, green chrome and middle chrome are some of the important inorganic pigments in these series. It is also used, to some extent, in textile industry. Sub-acetate of lead is used in the sugar factories for laboratory purposes. The process of manufacture of lead acetate is quite simple and involves in the conversion of lead metal into litharge by oxidation with the help of nitrates and, then, litharge is digested in acetic acid. Lead acetate was being imported in large quantities from abroad before the war; but, during war period, production of this chemical was taken up by a few manufacturers in the country. The imports in the past have been as under :

IMPORTS OF LEAD ACETATE

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	71.55	33
1938-39	...	...	79.25	34
1939-40	...	...	62.85	37
1940-41	...	...	78.75	65
1941-42	...	...	189.55	151
1942-43	...	...	77.50	65
1943-44	...	...	12.80	11
1944-45	...	...	114.80	96
1945-46	...	...	46.60	41
1946-47	...	...	2.45	4
1947-48	...	...	52.10	93
1948-49	...	...	18.25	25

The above figures indicate that imports of this commodity were nearly 80 tons per year in pre-war days, whereas during war period the imports dwindled as local production could satisfy major part of demand. It is understood that the entire demand of the country can be fulfilled by local production and there is no need of imports. The manufacturers should, however, be given facilities to import raw material like acetic acid, lead metal and the nitrates of either potash or soda. The prices of lead acetate have considerably been varying, depending on the supply position. The white crystalline qualities of lead acetate are sold at Rs. 100 to Rs. 150 per cwt., whereas the brown quality is comparatively cheaper. Lead nitrate is also being consumed occasionally by the pigment manufacturers when acetic acid is in short supply.

LIME : Chemically, lime is known as calcium oxide and is largely used as a building material. Lime is also an important constituent of mortars and cements. Besides these uses, lime plays very important role in the chemical industry. The utility of lime in some of the basic chemical products is very well recognised, *i.e.*, caustic soda manufacture by causticization process, the extraction of chromite ore for the manufacture of chromates and bichromates, manufacture of bleaching powder and bleach liquors, production of carbide and cyanamide of calcium. Lime is also used in the purification of cane juice in sugar industry and is also used as raw material for glass industry. It has disinfectant properties and has good many such important uses.

Lime is manufactured by the calcination of natural stones which must, necessarily, be carbonates of calcium and are termed as limestones. Marble and calcite are purer varieties of such stones. The simple method of burning a mixture of coal and limestone in open furnaces is very common. Limestone yields lime and carbon dioxide on burning. There are no provisions for collecting carbon dioxide in open furnaces but if closed kilns are worked for the production of lime, gas can also be collected and liquefied. Sugar factories which follow carbonation process for purification of sugar juice have equipments for recovering gas. Normally, open kilns work with over all efficiency of 75 per cent and the fuel consumption is up to 20 per cent. Soda ash factories where Solvay process is followed, have closed type of lime kilns.

The quality of lime produced, depends on the quality and percentage purity of limestone. The calcined lumps of lime, on having been heated to a great extent, come in contact with water and crumble into powder. The qualities, before and after the addition of water, are graded as unslaked and slaked lime. The manufacturers prefer limestones of high purity which should not contain calcium carbonate less than 85 per cent ; and in order to have high quality product, better grades of stones, containing 90 to 95 per cent calcium carbonate are used.

The production of lime is being carried out in the country at various places as the limestone reserves of India, are quite large and have spread in all parts of the country. Lime requirements of the country are, however, met through local production but there are no statistics maintained to record the extent of production. The reason is that it is extremely cheap material and, in pre-war days, lime could be made available at Rs. 20 to Rs. 40 per ton whereas the present prices at the mouth of the kiln are nearly two to three times, while, in the retail markets, good qualities of lime are sold at about Rs. 200 per ton.

LITHARGE, RED LEAD, WHITE LEAD AND LEAD PAINTS: Litharge, the yellow oxide of lead, is very popular lead compound. It is largely used in paint and varnish industry. In small quantities, it is consumed by the medical profession. Litharge is also used as a source for other lead salts and compounds. Red lead, the complex oxide of lead, is cheap red pigment used in paint industry. White lead, the basic carbonate of lead, is a white pigment and is largely used by the paint trade. These pigments have been imported in the past years, in considerable quantity from abroad. A couple of manufacturing concerns, in Calcutta, have successfully been able to produce them.

The figures of imports of lead compounds given on the opposite page, indicate that there have been practically little imports of litharge, red lead and white lead during the post-war period. However, it reflects that the local productions of the same have been adequate and attempts must, necessarily, be made to maintain the production. With the expansion of allied industries, the production of these basic compounds should be enhanced at a short notice. The prices of all these indigenous products are reasonably within the limits of import costs. Normally, the industry of lead salts should be considered as self-sufficient provided the flow of raw materials, is kept at sufficiently increasing rate and at reasonable prices. Unfortunately, lead metal, the basic raw material, is imported from foreign countries and it is observed that the circumstances have been very unfavourable as far as the supply position of the metal is concerned, and even the foreign quotations are unsteady.

Imports of Lead Compounds

Year	Litharge		Other Lead Compounds		Red Lead Genuine and Dry		White Lead Genuine Dry and Moist and Reduced	
	Quantity (Tons)	Rupees (Thousands)	Quantity (Tons)	Rupees (Thousands)	Quantity (Tons)	Rupees (Thousands)	Quantity (Tons)	Rupees (Thousands)
1937-38 ...	61.40	29	42.70	29	512.80	216	567.75	111
1938-39 ...	14.90	6	40.80	26	368.15	143	453.65	211
1939-40 ...	19.95	9	39.85	21	429.05	183	442.85	249
1940-41 ...	11.35	8	21.85	25	166.15	95	186.25	121
1941-42 ...	23.85	15	47.05	51	562.75	88	331.20	229
1942-43 ...	15.55	11	6.45	9	90.20	68	91.35	70
1943-44 ...	2.75	2	11.80	16	8.45	7	19.80	20
1944-45 ...	0.10	..	12.05	14	261.85	152	10.25	10
1945-46 ...	..	..	30.95	30	3.25	3	13.75	16
1946-47 ...	0.05	..	9.90	19	2.65	3	2.50	2
1947-48 ...	..	..	10.60	20	111.80	32	15.00	17
1948-49 ...	0.75	2	10.50	32	0.30	1	0.25	0.5

LITHOPHONE : Chemically, lithophone is a mixture of zinc sulphide and barium sulphate. It is prepared out of barium sulphide and zinc sulphate, duly precipitated from the solutions in molecular proportions. Lithophone essentially contains 28 to 30 per cent of zinc sulphide and the rest is sulphate of barium. It is very homogeneous in composition. It is an extremely important white pigment for the paint industry. This has a very high covering power. It is also largely used in the rubber industry.

The requirements of the country in lithophone are met through imports and the figures of imports are as under :

IMPORTS OF LITHOPHONE

Year	*Lithophone Dry*		*Lithophone Moist*	
	Quantity (Tons)	*Rupees (Thousands)*	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38 ...	1,852.25	345	9.05	3
1938-39 ...	1,564.30	288	19.50	7
1939-40 ...	2,312.40	530	19.00	8
1940-41 ...	1,120.00	376	3.00	1
1941-42 ...	1,804.15	781	..	..
1942-43 ...	1,599.95	756	..	..
1943-44 ...	1,458.75	712	25.00	11
1944-45 ...	1,449.75	644	53.00	21
1945-46 ...	974.55	434	..	..
1946-47 ...	699.95	304	9.95	4
1947-48 ...	655.60	564	1.00	1
1948-49 ...	1,912.65	1,658	..	..

Lithophone is not being produced in the country. The composition of the product is very simple and even the raw materials are easily available. It is an item of vital importance. It would be earnestly desired that the lithophone manufacture should be given encouragement in the country. The prices of the same have been varying to a considerable extent ranging from Rs. 50 to Rs. 100 per cwt. The reasonable price should be within the limits of Rs. 40 per cwt. but market prices have been fluctuating a good deal.

The prices were nearly Rs. 20 to Rs. 30 per cwt. in the pre-war days.

MAGNESIUM CARBONATE: The carbonate of magnesium in natural form, is obtainable as magnesite. Magnesite is largely used in the manufacture of refractory materials and also for producing certain chemicals like epsom salt. The chemically precipitated variety of magnesium carbonate is largely used in rubber industry as a light filler and is also the constituent of medical and toilet preparations.

In fact, very little attempt has been made to produce light variety of magnesium carbonate in the country. There is a big demand for extra light quality for rubber industry. The extent of demand should be estimated to a few hundred tons per year. The technique of manufacture of extra light variety is fairly simple. A few of the locally manufactured grades do not compete the imported qualities in lightness. Attention has, therefore, to be paid in attaining the standards of purity, lightness and fineness. The prices of this product have considerably been varying; and with scarcity of the product in market, prices rise to a very high level, whereas, in the pre-war days, it could be made available at much cheaper rates.

MAGNESIUM CHLORIDE: Magnesium chloride is a product from the sea bittern, and is largely used in textile industry. It is obtainable from the sea bittern, in the form of complex salt as chloride of potassium and magnesium, and is known as carnalite. The separation of potash chloride and the chloride of magnesium is based on certain adjustment of physical conditions of temperature and concentrations of solutions. Magnesium chloride was being imported in large quantities in India, before the World War I. The manufacture of magnesium chloride was taken up in early days of World War I and the local production was found to be sufficient for consumption. Later, the magnesium chloride was given protection in the year 1928 and, till this day, it enjoys protection. The import and production figures during the past few years, as tabulated below, indicate that the trend of imports is downward :

IMPORTS OF MAGNESIUM CHLORIDE

Year	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	593.80	40
1938-39	583.55	39
1939-40	349.40	22
1940-41	0.20	..
1941-42	8.10	5
1942-43	5.90	4
1943-44	0.10	..
1944-45	0.45	1
1945-46	0.40	1
1946-47	0.20	1
1947-48	1.85	3
1948-49	0.40	2

PRODUCTION OF MAGNESIUM CHLORIDE

Year	*Quantity (Tons)*
1938	5,074
1939	6,998
1940	5,863
1941	8,841
1942	9,251
1943	6,667
1944	976
1945	3,367
1946	6,098
1947	6,267
1948	7,705

During the years of World War II there had been no imports of magnesium chloride. It is evident that the local production is now quite sufficient and this industry is more or less on firm footings. The market prices are maintained at a fairly reasonable level.

METABISULPHITE OF SODIUM AND POTASSIUM : The metabisulphites of sodium and potassium are industrial preservatives and are used in the fruit canning industry, especially in the lemon and orange squashes. In photographic industry, these chemicals are recommended for developing and hardening baths. The potassium salts find use by preference.

These chemicals have a very limited demand as it is understood that the demand in the pre-war days never exceeded five tons a year ; whereas, during war days, the imports went up three to four times the pre-war figures. One of the manufacturing concerns of Bombay claims to have an equipment to produce the metabisulphites to the tune of 50 tons a year. The processes of manufacture are simple and involve in passing sulphur dioxide gas through the potassium or sodium carbonate solutions of particular concentration and the operations are performed under controlled conditions of temperature. The produced metabisulphites are crystallised, centrifuged, dried and packed. It is necessary to have a stainless steel equipment for the reaction, though, of course, porcelain lead lined equipments are quite cheap substitutes.

It is reported that the qualities of the locally produced metabisulphites are quite satisfactory and the same have been testified by the various fruit preservation factories and other laboratories. The cost of production is quite competitive and there is no need of imports when the country's requirements can easily be met with local production. The sale prices of these chemicals range from Re. 1 to Rs. 1-8 per lb. The case for protection to this industry has been examined by the Indian Tariff Board during the year 1947, and it is anticipated that this would be a self-supporting industry in due course.

PLASTER OF PARIS : Plaster of paris is obtained from gypsum and is produced by a semi-dehydration of the same at certain controlled temperatures. The various uses of plaster of paris are really based on the fact that it sets into hard mass after coming in contact with water.

Plaster of paris has found uses in the surgical operations for setting broken and fractured bones of the body. It is also used for making models and for producing moulds for good many industries, especially pottery, rubber and ceramics.

The manufacturing process of plaster of paris is very simple but the quality of manufactured product is based on the purity of gypsum. Several manufacturers are making all sorts of plasters for different purposes, *i.e.*, for medical and industrial uses, for arts, crafts and modelling work.

Gypsum deposits are located in South India, Rajputana State and near Dehra Dun in United Provinces and also in some of the other Indian States. Good quality gypsum is not much available in India except that from the Khewra deposits which now fall in Pakistan territory. A good quality Arabian gypsum is also used for the manufacture of plaster. Attempts should, however, be made to improve the quality and colour of the plaster so that it may meet the requirements of the medical profession and has also a proper setting time.

There are small imports of plaster of paris from abroad but the figures of imports and local production are not separately maintained.

PHOSPHATES AND PHOSPHORIC ACID: Phosphoric acid and the phosphate compounds are important salts of element phosphorus which need to occupy a big space in the chapter of chemicals. Amongst the complex phosphates are trisodium phosphate, disodium phosphate, monosodium phosphate, acid calcium phosphate, acid sodium pyrophosphate and the hypophosphites.

Phosphorus is obtained in amorphous and crystalline forms. The amorphous or the red variety is largely used as a raw material for safety matches. In small quantities, it is also used for producing phosphorus alloys, bronzes and other copper and tin alloys. Phosphorus pentoxide and other phosphorus compounds, rodent poisons, flares, smoke-screens are also produced from phosphorus.

Phosphorus is imported in considerable quantities in India. In fact, the demand for the same has increased a good deal due to the rapid expansion of the match industry. The prospects for producing phosphorus in this country should be thoroughly investigated. Attempts have, however, been made at the Indian Institute of Science, Bangalore, for setting up a pilot plant.

Ortho-phosphoric acid, the clear water white liquid, is obtainable in the commercial grades of 50, 75 and 85 per cent purity and is mixable with water in all proportions. Its principal uses are in the ceramic industry for increasing the translucency and for improving the colour of porcelain. It is also used as a vitrifying agent, as flux and as an opacifier in the glass manufacture. Various phosphates of sodium (mono, di, tri) and calcium are produced from phosphoric acid. Further, it is used in the manufacture of ethylene gas, in making albumin derivatives and also as drying agent in the synthetic process of various dyes and intermediaries. Litho-printers also use it in the engraving processes. The double and triple superphosphates and other ammonium phosphates are very important fertilisers. This acid finds good use in the preparation of pharmaceutical products, in making dental cements, in the manufacture of glycero-phosphates, in the manufacture and purification of hydrogen peroxide and, to some extent, in the production of gelatine. It also acts as penetrant aid for absorption of gums for envelopes. Further, it is also used as substitute for tartaric acid and citric acid as preservatives of jelly and soft drinks. In sugar industry, it is used as defecating and clarifying agent. The textile industry makes use of it for brightening the colour of silk, in calico printing and dyeing of cotton. The water treatment with this is also carried out for softening and correcting of alkalinity. The rust-proofing agents also contain phosphoric acid as one of the ingredients and are used for brightening the finish of ropes and twines. Phosphoric acid is also used as a coagulant for rubber latex. The tetra phosphoric acid which is water white viscous liquid has also industrial applications where a high strength phosphoric acid is desired. It is also used as a drying agent.

Trisodium phosphate is, however, known as the tribasic salt and exists as white crystalline material with water of crystallisation but, as anhydrous stuff, it exists as white powder. Its chief uses are, for producing cleaners and detergent for industrial purposes and as a softener in water treatment. Further, it is largely used in textile and leather tanning industry and also in the fruit preservation industry. It has minor use in medicines and also as a constituent of photographic developers.

Disodium phosphate is largely used in making glazes for ceramic industry, *i.e.*, potteries, porcelain, chinaware and enamels. It is also used in many chemical processes and, as an intermediate, for dyestuff manufacture. The textile industry uses it in the weighting of silk and impregnating of textile in dyeing and calico printing. It is used as the bath ingredient in galvanizing process, and also for tinning and soldering purposes. Further, it is used in the leather tanning process. The phosphates of cobalt are used as paint pigments. The dibasic salt also finds use as fertiliser and for fire proofing of wood and paper. In the dairy industry, it is used as emulsifier in making process cheese. In laboratories, it is used as an analytical reagent. It is also finding good use for the medicinal purposes and as an ingredient for boiler compositions, phosphoric acid has sufficient industrial value. The principal uses of monosodium phosphate, are for conditioning boiler water and finds use in electroplating and has also other minor uses in medicines.

Amongst other phosphates, the acid calcium phosphates and the acid sodium pyrophosphates are largely used in baking powders. The hypophosphites of calcium and sodium are of great medical importance and are largely recommended as nerve tonics and for other miscellaneous uses. Apart from the popular phosphates, there are good many complex double phosphates of ammonium, aluminium, barium, calcium, potassium, sodium, magnesium, and zinc. Other salts are pyrophosphates and metaphosphates, both single and double including organic complex of ethyl, diethyl and triethyl group which form a varied range of products and have considerable significance in the chemical and medical fields. The monobasic calcium phosphate, usually known as calcium dihydrogen phosphate, is largely used in bakeries for bread and biscuit making purposes. The dicalcium phosphate which is obtainable in both anhydrous and hydrated form, is largely recommended as mineral supplement in diets for calcium and phosphates deficiency in human body and has special biological and medical value. Dicalcium phosphate is used as a constituent for tooth powders and pastes, because it acts as a polishing agent and strengthens the teeth gums. The tribasic calcium phosphate is also recommended for tooth pastes and powder and is of similar medical value. Its slight presence prevents caking in the various crystalline powders of salt, sugar, talc, etc.

It may be difficult to correctly estimate the country's requirement of the phosphoric acid and phosphates, etc.; as no separate statistics relating the import figures in the country, are being published for general information. The local productions for the same are quite insignificant as they are being carried out on meagre scales. It is assumed that the unofficial estimates of the consumption of phosphoric acid range from 50 to 100 tons per year, whereas the trisodium and disodium phosphates including complex salts might annually be about 300 to 400 tons.

The manufacture of phosphoric acid and phosphates is being carried out by a few firms in the country but production is inadequate. The quality of the manufactured products is approved by consumers. The primary raw materials for the manufacture of these chemicals are bones and sulphuric acid. The dibasic and tribasic salts are, however, produced from phosphoric acid, caustic soda and soda ash. During the year 1946, the Indian Tariff Board had also examined this industry for the grant of protection and it is revealed that the cost of production of the indigenous products is in line with the imported cost. The workable sale prices are roughly estimated, *i.e.*, phosphoric acid at Rs. 95 per cwt., sodium phosphate at Rs. 45 per cwt. and acid calcium phosphate at Rs. 75 per cwt. There are no pre-war production of these chemicals.

It is necessary to restrict the imports and encourage the indigenous production of all the phosphates in India. The progress of the manufacturers must be watched to see that the quality and prices of the products are maintained at a proper level.

POTASSIUM CHLORIDE: Potassium chloride is most commonly found associated with sodium chloride, the common salt. The sea bittern, after the removal of sodium chloride, is found to be rich in the various chlorides like that of magnesium and potassium and also sulphates of potassium and magnesium, with varying percentages of bromides, iodides and other salt. Potassium chloride is found in physically combined form in such complex solutions. Combined with magnesium chloride, it is known as "carnalite." Carnalite, on analysis, is found to contain nearly 15 to 16 per cent of potassium chloride. Elaborate equipments are required for carrying out the separation and is effected under controlled conditions of temperature and pressure and the concentrations of the solution. Large numbers of salt works, in India, discard the sea bittern after the recovery of common salt and leave it as unextracted for rare chemicals. A couple of manufacturing concerns are producing potash chloride. Potash salts, in the form of carnalite, are suitable sources of potash fertilisers.

Muriate of potash is a commercial name given to potassium chloride. It is also found associated with saltpetre and other potash salts. Potassium chloride is also being produced in considerable quantities by the saltpetre manufacturers and the products are sent to the market in different grades of purity. Potassium bichromate is produced by the double decomposition of sodium bichromate and potassium chloride.

It will be of interest to note that potash manures, in the form of muriate of potash, are largely imported in India, and the figure of imports are :

IMPORTS OF MURIATE OF POTASH

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	2,928	286
1938-39	...	...	1,829	183
1939-40	...	...	2,110	270
1940-41	...	...	1,585	203
1941-42	...	...	100	24
1942-43	...	...	696	292
1943-44	...	...	1,258	522
1944-45	...	...	597	205
1945-46	...	...	1,493	419
1946-47	...	...	1,288	395
1947-48	...	...	2,989	860
1948-49	...	...	1,891	607

Evidently, figures indicate that considerable quantities of muriate of potash are imported under the heading of fertilisers, although there are huge resources for production of potash salts in the country. Further advancement in fertiliser industry are bound to create bigger demands and it may be quite reasonable to think of encouraging local production of potash salts. Potash minerals are also plentifully available in the country and it would be a matter of great interest if useful salts of potassium are produced from them.

POTASSIUM CHLORATE : Potassium chlorate is an important raw material for the match industry and is largely used in mixtures of pyrotechny and fireworks. It is also used in gun powders and detonating compositions and is classified as an important explosive chemical. In textile industry, its use is found in certain airline colours and calico printing. Being a strong oxidising agent, the chlorate of potash is used in important inorganic and organic reactions. In fact, it is an easily obtainable source for oxygen gas.

The process of manufacture of chlorate of potash is quite simple and is usually carried out by the chlorination of milk of lime at a specific temperature. The chlorate of calcium is formed as a primary product which is, later, converted into potash chlorate by the process of double decomposition in the presence of potassium chloride.

The potassium chlorate demands have considerably gone high with the progressive developments in the match industry and its increased use in explosives. The potassium chlorate requirements of the country are satisfied both from indigenous production and through imports. The figures of imports during the past few years are recorded below :

IMPORTS OF POTASSIUM CHLORATE

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	2,110.35	708
1938-39	...	...	1,362.45	539
1939-40	...	...	1,948.50	1,128
1940-41	...	...	1,249.55	2,213
1941-42	...	...	779.80	1,753
1942-43	...	...	147.35	443
1943-44	...	...	4.05	12
1944-45	...	...	10.00	19
1945-46	...	...	185.50	335
1946-47	...	...	66.65	69
1947-48	...	...	488.60	499
1948-49	...	...	1,080.05	1,148

There had been huge imports of this chemical before the war, but later, in war period the imports dwindled considerably. The present figures of indigenous production of potassium chlorate are to the tune of nearly 2,000 tons per year, out of which 90 per cent of the production is carried out by Messrs. Western India Match Co., Ltd., as they themselves are one of the biggest consumers of this item.

It may not be difficult to expand the potassium chlorate industry in India, and imports of this chemical could be discouraged. Efforts can be made to stabilise this industry and the production of chlorate of potash, in India, must be planned on serious lines. It would help in the utilisation of excess chlorine which would be available from proposed caustic soda production by electrolytic method.

The price of potassium chlorate has considerably been varying due to its acute shortage at different times. There was strict control enforced by the Government over the prices and its distribution, during war days, and till recently, the controls have been operating in a relaxed form. The rates vary from 14 annas to rupee one and annas four per lb. ; whereas, before the war days, the prices were about 50 per cent of the same.

POTASSIUM NITRATE : Refer saltpetre.

POTASSIUM PERMANGANATE : The permanganate of potash is an important chemical of medical interest and is a popular antiseptic used in hospitals. It has high germicidal value and is largely used for public sanitation purposes. It is a powerful oxidising agent and plays a predominant role in the various chemical processes. It finds use in the manufacture of fine chemicals, synthetic drugs, pharmaceuticals, dyestuffs and several organic compounds. Municipalities and city corporations consume it for the sterilisation of well waters. It is also used in different medicines and preparations. It is a good bleaching agent.

The process of manufacture of potassium permanganate is fairly simple. The chief raw materials are manganese dioxide and caustic potash. The potash manganate is formed as a primary product by the process of fusion and is later converted into permanganate either by the electrolytic process or by passing carbon dioxide in the manganate solution. Manganese dioxide is available in plenty in India. The potassium hydroxide, commercially known as caustic potash, is a suitable potash salt for this purpose. Direct fusion with saltpetre can also yield satisfactory results.

It may not be possible to give a correct idea of consumption of this chemical in the country, as separate figures of imports are not available. Rough estimates of pre-war days may be nearly 150 tons a year, but later, the import figures have been to the tune of about 200 to 250 tons. A few chemical concerns in India undertook production of the same during the war days, but with the reopening of import channels immediately after the war, the local manufacturers had to stop their production as they failed to compete with the foreign product. The imports of this product must be restricted and the needs of the country must, necessarily, be fulfilled through local productions. The case for protection to this industry was examined by the Indian Tariff Board in the beginning of the year 1947. It was revealed that the cost of production of potassium permanganate works fairly in competition with the landed cost of imported qualities. However, it is desired that the imports should be discouraged, in order to make the industry immune from foreign competition. It has now been proved to the satisfaction of the Indian Tariff Board, that if adequate facilities are received from the Government of India by at least half a dozen regular manufacturers, this industry can manage to become self-supporting.

SODIUM ACETATE: Sodium acetate is largely used in the manufacture of dyestuffs and in other intermediate dyeing processes. It finds use as mordant in the dyeing operations. Besides this, it is required in the tanning and soap industries. Further, it is consumed in small quantities, in the pharmaceuticals and photographic lines.

The process of its manufacture is rather simple. It is also obtained as a by-product in some of the chemical processes. The direct method of manufacture from acetic acid and soda ash is rarely followed. It can also be produced from calcium acetate which is recovered as a primary product from the wood distillation products.

No separate figures of imports of sodium acetate are available, but the requirements of the textile industry for this commodity are estimated to be in sufficient quantities. Local productions are also irregular. The prices of sodium acetate were controlled by the Textile Directorate of the Government of India during war period ; but, later, this item was decontrolled when supply position was improved. In fact, indigenous production of sodium acetate should be pitched to a level of maximum requirements and imports should be discouraged.

SODIUM HYDROSULPHITE : Sodium hydrosulphite is an important chemical of interest for the textile industry and is largely used in calico printing. It is, however, produced by the action of zinc dust on bisulphite of soda. Various chemical derivatives of hydrosulphite are sold under different trade names like rangolite, etc. Hydrosulphite of soda is mostly used in textile and sugar industry ; and the extent of such requirements can, however, be seen from the following figures of imports which were made during the past few years :

IMPORTS OF SODIUM HYDROSULPHITE

Year	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	2,449.25	1,398
1938-39	1,173.05	717
1939-40	1,533.00	1,806
1940-41	1,921.65	3,136
1941-42	775.70	1,393
1942-43	351.55	1,453
1943-44	1,145.15	3,303
1944-45	1,468.90	2,911
1945-46	1,195.30	2,134
1946-47	1,683.95	3,079
1947-48	3,115.30	6,146
1948-49	1,785.55	3,069

It can be judged from the figures of imports that the annual requirements of the country have been from 1,500 to 2,000 tons of hydrosulphite of soda. It is difficult to correctly estimate the imports of the substitutes. Being an important article of consumption for textile industry, there was a statutory control enforced by the Textile Directorate of Government of India, during the war period. The releases of the commodity have been allowed under the strict supervision of the authorities at a controlled rate of Rs. 1-3 per lb. which was, later, reduced to Rs. 1-1 per lb. The demand for hydrosulphite of soda, during war days, has been to a great extent ; and, in days of acute shortage, the black market rates had gone pretty high whereas the pre-war rates of the same were hardly more than a few annas.

Hydrosulphite of soda and its other derivatives are not being manufactured in India and it is earnestly desired that schemes to set up plants for their manufacture should be evolved.

The production must be taken up on commercial scales and serious efforts must necessarily be made to develop this industry in the country on a permanent scale, when the bisulphite manufacture is already being carried out satisfactorily.

SODIUM BISULPHITE AND SODIUM SULPHITE : Sulphite and bisulphite of sodium are the allied compounds and have, more or less, identical properties. The bisulphite is, however, formed as primary product when sulphur dioxide gas is passed through sodium carbonate solution. Further addition of sodium carbonate converts it into sulphite. These chemicals are finding use in the leather tanning industry and are also used as raw materials for producing thiosulphate of sodium.

Sodium sulphite and bisulphite are also used in dye stuff manufacture and for digesting wood pulp in the paper industry. They are also consumed in the photographic developing processes. Other uses of sulphites and bisulphites are in the food preservation industry. They also find uses as antichlors in the cotton bleaching process and in coagulating rubber latex. In laboratories, these products are used as analytical reagents. As regards individual and specific uses, the sulphite is used as a depressant in ore flotation, for removing oxygen from boiler feed water, for tanning leather, for desulphurising of wood grease, and for processing dehydrated food ; whereas the bisulphite is used in the manufacture of dyes and as a source for sulphur dioxide gas. The hydrosulphite of soda is produced from bisulphite for vat dyeing process. It is also used for bleaching vegetable tan extract, straw, rabbit fur, sugar syrup, glue and glucose and also as an important antichlors in laundries and in the wool bleaching process.

The process of manufacture of bisulphites and sulphites is fairly simple. The first stage of reaction of sulphur dioxide and sodium carbonate yields bisulphite and, on further addition of carbonate of soda, the sulphite is formed. These reactions are completed under certain specific conditions. The country's requirements for bisulphite are, however, estimated to be from 150 to 200 tons per year, whereas the sulphite is nearly 200 to 250 tons. More prospective annual consumption of both sulphite and bisulphite may be estimated from 500 to 600 tons in the course of two to three years.

The requirements of the country, in respect of sulphite and bisulphite, were fulfilled through imports before the war ; and it was only during war period that the manufacture of these products was taken up, on a commercial scale. The figures of import in the past are not separately available but it is estimated to be nearly 400 to 500 tons per annum. On the other hand, recent local production of each of these chemicals, as per the rated capacity of the manufacturers, is nearly 350 tons, giving a total of nearly 700 to 750 tons of both sulphite and bisulphite. It is observed that during the year 1948, actually 283 tons of sodium sulphite and 257 tons of sodium bisulphite were produced.

The details of the manufacturing cost of the local products, were examined by the Indian Tariff Board in April, 1946. It is revealed that the cost of production of sodium sulphite is expected to be quite competitive to that of the imported material which is about Rs. 40 per cwt. and in the case of the bisulphite the import cost is nearly Rs. 39 per cwt. The expected cost of production of these products, in India, is below Rs. 30 per cwt. The duties on imports must be quite protective and have lately been revised in the year 1949. In fact, the tendency towards decreased cost of production must be watched with keen interest and attempts must be made to assure the cheap availability of raw materials and, at the same time, the sale prices must be kept suppressed.

SODIUM THIOSULPHATE : Sodium thiosulphate is commercially known as "Hypo." It is an important chemical having varied uses in good many industries. In photography, it is used in the printing and developing solutions. It is also required in the chrome tanning process in the leather industry. The utility of hypo as antichlors, in the bleaching process of the textile and paper pulps industries, is quite recognised. Hypo is an important chemical reagent and is also a product for consumption by the pharmaceutical line.

The process of manufacture of hypo is simple and involves in heating the sodium sulphite solution with sulphur powder in an autoclave, under certain specific conditions. The sulphite of soda is, however, produced by passing sulphur dioxide in sodium carbonate solution. Sodium bisulphite is formed in the first stage of reaction and is, later, converted into sulphite with further addition of soda ash.

Hypo was imported from abroad before the war, but indigenous production was really started during war.

The figures of imports during the past years are given below :

IMPORTS OF SODIUM HYPOSULPHITE

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	455.75	81
1938-39	...	...	436.55	90
1939-40	...	...	595.25	155
1940-41	...	...	453.20	140
1941-42	...	...	450.75	151
1942-43	...	...	358.90	137
1943-44	...	...	514.15	235
1944-45	...	...	465.05	204
1945-46	...	...	158.75	71
1946-47	...	...	78.00	46
1947-48	...	...	6.55	3
1948-49	...	...	202.00	318

The above figures of import indicate that the prices of the product per unit have nearly gone up to three times. The import cost ranged from Rs. 8 to Rs. 9 per cwt., in 1937-38 ; whereas, between the years 1943-46, it was between Rs. 22 to Rs. 25 per cwt.

The Indian production has really been on the increase, during the past five years. The rated capacity of about half a dozen plants which are operating in the country exceed 1,000 tons per year. The actual production during the year 1948 was 775 tons. The consumption figures have been reported to be about 750 to 800 tons of hypo and, as such, the imports for the same are not required. The annual requirements of various industries are : in photography about 500 tons, in the leather industry from 100 to 150 tons, and in the textile industry from 50 to 100 tons. It may, however, be noted that the quality of the indigenous hypo has been approved by the prominent consumers like cine laboratories and the Government depots.

The manufacturing cost of the various manufacturers was investigated in the month of April, 1946, by the Indian

Tariff Board for considering the grant of protection to this industry. It is found that the present figures pertaining to the cost of production are less than the import cost and, as such, the existing duty, as levied on imports, gives the industry an adequate protection. Further, the custom duties on hypo have lately been revised in the year 1949. Constant threat of imports might be an instrument for suppressing the increasing trend of prices and enable the manufacturers to maintain their efficiency.

ZINC OXIDE AND ZINC SALTS : Zinc oxide and other zinc compounds are very important group of chemicals and their uses are quite well recognised in the various industries. Zinc oxide is a popular white pigment and has high covering power. It is largely used in producing white zinc paints in dry and ready mixed forms. Apart from its use in white paints, it forms ingredients of other genuine coloured paints. It is widely consumed in rubber industry, both for pressed goods and latex products. Other minor uses of zinc oxide are in the medical profession for use in ointments and adhesive plasters. Small quantities of zinc oxide are also used in glass industry and in enamel factories.

The chloride of zinc, both in fused and solution form, is largely used by the textile industry for weighting cotton goods. Its solution is used in separating silk fibres from wool, cotton and linen, which dissolve in zinc chloride solution. Zinc chloride is a powerful antiseptic and disinfectant and is used as a preservative in the preparation of office paste. It is also used as flux in the galvanizing and soldering process. The zinc sulphate is, however, largely used in textile industry and also as raw material for galvanizing and electrogalvanizing salts.

As already mentioned in the chapter of minerals, zinc ore is very scarce and there is, presently, real shortage of zinc minerals in the country.

Zinc oxide is being produced from zinc spelter at Calcutta by Messrs. D. Waddie & Co., Ltd. Different grades like that of red seal, green seal and white seal, are being manufactured by them. The production is, however, inadequate to meet the country's requirements. Imports from U.K. and U.S.A. are being made in good quantities. The annual production figure of zinc oxide, in India, is nearly 3,000 to 4,000 tons, but the country's requirements are rather estimated to be nearly one and half times the above figures. Lithophone, the zinc sulphide pigment, is another allied product to zinc oxide. The demand for zinc oxide is, sometimes, counter-met by the availability of lithophone.

Zinc chloride has considerably been imported in the past years and the attempt to produce the same in India, has more or less been a failure. There is a definite scope for the production of zinc chloride in the country, but the chief difficulty of materials of construction is one of the prohibitive factors. Various types of synthetic resins are recommended for this purpose but all such equipments have to be imported from abroad. The present annual requirements of zinc chloride, however, range from 2,500 to 3,000 tons, but the local production which had, primarily, been attempted by Messrs. Tata Chemicals Ltd., and by a few other concerns have not materialised. Difficulties exist about the procurement of materials of construction. The high cost of manufacture is also a handicap as the imported stuff is made available at quite a cheap price. The figures of imports of the zinc chloride, zinc compounds and zinc paints are, however, given overleaf to give a rough idea about the extent of imports :

The prices of zinc oxide, both of the imported and locally produced qualities, range from Rs. 40 to Rs. 80 per cwt., depending on the grades, but the markets are usually starved in this item and the consumers are always found grumbling about short supplies. The sale and distribution of the local production was under the directive of the Paints and Gases Directorate, during war days ; whereas, presently, such controls are withdrawn. The sale of zinc chloride was directed through the releases made by the Textile Directorate and there had also been a control over prices which were enforced in consultation with trade.

IMPORTS OF ZINC COMPOUNDS.

Year	*Zinc Chloride* Quantity (Tons)	Rupees (Thousands)	*Zinc Compounds* Quantity (Tons)	Rupees (Thousands)	*Zinc Paints* Quantity (Tons)	Rupees (Thousands)
1937-38	1,736.60	360	3,091.95	982	992.00	490
1938-39	2,068.40	520	2,276.55	636	1,487.00	667
1939-40	1,567.30	520	623.90	177	2,444.80	962
1940-41	1,416.30	591	67.60	48	1,057.20	513
1941-42	1,955.35	833	40.70	89	338.05	261
1942-43	558.50	260	39.60	86	187.20	112
1943-44	889.85	498	20.90	135	16.35	14
1944-45	691.00	444	24.40	28	141.85	148
1945-46	635.15	360	163.55	113	970.60	916
1946-47	818.50	587	40.75	58	981.10	882
1947-48	523.90	379	51.75	181	1,171.05	1,677
1948-49	832.10	691	66.65	129	1,521.75	1,765

It may, however, be taken for granted that zinc and zinc salts have basic importance for good many industries and, as such, Government must encourage the producers of these products and give them every possible help to set up additional manufacturing plants. Further, adequate arrangements must be made to procure suitable zinc ore as a raw material.

CHAPTER V

FERTILISERS INCLUDING AMMONIUM SALTS

INDIA is an agricultural country. The principal crop yield from the Indian soil is much below the average production from that of other advanced countries of the world. Apart from this fact, vast areas of land are lying waste and are undeveloped. It is only recently that the Government have started taking keen interest about agriculture, after the country had experienced food shortage during the war days. The increasing population of the country has further made the problem a serious one, as in the days of acute shortage of food grains the demand for the same has apparently gone up. This problem can be solved by bringing more lands under cultivation and special efforts are needed to develop waste lands and improve irrigation methods. The crop yield per acre can also be increased by the use of artificial fertilisers and manures or by the application of other methods of retaining the fertility of the soil.

The production and application of fertilisers and manures have presently gained world wide importance as the agricultural problems are getting grave on account of food shortage, accompanied by greater and greater demands. Indian agriculture requires very serious attention as her agricultural standard is very poor. Lately, much of the achievements in the agricultural science have made the people feel that the production of various food grains and industrial crops, can be increased by the use of proper plant nutrients. The study of various natural processes of plant synthesis, which progress under the influence of solar energy, reveal that plants also need various chemical elements. These elements are converted into complex compounds and the synthetic processes are classified under the heading of photo-synthesis. The basic needs of plants, which they get from soil and air, are carbon, hydrogen, oxygen, nitrogen, calcium, magnesium, potassium, sodium, phosphorus, iron, silicon, manganese, chlorine, etc.

It is observed that the supplies of carbon, nitrogen, and oxygen from the atmosphere are more or less quite limited and the photo-synthetic process are regulated under slow and steady natural conditions. Most of the elements including carbon, nitrogen, oxygen are supplied by the soil. It is a well known fact that if mineral plant food is not added to the soil, where crops are grown, the original resources necessarily get exhausted in due course, resulting in decreased growth of crops.

The soil that has got natural plant food in abundance and provides nutrition for plants, is considered to be fertile. There are limitations to the fertility of soil and, in practice, there are good many factors that help the soil to retain its fertility. In case no additional mineral plant food is added to the soil, the fertility of soil diminishes, resulting into low crop yield. The soil must contain the nutritive minerals for plants in proper quantity and in assimilable form. The respective ingredients help in building the plants as and when the crop growth occurs. The soil requires to be replenished for such ingredients, every now and then. It must be of such texture that may allow air and water contacts to plant shoots and roots. The physical condition of soil must adequately be suitable to the mechanical pressure of the plant stem. Soils may be clayey or sandy or loamy and react differently under different conditions.

The study of Indian soils and their character is quite important and needs specific attention before the fertilisers for them can be recommended. Rough divisional zones based on soil character have been recognised. The red soils of Madras, Mysore, and South East of Bombay, extending to east of Hyderabad, Central Provinces and Orissa, Chota Nagpur and the South of Bengal. Further, the black soil of Bombay; Berar and west of Central Provinces; Hyderabad extending into Central India and Bundelkhand; other zones comprising of Indo-Gangetic plains, which have lately been effected by the partition of the country, now include East Punjab, plains of United Provinces, Bihar, West Bengal and northern part of Rajputana. This Indo-Gangetic plain is extremely fertile tract of land of the Indian soils. Other soils of the type known as alkali soils are found in United Provinces. Besides these, certain soils are having excess of free salts like saltpetre, chlorides of soda and potash and other sulphates and are unsuitable for growing crops.

The use of manures and fertilisers have to be recommended for the purpose of supplying crops with readily available food to enable the crops to have maximum growth. This also helps in maintaining the original fertility of the soils and modifies the characteristics for balancing chemical composition and the adjustments of physical character of the soil. Manures and fertilisers may roughly be classified under two broad heads :

(*a*) Natural manures.
(*b*) Artificial manures.

The natural manures are further separately classified as organic and mineral manures. The organic manures are a varied class of perishable matter of the type human and animal excreta, fish refuse, sewage manures, blood manures. The popular types of mineral manures are lime, gypsum, kainite, carnalite, mineral phosphates, etc. The artificial manures are more popularly known as chemical fertilisers and amongst important compounds are the ammonium salts which are the richest nitrogen yielding compounds. The cheapest ammonium salt is sulphate of ammonia. Other nitrogenous salts are nitrates of sodium, potassium and ammonium. The phosphates and superphosphates are also important group of artificial manures and fertilisers. Other important chemical fertilisers are calcium cyanamide and calcium nitrate.

A further detailed chemical study of soils and the suitable use of fertilisers and manures helps in classifying them on the basis of the various elements that are required for crop growth.

Nitrogenous Fertilisers: Oil cakes, blood manures, ammonium salts ; nitrates of sodium, potassium, ammonium and calcium ; cyanamide of calcium, urea, etc.

Phosphate Fertilisers : Mineral phosphates, bones, dung, superphosphates, etc.

Potash Fertilisers : Kainite, carnalite ; nitrates, chlorides and sulphates of potash ; felspar, etc.

Carbonaceous Fertilisers : Green manures, straws, leaves, saw dust, animal and human excreta; and slaughter house refuse, etc.

Other types of manures are soda fertilisers which are mainly the sodium salt and compounds including nitrate, sulphate and carbonate of sodium. The calcareous and silicious manures are chiefly the mineral products like lime, gypsum, coal ashes, silica, calcium carbonate which help in modifying the physical character of soil, besides entering into the chemical composition of soil.

ORGANIC MANURES : The use of organic manures is, no doubt, quite well known to the Indian cultivators but, in actual practice, very little efforts are made to utilise them on an organised system. Until the introduction of artificial fertilisers, manuring by natural products had been the only medium for restoring the fertility of the soils. In fact, all kinds of organic matters both vegetable and animal are used for this purpose. The various types of organic matters are briefly described.

ANIMAL EXCRETA AND OTHER REFUSE: These are really the cattle manures which are a mixture of dung, urine and litter and are fairly useful types of manures giving very useful results as the various bacteria present in them help a good deal in fixing the different elements in soil. The chemical decomposition of various complexes is supplemented by the biological actions. The constituents available for plant nutritions from such sources are dependent on assimilable part of animal food. Most of soluble salts are excreted in the urine and are also available from blood waste.

Strictly speaking, the Indian cultivators have got very poor standard of life and do not afford better feeding to their live stocks. The dung is used as fuel and thus useful manures are utilised for less important job. The mode of keeping composts are also defective and little attention is paid towards the fermentation processes. Apart from the animal excreta, the animal refuse of the type hide and leather clippings, hair and horns can be best utilised in the form of composts.

It may be difficult to speak of statistics regarding such type of manuring but it will have to be admitted that, if more attention is paid on this type of organised manuring, the results would be better with no extra cost.

BLOOD MANURE: Dried blood is a very effective manure containing about 14 per cent nitrogen. The drying of blood can be easily carried out with the help of lime. The blood manures can be collected from slaughter house, but are not the products of very common availability and even their use is limited. In fact, they are of little interest in a country like India where people have religious objections to its use.

OIL CAKES: It is a well known fact that oil seeds cultivation is carried out on a fairly extensive scale in India and quite a major portion of such seeds are exported out of the country.

The extraction of oils is also carried on a moderate scale. The oil cakes produced thereafter extraction, are largely used as cattle food; the rejected and unsuitable lots are sent as fertiliser. It is observed that oil cakes have got a high manuring value as the nitrogen, phosphate and potash contents are in sufficient quantity to encourage their use as manures. The important varieties of oil cakes are rape cake, mustard cake, castor cake, cotton seed cake, linseed cake, groundnut cake, etc. The chemical composition of all such varieties of cakes vary. The usual contents are from 4 to 7 per cent nitrogen, 1 to 3 per cent phosphoric acid and 1 to 2 per cent potassium. The application of oil cakes as manures is always carried out after mixing with other manures. Oil cakes are slow acting fertilisers.

Fish guano and the dried fish are rich in nitrogen and phosphates and are recommended as good fertilisers. Besides the above-mentioned manures, there are large numbers of other organic natural manures which can be suitably recommended for the purpose if proper attention is paid towards their utility.

ARTIFICIAL OR CHEMICAL FERTILISERS

There are large number of artificial or chemical fertilisers which have proved useful for the agricultural production. They are, however, classified broadly as under :

(1) Nitrogenous fertilisers ;

(2) Phosphate fertilisers ;

(3) Potash fertilisers ;

(4) Miscellaneous fertilisers.

Nitrogen is probably the most popular element which goes into the composition of large numbers of plant nutrients. Nitrogen is assimilated by plants in combined form and the most important compounds recommended for the use are the ammonium salts and the nitrates. The fundamental importance of nitrogen is recognised in plant biology as it promotes the growth of plants and enables them to resist diseases. The developments of leaves and stems are also due to the presence of nitrogen. The phosphates, however, help in the development of roots and stems. The fruiting and flowering tendency in plants is due to the phosphates which also assist in ripening. The production and maturing of seeds depends on phosphates. The presence of potash helps in the developments of size and weight of roots, seeds and fruits.

The chemical composition of soil has a direct bearing on the power of fertilisation of crops. It is an admitted fact that the chemical composition of soils vary considerably and it may be quite essential to record the following information, if practical measures are to be taken for curing the soils :

(1) Percentage of water soluble nitrogen.
(2) Percentage of water insoluble nitrogen.
(3) Percentage of available insoluble nitrogen.
(4) Percentage of available phosphoric acid.
(5) Percentage of water soluble potash.
(6) Percentage of organic matter.
(7) Detailed chemical composition.
(8) Acidity or basicity of soil.
(9) Moisture contents.
(10) Other undesirable ingredients.

The application of fertilisers to the soil would necessarily depend on above information. It may not be difficult to study the response of individual plants to the plant nutrients if matters are pursued scientifically. Ordinarily, it may be difficult to detect the deficiency of mineral food in plants but careful and scientific study may reveal that conclusions can be derived from the various symptoms that are sometimes visible.

SYMPTOMS OF NUTRITION DEFICIENCY : It may be possible to see the effects of nutrition deficiency in the plants in general and the same may be found localised on certain specific parts of the crop, *i.e.*, stems, roots, leaves, old leaves, new leaves, buds, flowers or fruits. Such visible deficiency may ultimately lead to plant diseases. The following table will give certain brief hints about the various symptoms.

Effects Localised on Parts	*Symptoms (Brief Hints)*
I. Whole Plant: (except natural yellowing and dying of older leaves).	(*a*) Foliage light green; growth of the plant checked; stalk of the plant slender and sometimes fresh ones break; leaves are small and lower leaves are slightly yellower than upper ones; from yellowish shade it dries into light brown colour; usually little dropping. Nitrogen deficiency is observed in such cases.
	(*b*) The foliage is dark green, growth of the plant is retarded, lower leaves sometimes yellow between veins, but more often purplish. Leaves drop yearly. Phosphorus deficiency is anticipated.
II. Older Lower Leaves:	(*a*) Lower leaves mottled usually with necrosis near the tip and margins. When yellowing proceeds from margin to centre, later margins become brown and curve under and older leaves drop. It is found that there is potash deficiency.
	(*b*) The lower leaves develop chlorosis and later become necrotic. Chlorosis appear between the veins and the veins are green. Leaf margins curl upward or downward or develop a puckering effect.

Effects Localised on Parts		*Symptoms (Brief Hints)*
		The developments of necrotic effect between the veins are very sudden. In such cases, it is judged that there is magnesium deficiency.
III. New Leaves :	A.	Where terminal bud is alive.
	(*a*)	The veins of the leaves remain green but chlorosis develops in between the veins.
	(i)	Necrosis is not visible but, in extreme cases, necrosis develop at margin and tip of leaf which, sometimes, extends inward. Large veins remain green. Iron deficiency is suspected in such cases.
	(ii)	Necrosis is visible in spots and is scattered over the leaf surface. Sometimes, leaves develop checkered or finely netted appearance. Bloom is poor and size and colour remain undeveloped. Manganese deficiency is found in such cases.
	(*b*)	Leaves are light green and veins are lighter than adjoining intervenal areas. Necrotic spots are visible at certain places. There is little or no drying of older leaves. It is sulphur deficiency that is found in such cases.

Effects Localised on Parts	*Symptoms (Brief Hints)*
	B. Where terminal bud is dead :
	(*a*) Necrosis develop at tip and margins of young leaves, which are often definitely hooked at tip. The death of roots actually precede all the above symptoms. There is calcium deficiency in such cases.
	(*b*) The young leaves break down at the base and even stem and petioles are brittle. Boron deficiency is observed in these cases.

It is also observed that water is not the only limiting factor to the crop growth. Sometimes, when the crop growth is unsatisfactory, the efforts must necessarily be made to determine if some of the plants nutrients are deficient and, further, physical character of soil must also be studied. The following table might help to supplement the further characteristic of plant growth, where deficiency and abundance of elements effect the ultimate yield of agricultural products.

A. EFFECTS OF NITROGEN :

Insufficient	*Plenty*
1. Soil is sandy.	1. When soils contain organic matter in large quantities.
2. Soil is deficient in organic matter.	2. Plants mature slowly.
3. Soil is greyish in colour.	3. Plants show healthy growth.
4. Soil is extremely acidic in character.	

A. EFFECTS OF NITROGEN :—*contd.*

Insufficient	*Plenty*
5. Where top soil is removed by erosion.	
6. Where soil addition of poor nitrogen is made.	
7. Where land is burnt frequently.	
8. Plants appear stunted and have pale green or yellowish leaves.	
9. Plants mature prematurely.	
10. Leaves of trees are shed early.	

B. EFFECTS OF PHOSPHORIC ACID :

Insufficient	*Plenty*
1. Colour of the soil is grey.	1. Plants develop good root system.
2. Soil has fine texture.	2. Plants attain maturity at proper time.
3. Soil develops extreme acidity.	3. Plants make proper growth.
4. Soil is deficient in organic matter.	
5. Ultimate yield may be poor although crop growth has been satisfactory.	
6. Plants appear stunted where nitrogen and potash are already fed.	

C. EFFECTS OF POTASSIUM :

Insufficient	*Plenty*
1. Soil has greyish colour	1. Plants have good root system.
2. Soil is sandy.	2. Plants growth has been normal.
3. Soil is peaty.	
4. Soil is of calcareous nature and appear to be of limestone origin.	

Details about the utility of other elements can also be studied. In fact, the importance of chemical fertilisers cannot be ignored ; and with all the information about the effects of elements, it may be considered very essential to make use of various chemicals and products. There are several chemical compounds which are useful for this purpose.

It is a matter of great interest to note that the chemical fertilisers are being imported in huge quantities in India. Lately, some of the progressive schemes to take up the manufacture of fertilisers at Sindri (Bihar) have been explored.

NITROGENOUS FERTILISERS : The assimilation of nitrogen by the plant, from the nitrates and the ammonium salts or through the agency of the nitrifying bacteria, is an important biological operation. The various chemicals of interest in this group are as under :

Ammonium Sulphate : Ammonium sulphate is the cheapest ammonium salt and is largely recommended as a fertiliser. Application of ammonium sulphate as fertiliser to the soil is universally recommended but, on continuous use, it is observed that the calcium contents of the soil are reduced. Ammonium sulphate has also other industrial uses. It is used as a source for producing ammonia and other ammonium salts. The demand of ammonium sulphate has considerably been increased in India and major part of the requirements is satisfied through imports. The actual indigenous production, during the year 1948, is recorded as 35,210 tons. The actual figures of imports are as follows :

IMPORTS OF AMMONIUM SULPHATE

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	53,216	5,610
1938-39	...	...	76,748	8,299
1939-40	...	...	79,922	9,637
1940-41	...	...	32,154	5,469
1941-42	...	...	1,627	369
1942-43	...	...	1,361	354
1943-44	...	...	2,550	374
1944-45	...	...	50,841	10,861
1945-46	...	...	69,260	14,374
1946-47	...	...	126,513	28,219
1947-48	...	...	137,456	34,512
1948-49	...	...	133,183	39,426

The method of manufacture of ammonium sulphate is fairly technical. The destructive distillation of nitrogenous material or coal yields ammoniacal liquors which are directly neutralised with sulphuric acid. Production of ammonium sulphate by the fixation of atmospheric nitrogen is probably the most popular method and has certain basic advantages of cheapness and there are several other favourable factors. The installation of synthetic ammonia plants in India has strongly been recommended and it is anticipated that production of sulphuric acid will have to be stepped up if ammonium sulphate manufacture is taken up in India.

A technical mission from the United Kingdom visited India, during the year 1944, to investigate the possibilities of production of artificial fertilisers in India and had, later, recommended the installation of plants to manufacture 350,000 tons of ammonium sulphate annually. The problem has also been studied with respect to the availability of raw materials, fuel and power. Other economic factors for the location of factory sites have duly been examined.

The processes for the manufacture of ammonium sulphate had also been recommended by the technical mission. The synthetic process for the manufacture of ammonia from hydrogen and nitrogen is quite suitable. Hydrogen could most suitably be produced by any of the commercial methods of manufacture and the possible sources for the same were fully examined. The process of conversion of ammonia into ammonium sulphate was also scrutinised and the possibilities of increasing sulphuric acid production had also been kept in view. The utilisation of gypsum, on a commercial scale, are strongly recommended. The various raw materials for the production of ammonium sulphate are, therefore, enumerated as sulphur, pyrites, gypsum, coke, coal, nitrogen and hydrogen. Besides these, the availability of cheap power and electric energy are the basic points for consideration.

The prospects of fertiliser production schemes as recommended by the technical mission, are primarily based on the availability of various raw materials. The natural sulphur resources in India are, decidedly, of minor importance. The Baluchistan deposits as originally surveyed in 1941 were estimated to yield several thousand tons of sulphur but, later during the war period, the working of such deposits was found to be uneconomic. These deposits are now really inaccessible after the partition of the country as such reserves fall to the share of Pakistan. The sulphuric acid industry in India has all along flourished on imported sulphur which was obtained from Japan and Italy before war; but, during the war days, American sulphur has also been imported in large quantities. The prospects of utilisation of pyrites as a source for sulphuric acid industry in India are not very bright. The gypsum deposits, as originally located, are found in Bikaner and Jodhpur States of Rajputana and in Trichinopoly. The reserves of gypsum of Western Pakistan which are located at the Salt Range are now excluded, until some suitable arrangements are made to procure supplies from Pakistan. Presently, it is felt that the requirements of gypsum for cement industry are equally important and it would be a matter of constant anxiety if the existing reserves of gypsum of the Indian Union are diverted to the fertiliser industry.

The availability of coke, charcoal and coal are also the items of keen consideration. It is observed that fairly large quantities of a high quality coke are required for this purpose and it will be necessary to set up additional metallurgical coke furnaces to cope up with the demand. The existing production from some of the metallurgical furnaces go to the iron and steel industry which would, necessarily, need still further quantities of coke if iron and steel industry expands. The suitability of charcoal for the fertiliser industry is also examined but it may not find economic use on account of certain basic difficulties. The utilisation of coal as source for steam and electric power is quite important and need be considered when other factors are being properly examined.

Various schemes had been recommended by the technical mission, *i.e.*. for the installation of six factories, three factories, two factories and a single factory and relative figures for cost of production of ammonium sulphate at different scales in the specified number of factories were worked out. Two suitable sites were recommended for installation of the factories, *i.e.*, one in the province of Bihar and the other in the United Provinces. In Bihar, a place known as Sindri which is located on the river Damodar near Dhanbad was selected. The erection projects of plant installation have also been taken up in hand by the Government of India. The suitability of Sindri as a site for the purpose was mainly based on the fact that it is situated near the coal fields and the easy and economic availability of coke and coal is anticipated and, at times, it may be considered worthwhile to consume some of the low grade coals. Other factors relating to the availability of other raw materials and the distribution of finished products were also taken into calculation. The second site was recommended at Harduganj near Aligarh in the United Provinces. The various factors which appear to be favourable are the economic availability of water supplies by tube wells and, besides this, some of the existing building constructions including a thermal power station, were the tempting factors for effecting the selection of site. Other points were also determined to be favourable. Some of the brief estimates of cost of production, as worked out by the mission, are reported to be nearly Rs. 114 per ton in the case of single factory scheme with initial cost of Rs. 10.1 crores. The cost of production figures are high if two, three and six factory schemes were to be worked out and, at the same time, the initial capital cost would be comparatively higher. It is now anticipated that the above theoretical figures would be much different as the partition of country has considerably effected the position of raw materials.

Ammonium Nitrate : Ammonium nitrate is one of the richest nitrogen containing chemical compound which can also be considered for use as fertiliser ; but the main difficulty being that it is an explosive and is also hygroscopic in character. On account of its high solubility in water, there is a danger of quick washing away. The process of manufacture of ammonium nitrate is quite simple, but, involves in the installation of nitrogen fixation plants from which this product can be produced at a very cheap cost. Its use may be tried in more stable forms to ensure proper assimilation of the same by plants. Production of ammonium nitrate has so far not been taken up in India, but, in due course, it could be considered.

Ammonium Chloride : Amongst other ammonium salts, the chloride of ammonia is an important salt as it is greatly demanded for various industrial purposes. Ammonium chloride is largely used in batteries and electrolytic cells, and its specific use in the dry batteries is quite popular as it is a very good electrolyte. Ammonium chloride is also used in the soldering, tinning and galvanizing industries. In small quantities, it finds use in the textile and rubber industries. It has also a minor use as a medicine. Further, it can find use as a fertiliser but is a costly product to be recommended on a commercial scale.

Ammonium chloride is manufactured by absorbing ammonia in dilute hydrochloric acid solution. The commercial product, thus obtained, is purified by the process of sublimation. Another commercial process of manufacture is by the double decomposition of solution of ammonium sulphate and sodium chloride. The products after reaction are ammonium chloride and sodium sulphate and are later separated from each other.

The country's requirements in ammonium chloride were being fulfilled through imports before the World War II. During war period, production of ammonium chloride was taken up in India on small scale but foreign competition did not allow the local producers to flourish. The figures of import during the past period have considerably been varying as it would be clear from data given below :

IMPORTS OF AMMONIUM CHLORIDE

Year	*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	1,524.15	396
1938-39	1,279.65	352
1939-40	2,110.20	708
1940-41	2,026.95	754
1941-42	1,968.85	821
1942-43	1,291.30	677
1943-44	1,033.65	560
1944-45	5,373.50	2,472
1945-46	1,370.55	851
1946-47	2,063.95	1,007
1947-48	1,630.60	754
1948-49	3,984.55	2,122

In actual practice, ammonium chloride is being imported in the country in three forms, *i.e.*, powder, tablets and bars. The imports were more or less monopolised by Messrs. Imperial Chemical Industries (India) Ltd., and are sold under different trade names. It may be considered worthwhile to revive this war industry in India, and the production may be taken up on a more elaborate scale. There is no doubt that ammonium sulphate, the basic raw material, will have to be imported for the time being; but with the introduction of synthetic ammonia plants, situation will improve and utilisation of hydrochloric acid or chlorine productions would be in somewhat useful direction.

SODIUM NITRATE: Sodium nitrate contains about 15 to 16 per cent available nitrogen and is one of the most popular fertilisers, besides being an important chemical product. Natural deposits of sodium nitrate are found in Chile in South America and, this product is commercially known as Chilean saltpetre. It is being imported in India in large quantities for both chemical and agricultural purposes. The import figures during the last few years, as indicated by the table below, appear to be quite unsteady. The food shortage in India has urged the Government to import sodium nitrate on State account to enable them to allocate and, thus, allot the quantities of the same to the agricultural consumers strictly on regional basis.

IMPORTS OF SODIUM NITRATE

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	3,208	319
1938-39	...	...	2,137	224
1939-40	...	...	6,226	803
1940-41	...	...	3,151	485
1941-42	...	...	2,639	714
1942-43	...	...	2	0.3
1943-44	...	...	..	..
1944-45	...	...	..	..
1945-46	...	...	..	..
1946-47	...	...	1,711	396
1947-48	...	...	10,361	2,534
1948-49	...	...	21,831	4,103

The crude Chilean ore has been the world's source of supply for a considerable period; but with the introduction of synthetic nitrogenous compounds, the importance of natural products is reduced. Sodium nitrate is readily absorbed by the plants and ensures quick growth in cold and moist conditions. Diseased plants, in early stages, recover from diseases by the application of this fertiliser. Care must, therefore, be taken in adjusting the quantities of the same, as excessive amount prolongs the growth period and also encourages underground growth. It is a quickly washable product and must be applied at a proper season and at a proper spot to avoid wastage. Sodium nitrate manures must be stored in dry places as, otherwise, lumps are formed in moist atmosphere. Suitable proportions of sodium nitrate in fertiliser mixtures are required for different crops. The cereal crops require moderate quantities. Meadows show very healthy results with soda nitrate manures. The growth of cabbage is much quicker with soda nitrate manures.

CALCIUM NITRATE: Calcium nitrate is also an important fertiliser like sodium nitrate. There is an additional advantage for the better fertility as the element calcium is also introduced into the soil by its use. It also helps in improving the texture of the soil. The use of calcium nitrate is, however, limited because it is deliquescent and the problems of storage and blending are rather of serious nature. In actual practice, it is carried to the fields in air-tight tins. The use of fillers like calcined gypsum or other inert materials is recommended along with calcium nitrate as, otherwise, it has a tendency of cake formation.

Calcium nitrate is commercially known as Norwegian saltpetre and is produced by the action of nitric acid on limestone. The synthetic process of manufacture involves in the fixation of nitrogen into oxide and peroxide which, on absorption in water, yield dilute acidic solutions. Neutralisation of the acid solution with limestone forms calcium nitrate in solution and the same is, subsequently, concentrated and fused into a solid mass. It may be advisable to study the problem of actual manufacture of calcium nitrate after the results of utility are testified through experiments and practical demonstrations.

CALCIUM CYANAMIDE: Calcium cyanamide is a very popular fertiliser and shows effective results because it is a water insoluble product. The decomposition of calcium cyanamide into urea, calcium carbonate, ammonia and nitrates takes place in the soil and assimilation of the same by plants takes place in a very effective way. It gives good results with loamy soil of average fertility. It is also quite cheap. This fertiliser has a big disadvantage as there are chances for the conversion of cyanamide into dicyanamide. It does not even show effective result in light sandy soil, peaty soil and humus acid containing soils. The process for the manufacture of calcium cyanamide is rather tedious and involves in the installation of high temperature electro-thermic furnaces. Nitrogen on reacting with calcium carbide at high temperature yields calcium cyanamide. The scope and the methods of manufacture can be considered under the heading of electrothermic reactions.

PHOSPHATE AND PHOSPHATIC MANURES: The main source of phosphatic manures are mineral phosphates or rock phosphates, superphosphates, basic slags, bone powders and bone meals.

MINERAL PHOSPHATES: The natural phosphate rock deposits and soils contain tricalcium phosphates in complex forms are located in some of the districts of Bihar and South India. Apatite, the complex natural mineral, contains phosphates combined with chloride or fluoride of calcium. The rock phosphates are found associated with silicates of iron and aluminium and calcium carbonate. The utilization of such resources of mineral phosphates can be attempted as the process of chemical treatments for the recovery of phosphates is quite easy. The correct estimates for such reserves of mineral phosphates in India must also be made.

BONE POWDERS AND BONE MEALS: Bones are very rich in phosphates. Besides, they contain nitrogen, calcium and other constituents. The use of bones, directly as fertilisers, is very limited as they take extremely long time to decompose in the natural course. Bones also contain fat which prolong the decomposition of inert phosphates. Fat is, therefore, removed by steaming process or by the process of extraction with solvents. For practical purposes, bones are crushed in disintegrators and then fat is extracted with the solvents and later steaming is done, or sometimes only steaming is done. In certain cases, bones are also given sulphuric acid treatment.

Commercial gradation of bone products are under different names, *i.e.*, bone meal, bone ash, bone black, and bone superphosphates, etc. Normally, bones contain nearly 50 per cent of phosphates in the form of tricalcium phosphate and magnesium phosphate and also nearly 3.5 to 4.5 per cent of nitrogen. The degreased bones, still rich in organic matter, ground to coarse meal are known as " bone meal " and serve a useful purpose as a substitute for superphosphates for certain crops. Soils deficient in lime or with excessive humus, give effective results with bone meal. Calcareous soils do not respond satisfactorily to bone meal. Bones when degreased and finely crushed, are also treated with sulphuric acid. This process yields partially soluble stuff. Bones are, sometimes, given alkali treatment with caustic soda and caustic potash solutions and the reaction is hastened by boiling. The use of quicklime is also made in crude processing but the results are far from satisfactory as the process is very slow. The processes of bone fermentation are also tried in certain cases. Bone ash is obtained when organic matter and adhered fats are destroyed by the process of calcination, leaving the residue rich in tricalcium phosphate of nearly 70 to 75 per cent contents.

Further charring of bones in closed retorts, yield bone black of nearly 10 per cent activated carbon and the remaining residue with contents of calcium phosphates. Bone black is largely used in sugar refineries for the decolourisation of sugar juice as the same stuff, after it has served the purpose, can be used as fertilisers in the fields.

SUPERPHOSPHATES : Superphosphate has great commercial value as a fertiliser and is a soluble phosphate prepared from the rock or bone phosphates. The insoluble tricalcium phosphate is converted into monocalcium phosphate by the action of sulphuric acid. The process of manufacture is quite simple and involves in mixing the bone powder with the acid. Finely powdered raw phosphates are thoroughly mixed with acid and are allowed to decompose in an open space. The mixers and other equipments for the same must be acid resistant. Phosphoric acid can also be manufactured at the next stage of reaction. Superphosphate manufacture is being carried out on a very moderate scale by a few manufacturers in the country. During the year 1948, the production of superphosphates was 21,358 tons in India. The figures of import for the last few years are as under :

IMPORTS OF SUPERPHOSPHATES

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	7,405	568
1938-39	...	...	6,788	565
1939-40	...	...	7,758	628
1940-41	...	...	6,732	1,050
1941-42	...	...	2,722	460
1942-43	...	...	..	..
1943-44	...	...	148	37
1944-45	...	...	1,572	389
1945-46	...	...	901	137
1946-47	...	...	60	17
1947-48	...	...	380	146
1948-49	...	...	1,000	367

The above figures clearly indicate the extent of demand for phosphates and superphosphates in India. There is, however, a bright future for this industry as country's requirements for phosphate manures are bound to go up in due course.

AMMONIUM PHOSPHATE: Ammonium phosphate is another important fertiliser which supplies both nitrogen and phosphate groups to the soil and serves the double purpose. It is annually imported, in India, in fairly large quantities and prospects for its manufacture in the country must be carefully considered. Figures of imports, during the past years, are as follows:

IMPORTS OF AMMONIUM PHOSPHATE

Year			*Quantity (Tons)*	*Rupees (Thousands)*
1937-38	...	...	2,167	317
1938-39	...	...	2,569	395
1939-40	...	...	973	160
1940-41	...	...	1,389	338
1941-42	...	...	250	64
1942-43	...	...	..	..
1943-44	...	...	..	..
1944-45	...	...	54,822	2,714
1945-46	...	...	3,853	969
1946-47	...	...	3,026	753
1947-48	...	...	7,918	2,768
1948-49	...	...	3,984	1,450

POTASH FERTILISERS: The presence of potassium salts in the soil have been found helpful in improving the size and weight of roots, seeds and fruits. The stem of some of the cereals plants, pick up strength quickly if soil has adequate quantities of potash. Large numbers of crops like sugar-cane, potatoes, tomatoes, sugar beet, barley and some of the fruit crops develop rapidly in the soils wherein potash fertilisers are applied. The various potassium salts, including the complex ones which find use as fertilisers, are of marine origin and are also available as natural geological deposits. The important ones are kainite, carnalite, sylvinite which are double sulphates and double chlorides of magnesium and potassium and are complex salts. The common potassium compounds are potassium chloride, potassium nitrate, carbonate of potash and sulphate of potash. Potassium is also largely found, in chemically combined form, in good number of minerals like felspar and a large number of clays. The use of potash fertilisers in India has not been made with keen interest and little attention has so far been paid to the developments of potash industry. Some of the details about potash minerals and prospects of the production of potash salts have already been dealt with, in the chapters of minerals. The production of potassium sulphate and potassium chloride is carried out from the respective complex compounds by fractional crystallisation. The potash industry has bright prospects and can be developed side by side with the sea salt industry along the coastal line of the country. The nitrate of potash, known as saltpetre, is also available at various centres in India although major proportion of such production centres has fallen to the lot of Pakistan, after the partition. The production of carbonate of potash is more or less dependent on saltpetre and, with the increased prices of saltpetre, the manufacture of potash carbonate has become uneconomic. The commercial uses of these potash salts as fertilisers like nitrates and carbonates are getting limited as their prices are quite prohibitive today.

The production of potash salts from minerals like felspar and clays can be taken up in hand if only proper attention is paid to the industry. Recovery of potash from wood ashes and from spent molasses liquor is also possible. Wood ashes are directly sent to fields to be used as fertilisers and the process of potash recovery are not pursued.

NATURAL MINERAL FERTILISERS: There are a large number of natural minerals which act, directly or indirectly, as suitable plant nutrients. Some of the complex minerals slowly decompose into simple salts and constituents which are easily assimilated by plants. The various calcium minerals like lime, limestone, chalk, corals, gypsum, shells, etc., are amongst very common types of mineral fertilisers. Apart from these, a large number of clays and soils, on decomposition, yield suitable nutritive ingredients to the plants.

The various calcium minerals correct the soil acidity as the same is neutralised by the alkaline action of the different oxides and carbonates of some of the elements like calcium and magnesium. Certain silicates and phosphates of calcium also behave in this manner. Such minerals provide for the calcium deficiency of the soil and have manifold advantages with quicker results. Burnt lime of slaked and unslaked qualities is directly used. Other slow processes of weathering of limestone and natural carbonates of lime and gypsum also help in introducing calcium element into the soil. Lime has got a direct nutritive function and, in soluble forms, it is directly assimilated by plants. Presence of calcium in plants creates immunity from diseases and makes the plants more resistive in character. Lime also tends to neutralise toxity in plants and eliminates poisons. The ascent of sap in plants is indirectly influenced by calcium as the *pH* value of the sap which is responsible for this conducive action, is corrected and maintained by the same. Some of the biological reactions, inside the plants cells, are initiated by the presence of lime. The application of lime and its allied ingredients to the soil has to be done at proper period of the year and in proper seasons. Lime effects the soil, both chemically as well as mechanically. Chemically, lime if applied to peaty soils containing humus will react with humus and releases useful ingredients as plant food, thus, the causticity of lime helps considerably. The mechanical purpose is served by improving the texture of the soil. Amongst the other mineral fertiliser, it may be worthwhile to mention about the sulphates of magnesium, sodium, and iron but the quantities recommended in each case are very minor and their scope for utility is more or less limited. They, definitely, help to produce effective results.

Scientific study of the various fertilisers has revealed that certain suitable mixtures of such chemicals and natural products, both of vegetable and animal origin, can be blended to prepare various types of plant nutrients. Manure mixtures are prepared after careful study of plant requirements which can be concluded from the analytical reports, supplemented by the keen observation of biological growth of plants. It may require a vast space in this chapter to go into the deep details of suitable plant manures for various crops, *i.e.*, wheat, barley, rice, cotton, sugar-cane, tea, coffee, tomato, jute, potatoes, flax, hemp, vegetables and fruit gardens including meadows and pasture lands. The problems of storage and application of fertiliser are also very important and need to be studied before completing investigations on the subject.

CHAPTER VI

FINE CHEMICALS

THE term "Fine Chemicals" covers a varied group of chemicals and products. It includes medicinal and pharmaceutical preparations, pure chemicals, analytical reagents, perfumes, flavours and a large number of organic and inorganic compounds used in various industries. Besides these, there are various other chemicals required for certain refined types of industries, and are like photographic chemicals, solvents, anæsthetics, drugs, insecticides, antiseptics and disinfectants which also fall under this category. It is, however, difficult to restrict the definition of fine chemicals to any specific class and it may not be possible to generalise the mode of classification but, roughly, they may be grouped as under :

(*a*) Industrial Fine Chemicals.
(*b*) Laboratory Analytical Reagents.
(*c*) Wood, Coal and Coal Tar Distillation Products.
(*d*) Drugs, Medicines and Pharmaceuticals.
(*e*) Miscellaneous chemicals and solvents.

A. INDUSTRIAL FINE CHEMICALS :

There are a large variety of industrial fine chemicals of organic and inorganic type. Some of the inorganic compounds are oxides, hydroxides, carbonates, bicarbonates, chlorates, sulphates, chlorides, nitrates, sulphites, bisulphites, bisulphates, persulphates, cyanides of sodium, potassium, ammonium and several other metals and non-metals. The processes for manufacture of fine chemicals are quite simple. In most of the cases, general equipments to be installed are reaction tanks, filters, settlers and decanters, distillation stills, crystallisers, hydro-extractors, vacuum driers, centrifugal pumps, etc. Fabrication of these machinery units is not very difficult, but the main object of attaining highest degree of efficiency is of paramount importance. Fine chemicals serve a large set of industries, *i.e.*, textile, leather tanning, rubber, paper, match, glass, explosives, food and fruit preservation, electroplating, photography, etc. Besides these chemicals, various fluxes, tempering chemicals and case hardening compounds used in foundries and metallurgical workshops are also classified under this heading.

Mordants and certain auxiliaries are another class of industrial fine chemicals and are the products of interest to textile industry. These are required for the treatment of cotton, silk, art silk and woollen yarn and fabrics. The consumption of all these chemicals is in fairly large quantities in all the textile mills of the country. Leather tanning industry consumes various chromates, bichromates, sulphites, bisulphites, thiosulphates, sulphates, sulphides and other alkaline salts and have a wide scope for their production in India. It may absolutely be essential to examine and consider the scope for developments in the production of all such chemicals at the various leather tanning centres. The electroplating industry is, however, spread all over the country and the production of various plating and polishing compounds has got to be encouraged in India, as at present all requirements are covered through imports. The various plating salts are that of copper, nickel, chromium, silver, gold, cadmium, manganese, zinc and tin, etc., which are, essentially, water soluble salts and, in certain cases, they are cyanides and double cyanides and have a great industrial value. It must clearly be borne in mind that annual imports of patent electroplating salts worth several lakhs of rupees are made in the country. Similar products, comparable to the foreign ones, can be manufactured in the country, but sufficient propaganda and publicity is required to popularise the use of such basic plating salts. Practical demonstrations combined with utility tests must be organised to use them advantageously. The iron and steel industry and other metallurgical workshops require a large set of tempering chemicals, case hardening compounds, anti-corrosive salts which are like phosphoric acid, phosphates and other complex salts like cyanides, ferrocyanides, etc. The various fluxing salts are prepared from carbonates and bicarbonates, boric acid, borax, fluorides, ammonium chloride, etc. There are large number of other industries like cosmetics and perfumery, laundering and manufacture of fungicides herbicides, germicides, which also consume fine chemicals. Baking powders which are manufactured from bicarbonate of soda or carbonate of ammonia with other salts like trisodium phosphate and tartaric acid are also amongst this class of fine chemicals.

A large number of organic chemicals is also classified under the heading of fine chemicals. A few of the monobasic, dibasic, tribasic acids of aliphatic series and also acids of aromatic group are included in this category. In addition, there are hydrocarbons of aliphatic series of saturated and unsaturated groups, and also cyclic hydrocarbons of aromatic series, aldehydes, alcohols, amines, amides, azides and carbamides and phenols, etc. Further, there are other groups of the type of industrial solvents like ethyl acetate, butyl acetate, amyl acetate, carbon disulphide, carbon tetrachloride, chloroform, acetone, alcohols ethers, etc. Production of these organic fine chemicals may be considered as a highly technical task and involves in several chemical actions and physical operations and in setting up distillation and purification units and fermentation plants. It is decidedly a matter of great interest to note that there is no appreciable production of such organic chemicals in the country. It is absolutely essential to consider the scope for manufacture of these fine chemicals here in India on an elaborate scale.

B. LABORATORY ANALYTICAL REAGENTS :

Chemicals which are required for research work and other routine analytical work in laboratories are of highest degree of purity and are more or less of standard specifications where impurities are covered under limitations. Products labelled as A.R. (analytical reagent), C.P. (chemically pure) E.P. (extra pure), B.P. (specified under British pharmacœpea) are supplied to the laboratories. The various consumers of such chemicals are schools, colleges, university laboratories and other industrial and research institutes. It is estimated that laboratory chemicals worth several lakhs of rupees are imported every year in the country. German chemicals were very popular in India before the World War II and preparations bearing trade marks " Merks," " Bayer," etc., always carried high reputation. Chemicals of B.D.H. (British Drug House), M.B. (May and Baker) and Johnson's make also hold high significance in this trade. It is observed that some of the American reagent chemicals have also found market in India and are being imported in fairly large quantities.

Production of laboratory chemicals and analytical reagents of inorganic series can be taken up without much difficulty as it is simply a matter of further purification of commercial chemicals. Some of the heavy chemicals, that are already being produced in the country, can be sent for further purification during manufacturing operations. There are a large set of rare inorganic laboratory chemicals of the type molybdic acid, molybdates, salts of lithium, vanadium, palladium, thorium, titanium, selenium, uranium, etc., which have got to be imported at present as the same are not available in the country. As already mentioned, serious efforts have to be made for the production of organic chemicals. It may be considered quite essential to work out plans for setting up suitable equipments which are primarly meant to attain the highest degree of purity for the production of organic reagents of correct melting points, boiling points and other physical constants, with corresponding chemical analysis. The demand for fine chemicals is limited; hence, the plant units for the manufacturing purposes must be of comparatively smaller sizes and dimensions, but all connected processes command the use of highly skilled labour and technique. The use of crystallisers, filters, hydro-extractors, vacuum driers, vacuum distillation stills is essential and performance of other ordinary physical operations is usually recommended for the various methods of processing and purification.

C. WOOD, COAL AND COAL TAR DISTILLATION PRODUCTS :

Chemicals and products which are obtained from dry distillation of wood, coal and coal tar are also classified under the heading of fine chemicals. The importance of coal carbonisation industry can be realised from the fact that innumerable chemicals and dyes and other intermediaries which are obtained from such products, are finding use in almost all the industries and form basic raw materials for most of them.

WOOD : It is observed that during the process of charcoal production from wood by crude method, various useful volatiles are allowed to go waste. Recovery of such volatiles reveals that a good number of important chemicals can be obtained from wood. Apart from gaseous products, the condensed pyroligneous liquor yields methyl alcohol, acetic acid and acetone. The residual tar further yields certain solvents on distillation and the last residue left behind is pitch.

Truly speaking, there is no wood distillation industry in India. Charcoal production is indiscriminately carried out by primitive methods. The coke production industry, which is operated in conjunction with iron and steel smelting furnaces at a few centres, has enabled the manufacturers to recover some of the chemicals like non-condensible gases, methyl alcohol, calcium acetate, and pitch. Acetone and acetic acid can be produced from calcium acetate. Apart from these, other products like ketones, creosote and soluble tar are also recovered.

Wood distillation is quite popular in other Western countries and it is believed that such achievements were pronounced to a very great extent in Germany before World War II. Similar products have been obtained in countries like U.K. and U.S.A. with successful results. Investigations on experimental scale have been carried out in India and some of the recovery units attached to the iron and steel industry, have shown appreciable achievements. Messrs.

Mysore Iron & Steel Works Ltd., are recovering a few important chemicals, although the cost of recovery is a bit high as compared to that of the foreign products. Practical utilities of the recovered products are too numerous to be listed here. Acetic acid and acetic anhydride have vast scope in textile, rubber and acetate silk industries. In the productions of cellulose lacquers these chemicals find sufficient use. Methyl alcohol is very useful solvent for shellac and certain gums and resins. It can also be oxidised to produce formaldehyde. Methyl alcochol is also used as a denaturant for rectified spirits. Calcium acetate is used for the production of soda acetate, and other complexes. Acetone is also recovered from the crude acetate and it acts as an important solvent for a large number of products.

It is difficult to record separately the extent of requirements of the wood distillation products in this country. Serious efforts have to be made for setting up nearly a dozen centres of wood distillation and such centres must necessarily be near some forests where suitable hard wood is available in plenty. The wood distillation technique is presently lacking in the country and foreign experts may be required for assistance.

COAL AND COAL TAR PRODUCTS : Coal and coal tar distillates are very important set of chemicals and intermediaries, which are very valuable to the dyestuff and drugs industries. Coal distillation is mainly being carried out in India for the purpose of producing coal gas or for the manufacture of coke for metallurgical purposes for the iron and steel industry, where the distillation operations are carried out in coke ovens and very small percentage of coal tar is obtained. Distillation of coal tar yields low boiling oils and solvents like coal tar naphtha. On further process of distillation and refining, a large set of products are separated ; some of them are phenols, cresols and the tar base pyridine. Naphthalene can be isolated at the next stages of refining. The coal gases, on condensation, yield some of the important groups of solvents like benzol, toluol, xylol, etc. The coal tar distillation has been encouraged near the coal fields in Bihar and Bengal and nearly half a dozen concerns are carrying out distillation at those centres. The production of creosote oil and naphthalene has successfully been taken up by them. The benzol recovery plants installed by two iron and steel factories, *i.e.*, Tata Iron & Steel Co., Ltd. and Indian Iron & Steel Co., Ltd., were started at the initiative of the Government during the period of World War II. The working capacity of these benzol recovery plants is several million gallons of solvent naptha, benzene and toluene.

The existing coke ovens are operated at a high temperature and, hence, some of the organic compounds polymerise and are beyond recovery ; therefore, the coking process must necessarily be carried out at a low temperature. Some of the suitable products that have successfully been recovered are naphthalene, phenol and cresols and amongst solvents are benzene, toluene and solvent naphtha. A few leading distillers are Messrs. Shalimar Tar Products Co., Ltd., Messrs. Bararee Coke Co., Messrs. Balmer Lawrie & Co., Ltd., Messrs. Indian Iron & Steel Co., Ltd., Messrs. Tata Iron & Steel Co., Ltd., Messrs. Bengal Chemical and Pharmaceuticals Co., Ltd., Messrs. Bombay Gas Co., Ltd., etc. Coal distillation industry had received impetus from the official circles, primarily, during the war period ; as foreign sources for most of the products were suspended. War contracts for the supply of cresylic creosote, naphthalene, and solvents and disinfectants were placed with those firms. The war time annual productions recorded are as under :

Naphthalene	... 600 tons.
Phenol ...	... 50 tons.
Cresols ...	... 100 tons
Benzene ...	...20 lakh gallons (nearly)
Toluene ...	... 4 to 5 lakh gallons (nearly)
Solvent naphtha	... 1 lakh gallons.

The solvent distillation units were installed and operated by the Iron and Steel Companies on behalf of the Government of India.

It may be a matter of common interest to both drugs and dyestuff industries to encourage coal tar distillation industry in the country, but the future developments in the industrial sphere need be properly watched. The co-ordination of production and consumption of these groups of fine chemicals is extremely essential as, at present, the production scale of this industry is pretty small and it would essentially command a progressive review of all the aspects.

It may not be out of place to mention that the production of disinfectants and antiseptic fluids from cresylic creosote is being carried out on an elaborate scale in India. The figures of imports of naphthalene and other disinfectants in the past, as given overleaf, indicate the importance of the coal tar distillation industry.

The imports of the basic disinfectants have considerably dwindled as the local productions, which were primarily a war time programme, are now in full swing and are meeting major part of country's requirements. It is anticipated that the coal tar distillation industry has a very bright future in India and, in due course, it is going to attain necessary importance.

D. DRUGS, MEDICINES AND PHARMACEUTICALS :

The progress of the medical science has, in fact, direct bearing on the application of various drugs, medicines and pharmaceuticals which have been produced as the result of chemical and biological researches. A large number of products of animal and vegetable origin have shown curative results in the cases of various diseases. Some of the synthetic drugs and chemicals have also proved extremely useful. The subject of drugs and pharmaceuticals is really very vast and innumerable sets of products have been found to play a magnificent role. The results in several cases have been recorded to be quite successful and admirable. The various

IMPORTS OF DISINFECTANTS

Year	Naphthalene		Carbolic Acid		Other Sorts	
	Quantity (Tons)	Rupees (Thousands)	Quantity (Tons)	Rupees (Thousands)	Quantity (Tons)	Rupees (Thousan
1937-38	461.95	159	27.10	30	1,044.30	662
1938-39	510.65	151	44.20	44	828.65	425
1939-40	391.75	122	29.35	28	1,197.55	519
1940-41	172.85	80	31.15	42	929.90	600
1941-42	394.40	241	59.00	73	1,054.90	745
1942-43	13.25	13	6.05	10	395.05	342
1943-44	31.30	26	82.15	143	415.20	407
1944-45	222.20	223	290.90	555	825.95	811
1945-46	217.45	218	83.05	166	1,120.95	1,160
1946-47	105.15	138	13.35	14	1,588.90	3,090
1947-48	52.10	79	5.40	7	1,057.65	1,118
1948-49	71.20	68	29.15	42	450.00	843

animal and vegetable products are like vitamins, hormones, liver extracts, extracts from thyroid, adrenaline, pituitary extract, etc. and the extracts obtained from vegetable plant roots, barks, flowers, leaves, seeds, fruits, etc. Besides these, there are a large number of other synthetic chemicals like sulpha drugs, such as sulphanilamide, sulphathiazole, sulphadiazine, sulphamethazine, sulphaphthalidine, etc., and other chemicals like mepacrine, paludrine, dichloro-diphenyl-trichloroethane, *p*-carbaminophenyl arsonic acid, and antibiotics like penicillin and streptomycin, etc. A broad grouping of these products may be as under :

(1) Animal Products.
(2) Vegetable Products and Galenicals.
(3) Synthetic Drugs.
(4) Vitamins and Hormones.
(5) Miscellaneous Products.

The pharmaceutical industry in India has made a commendable progress, since the World War I, in the manufacture of biological products like vaccines, sera. antitoxins, common injectables, proprietary medicines, tinctures and extracts, but little attention has been paid to the production of synthetic drugs, vitamins, hormones, etc.

ANIMAL PRODUCTS : There are innumerable products which can be listed under the heading of animal products. The chief sources for various animal products are slaughter houses where goats, sheep, buffaloes, cows, bullocks and calves are killed in thousands every day, in almost all the principal towns of India. The glandular materials recovered from the slaughter houses yield sufficient amount of insulin, thyroid extract, liver extract, adrenaline, pituitary extract, etc. The bile extract is used for the production of bile salt, known as sodium taurocholate and glycocholate, etc. Production of cod liver oil, shark liver oil and extracts rich in vitamins and hormones is also carried out in the country to a certain extent.

In actual practice, it may be desired that the removal of glands and tissues from a slaughter house to the spot of extraction may be done as quickly as possible, because, there are chances of deterioration and decay. In several cases, inferior products are obtained because the slaughtered animals are originally undernourished.

A good variety of patent medicines are put in the market which, in most cases, contain products of animal origin. Extracts from blood, urine are also found to yield some of the useful products. The juices from glands from certain animals are compounded with other chemicals and are marketed under particular trade names. Some of the sex hormones have sufficiently helped in the most complicated cases of maternity.

A large number of vaccines, antitoxins and sera have been put in the medical field to fight the bacterial infections such as cholera, typhoid, smallpox, plague, etc., and production of the same is being carried out at various laboratories in India. The centres of vaccine production are organised by the Central and Provincial Governments. The various important laboratories in India are :

(1) The Cholera Vaccine Laboratory, Calcutta.
(2) Central Research Institute, Kasauli.
(3) Pasteur and Medical Research Institute, Shillong.
(4) King Institute, Madras.
(5) Haffkine Institute, Bombay.
(6) The Provincial Hygiene Laboratory, Lucknow.

The production of antirabic vaccine is being carried out at the Pasteur Institute of India, Kasauli, and the Pasteur Institute of India, Calcutta, and the Pasteur Institute of Southern India, Coonoor. The production of vaccine lymph is being carried out in several big towns of various provinces.

The antitoxins and sera are produced in India by some of the laboratories, managed by the Government and, besides this, a few commercial firms have successfully put sera in the market. The popularity of various vaccines, antitoxins and sera depends entirely on the medical propaganda which is presently being carried out, directly or indirectly, by the health institutes and is rather a responsibility of the Government. The production of cod liver oil, shark liver oil, along with vitamin extracts is a matter of developing fish oil industry in India and the same can flourish at the various coastal centres. The fish oil industry in India is now in its initial stages, and efforts must be made to develop the same for producing extracts of cod liver and shark liver oil and also for recovering vitamins and vitamin concentrates.

VEGETABLE PRODUCTS : Drugs of vegetable origin extracted and preserved in the form of tinctures, are more popularly termed as "galenicals." Roots, barks leaves, seeds and flowers of certain specific plants have got important alkaloids or active principal compound ingredients, which are toxic and antitoxic in character, possessing medicinal and therapeutic properties. Some of the important drugs are like codeine, quinine, strychnine, ephedrine, caffeine, santonin, morphine, emetine. Besides these drugs, other products of vegetable origin are essential oils like oil of peppermint, thymol, menthol, sandalwood oil, eucalyptus oil, palmrosa oil, cardamom oil, lemon grass oil, citronella oil and several other similar products. Utility of such oils is of great interest to the medical science and production of these oils may be considered as an equally important job.

India is sufficiently rich in crude drugs and these are abundantly found in hills and valleys. Collection and selection of crude drugs is really a skilled job and is to be carried out on scientific lines. Presently, the process of artificial cultivation of such drug plants is not carried out on an elaborate scale except that collection from natural herbs is done in crude and primitive fashion. The detailed studies of cultivation of drug plants and herbs can help in improving the yield and in preparing the plants at proper degree of maturity, thus enabling the extraction of drugs in maximum quantities at the suitable period of growth.

Extraction of alkaloids and active principals from plants is carried out very easily with proper solvents in suitable equipments. The various solvents used for the purpose of extraction are the types of organic low boiling liquids, *i.e.*, alcohols, acetone, ether, petroleum ether, benzol, chloroform, etc. Other useful solvents are acid and alkaline solutions and the principle of extraction is based on chemical reactions and in the formation of certain soluble complexes from which original alkaloids can be separated, if so desired. The alkaline solutions are generally that of caustic soda, soda carbonate, ammonia, etc., and, in the case of acid solutions, sulphuric and hydrochloric acids are preferably used. A large number of important crude drug plants and other crops grow in plenty, a few out of the same are *aconite, aloe, areca nut, ajowan, catechu, castor seed, cardamom, chiretta, cinchona bark, cinnamon, coffee, datura, ephedra herb, eucalyptus, ginger, ipecacuanha root, liquorice, neem, nux vomica, opium, sandalwood, tamarind, tea, etc.* Some of these crops are regularly cultivated in different plains, hilly and mountainous tracts while others grow wild and are collected by the local inhabitants of the particular regions. It may not be out of place to give details of a few of the important drugs.

QUININE : Quinine, the anti-malarial drug, has shown marvellous results in curing millions of cases of malaria and is extracted from cinchona bark which is obtainable in sufficient quantities from the cinchona plants. Cultivation of cinchona is already carried out in the districts of Darjeeling and Nilgiris in India. There are several varieties in cinchona species and a large number of similar alkaloids are obtainable from them, *i.e.*, quinidine, cinchonine, cinchonidine, etc. It is observed that the climatic conditions of India are very favourable for better yield of quinine from the bark. Recovery of quinine from the crude drug is in the form of complexes like bisulphates, bihydrobromides and bihydrochlorides, which are the soluble salts. Usual percentage of quinine recovery is ranging from 1.5 to 4 per cent of cinchona.

The requirements of quinine have been met with imports in the previous years and, at the same time, huge quantities of cinchona bark were exported. Later, official estimates indicated that it would be advisable to stop exports of cinchona and prospects of extraction of quinine here in India must be considered more seriously. Malaria and the effects of this disease are quite pronounced in India where conditions of sanitation are very poor and millions of lives are lost every year. The importance of quinine and its salts may be calculated on the basis of population of the country and the comparative occurrence of the malaria diseases. The use of synthetic anti-malarial drugs like atebrin, mepacrine, paludrine, etc., has greatly been recommended in the absence of sufficient supplies of quinine. Apart from the internal administration of the drugs for fighting out malaria, it is now quite well realised that other preventive measures which could physically eliminate mosquitoes, would certainly help in curtailing the demand for drugs. Use of kerosene oil, naphthalene, D.D.T., pyrethrum extracts and other means for improving hygienic conditions of the residential places would help in the campaign against the spread of such diseases. The Anti-malarial Institute with its headquarters at Delhi and sub-centres in various towns, are vigorously functioning to supplement health and hygiene schemes.

It may be difficult to speak correctly of the figures for future production of quinine since imports and consumption of the same would depend on sanitation of the villages and towns and, further, on the application of the various preventive measures adopted for the purpose of fighting malarial diseases. The popularity and cheapness of other synthetic drugs is another factor which can also effect the demand for quinine. It is realised that quinine is comparatively cheap and a very effective drug. Its production in the country must be encouraged and official estimates of the target of production are laid down to nearly two million lbs. of quinine every year. The figures of imports of quinine salts and export of cinchona bark, during the past few years, are given below :

Year		*Imports of Quinine Salts*		*Exports of Cinchona Bark*	
		Lbs. (Thousands)	*Rupees (Thousands)*	*Lbs. (Thousands)*	*Rupees (Thousands)*
1937-38	...	105	2,629	28	10
1938-39	...	98	2,537	33	11
1939-40	...	83	2,487	69	24
1940-41	...	101	3,228	37	17
1941-42	...	175	6,016	22	11
1942-43	...	40	1,548	..	..
1943-44	...	2	81	..	..
1944-45	...	3	167	..	..
1945-46	...	18	358	..	..
1946-47	...	61	2,933	..	..
1947-48	...	124	3,045	..	..
1948-49	...	243	9,332	..	..

It may be difficult to derive any conclusion from the above figures as local production statistics of quinine salts are not included in the above statement. Estimates of demands can roughly be guessed from the import figures.

There are a large number of other alkaloids and active principal ingredients which can be recovered from Indian herbs and plants. The following table will briefly indicate the scope in these lines.

Alkaloid	*Sources*	*Remarks*
Emetine	Ipecacuanha root	Ipecac plant growth is not yet popular in India. Successful growth has been tried in Darjeeling district and Nilgiris. Yield is approximately 1.25 per cent. Prospects for artificial cultivation of plant must be examined very carefully as the product obtained is in good demand. Present requirements are covered through imports. Initially production of nearly 2,000 lbs. per annum must be considered. It finds use in the cases of amœbic dysentery.

Alkaloid	*Sources*	*Remarks*
Ephedrine	Ephedra Herb	Ephedra herbs are found plentiful in the country. Yield of alkaloid ranges from 0.5 to 1.0 per cent. Present production is nearly 3,000 lbs. per year whereas requirements are estimated to be nearly 5,000 lbs.
Caffeine	Tea waste	Production centres in Assam: yield of alkaloid is nearly 2 per cent. Requirements estimated to be nearly 30,000 lbs.
Morphine and Codeine	Opium	Production carried out at Alkaloid Works, Ghazipur, with production of morphine 1,100 lbs. and codeine 200 lbs. per annum before World War II. Requirements are estimated to be 3,000 lbs. of morphine and 1,500 lbs. of codeine.
Santonin	Artomesia	Santonin is required for the prevention of helminthic infections. Artomesia cultivation is carried out in Kashmir. Present production is nearly 2,000 to 3,000 lbs.
Strychnine	Nux vomica	Nux vomica is the natural herb plentifully available in India. Nux vomica seeds are largely exported out of India. Yield of strychnine is nearly 1.5 per cent. Present production is about 15,000 lbs per annum.
Pyrethrin	Pyrethrum flower	Pyrethrum growth is very popular in Kenya, East Africa. Successful growth has been tried in Kashmir, Madras, Punjab and also in Mysore and Assam. Pyrethrin is very effective mosquito repellant and is extremely useful in preparing mosquito sprays.

VITAMINS AND HORMONES: **The discovery of vitamins and hormones has certainly proved to be a great asset to the medical profession. The presence of vitamins in**

various food stuffs and other vegetable and animal products has considerably helped in the study of nutritive effects of diets. Deficiency in vitamins, if detected, can be supplemented at times by the administration of vitamin extracts. The various products like green vegetables, fruits and milk, etc., are found to be rich in vitamin contents.

The chemical composition of the various vitamins like A, B complex, C, D, E and K, etc., have been ascertained and, in certain cases, are successfully isolated and various extracts are marketed under proprietory rights. The isolation of vitamins from their natural sources has so far not been properly carried out in India, although the work on experimental scale is successfully done. The following chart will briefly indicate the scope for production and recovery of various useful vitamins :

Vitamins	*Sources*	*Remarks*
Vitamin A	Milk, shark liver oil, carrots, green vegetables and fruits.	Serious efforts towards the production of milk and milk products are needed. Shark liver oil industry can be developed with bright prospects. Vitamin A has high nutritive value for the growth and developments of children and adults. Its deficiency causes night blindness and resistance towards infections diminishes.
Vitamin B complex (B-1, B-2, etc.)	Unpolished rice, meat, milk, egg yolk, green vegetables and fruits.	Production of vitamins B complex, B-1, B-2, thiamin, riboflavine and nicotinic acid is highly recommended as a good lot of diseases prevail on account of their deficiency.
Vitamin C	Citrus fruits, fresh fruits, fresh vegetables, dried Amala.	Deficiency of this vitamin causes scurvy and also other diseases. Synthetically, vitamin C has also been produced as Ascorbic acid and prospects for production in India are quite favourable.

Other vitamins D, E, K, etc., are also of very useful category and it is observed that requirements of the same, in the isolated form, are very limited. It may be considered worth while to proceed vigorously with researches for locating and isolating vitamins in largest quantities.

Hormones are a very useful class of chemical products and are isolated from the various animal glands. A few of the important hormones are adrenaline, thyroid, pituitary extract, insulin, estrone, progesterone, testosterone, stilboestrol, etc. Production of the same must be taken up on an elaborate scale.

SYNTHETIC DRUGS : The subject of synthetic drugs is extremely vast and covers a large number of specific groups :

(1) Sulpha drugs.
(2) Anti-malarials.
(3) Narcotics.
(4) Local and General Anæsthetics.
(5) Anti-pyretic and Analgesics.
(6) Antiseptic, Disinfectants and Anti-biotics, etc.

It may not be possible to go into the details of all such groups as the scope of this chapter is limited. The importance of various synthetic drugs is today well known in the world, though there is no appreciable progress so far as their production, in India, is concerned. Large number of infectious diseases are today cured by the use of sulpha drugs of the type sulphanilamides and several of their derivatives. Their popularity with the medical profession has made the people feel that immediate steps towards the production of the important group of sulpha drugs and the various derivatives, must be taken up on a commercial scale. Scope for the production of anti-malarial drugs like Atebrin, Plasmochin, Mepacrine, Paludrine, etc., have also got to be considered on serious lines. The latest introduction of anti-biotics like penicillin and streptomycin have further opened avenues for the adaptation of synthetic chemicals in India as, presently, huge imports of the same are made. Similarly, there are other groups which are of vital importance in the medical field. It is sincerely desired that the production of synthetic drugs in India must be planned on sound lines and practical measures must be adopted for the materialisation of various schemes.

E. MISCELLANEOUS CHEMICALS AND SOLVENTS :

Apart from the fact that there are a large number of miscellaneous fine chemicals, which need to be dealt within this chapter, it will equally be important to touch the subject of solvents. Large number of industries have already been referred to as the consumers of fine chemicals.

SOLVENTS : The importance of solvents and process of extraction is very well recognised in almost all the branches of chemistry. There are a large number of liquid solvents which find practical uses in commercial processes of extractions. The utility of various solvents is, primarily, based on chemical and physical properties of solvents and that of the products to be extracted. A large number of low boiling organic liquids are very popular solvents. Besides these, acid and alkaline solutions are also used for the purpose.

Some of the popular solvents are given below :

(1) Alcohols.
(2) Hydrocarbons and petroleum products.
(3) Esters and Acetates.
(4) Chloro and sulphur compounds.
(5) Miscellaneous solvents.

The following table will indicate the present position of solvents in India :

Group	*Important Products*	*Remarks*
Alcohols	Methyl alcohol Ethyl alcohol Furfural alcohol Butyl alcohol Propyl alcohol Amyl alcohol, etc.	Production of methyl alcohol is being carried out in India on quite a limited scale. It is an item of fairly big demand for chemical processes, and for its use as a solvent. Methyl alcohol production depends on wood distillation industry. Ethyl alcohol production is quite adequate in India as large number of distilleries are operating. Use of other alcohols is quite limited.
Hydrocarbons and Petroleum products.	Benzene Toluene Xylene Petroleum ether Solvent naphtha.	Production capacity of existing plants for benzol and toluol is quite in order for the present requirements but it will go up in due course. Xylene demand would go up for D.D.T. productions, if it is taken up in the right earnest.
	Kerosene Mineral oils, etc.	Present production is limited. Solvents of petroleum origin are imported in huge quantities.
Esters and acetates	Ethyl acetate Butyl acetate Amyl acetate Vinyl acetate Gylcol and Glycol acetate, etc.	The production of all these acetates is already being carried out and these are available in sufficient quantities. They have huge demand as thinners in the paints, varnishes and lacquer industries.
Chloro and Sulphur compounds	Chloroform Carbon tetrachloride Chlorine Chloro-ethylene Sulphur chloride Carbon bisulphide, etc.	Except chloroform, all these chloro and sulphur compound solvents are imported for the present. Chloroform is also imported. It has an anæsthetic value and is in sufficient demand. Carbon bisulphide is an important solvent for rubber and rayon industries. Chlorine is produced in India in sufficient quantities.

Group	*Important Products*	*Remarks*
Miscellaneous solvents	Acetic acid Glycerine Pyridine Ammonia aqueous Nitrobenzene Acetone Ethyl ether Acid solutions Alkaline solutions.	The importance of miscellaneous solvents depends on the individual industrial requirements. Most of them are imported in large quantities. Acetone is very important solvent for celluloid and its production must be attempted on a commercial scale. Present production is inadequate. It can develop with wood distillation industry.

In nutshell, it may be expressed that the importance of fine chemicals is increasing in India every day and it is anticipated that, in course of time, some of the schemes for the production of synthetic drugs might mature. The various processes that are involved in production are technical and need trained and skilled personnel.

CHAPTER VII

ELECTROCHEMICAL INDUSTRIES AND ELECTROPLATING ACCESSORIES

SOME of the important electrochemical industries which can be started most successfully in India are really dependant on the cheap availability of electrical energy. These industries may be classified under the following broad heads :

(1) Electrolytic Products.
(2) Electrometallurgical Products.
(3) Electrothermal Products.
(4) Electrolytic Oxidation and Reduction Products.
(5) Electrochemistry of Gases.
(6) Electrochemical Energy.
(7) Electronics and Atomic Energy.

There is a wide scope for the establishment of electrochemical industries in India. These industries involve the application and utilisation of electrical energy which conducts the chemical processes. Apart from the theoretical operational details, it may be quite important to consider the following technical points :

(*a*) Designs of machinery.
(*b*) Constructional details of plants.
(*c*) Operations of the equipments.
(*d*) Economic considerations of cost and quality of the products.

Electrochemical processes are more direct than the corresponding chemical ones and, hence, have better efficiency. The purity of the products obtained by the former process is usually higher but the same may be somewhat expensive. Electrochemical processes, if carried out under uniform conditions, give satisfactory results. Raw materials of high purity are usually demanded in the electrochemical processes.

as accumulation of impurities are sometimes detrimental to the equipments and, in certain cases, efficiency is also lowered down. These industries require specific equipments for particular processes which need specialised attention of the experts. Some of the industries are briefly stated below.

ELECTROLYSIS OF AQUEOUS ELECTROLYTES : The most important process of this type is the electrolysis of common salt solution for the production of caustic soda which also yields chlorine and hydrogen as the by-products. It has already been mentioned in the chapter of chemicals that caustic soda holds extremely important commercial and industrial value in the field of chemical industries.

A good number of patents have been obtained for the working of the various electrolytic mercury cells in the foreign countries. The various cells, *i.e.*, Castner cell, Sorensen cell, Krebs cell, Hargreaves-Bird cell, Townsend cell, Allen-Moore cell, Nelson cell, Hooker cell, Basle cell, Gibbs, Wheeler and Vorce cells, etc., have got different working efficiency. The constructional details of various equipments differ and even the working and operational specifications like voltage, current density, concentration of solutions, etc., vary from plant to plant.

Selection of a particular equipment has to be affected by keeping in view several factors, *i.e.*, suitability of raw materials; quality and purity and the ultimate cost of finished products. This also includes other factors which govern the selection of sites. In the case of caustic soda manufacture, it has already been recommended in the previous chapters that a series of electrolytic plants must be set up at the big port stations along the Indian coastal line.

It is a well known fact that hydrogen and oxygen gases are obtained from water as a result of electrolytic decomposition. Commercial electrolytic cells for hydrogen and oxygen production are entirely built of iron and steel, with insulating materials, using asbestos cloth as diaphragm. Several patents for such cells are obtained in foreign countries, *i.e.*, Levin cell, Knowles cell, etc. These gases are produced as a result of electrolytic action and are, later on, separately taken to their respective chambers, and from there, these are utilised according to the requirements.

The uses of hydrogen and oxygen are too many but it may briefly be stated that the production of oxygen by this process can only be preferred when hydrogen is simultaneously required. Oxygen alone can be recovered from the fractional liquefaction of air and it is a better commercial method. It is more economical than the electrolytic process.

Oxygen is finding good use in the autogenous welding and metal cutting processes. Metals like cast iron, steel, magnalium, aluminium can easily be welded and quick repairs can be done in the case of broken parts. Welding finds important use in the motor car industry. A jet of oxygen, impinged on lime, gives highly illuminating flame. In the iron smelting furnaces, the blockades are cleared through by the oxygen flames. Oxygen is also used in the mining and tunnelling operations. In the tinning and enamelling industry, it is required for melting and welding different parts. Apart from such industrial uses, oxygen is largely used for artificial respiration in hospitals and on other life-saving occasions.

Hydrogen is very largely demanded for many important industrial purposes. It is used as a combustible gas. Mixed with carbon-monoxide, it is commercially termed as " water gas." It is required in large quantities for the hydrogenation of fats. The production of synthetic ammonia from hydrogen is its another important use. Owing to its extreme lightness, hydrogen is used for filling balloons. It has a good lifting power, therefore it is utilised for aerial navigation.

There are various methods for producing industrial hydrogen. The electrolytic method of production can be taken up where electrical energy is quite cheap or where alternative methods are unsuitable.

The fact that the electrolytic process of refining metals gives highly purified products, is one of the main factors responsible for the popularity of this process. The purity attained by ordinary heating and smelting process is usually of a limited standard, and after that, a stage is reached when the scope for further purification vanishes. The electrolytic processes give most wonderful results in the refining of certain important metals, *i.e.*, copper, lead, nickel, tin, silver, gold, bismuth, etc. These processes are mainly based on simple principles of electrochemistry. Electrolytic refining gives products of highest purity and eliminates all possible impurities. At times, it assists in recovering some of the precious elements like gold and silver from waste impurities.

These processes of electrorefining are mainly of metallurgical interest especially for non-ferrous metals. The applications of electrorefining processes are, however, limited in India as the resources for such metals are very meagre in this country, but it is possible that, in due course, these processes may gain importance.

The process of electrowinning is one of the allied operations of metallurgy and is found useful in the case of copper and zinc ores and also in the recovery of cadmium and manganese. This is a case of preferential electromotive force that is created by the contact of electrolytes and certain alloys, metals and salts. The application of this process is really dependent on the progressive developments in metallurgy in the country.

The subject of electrodeposition is really very important as it has attained a great commercial value in India. It involves in giving a thin coating of one metal on another, either to serve protective or decorative purpose. Its importance is well recognised in the automobile, aviation and aircraft industries and further, it has applications in the manufacture of surgical instruments, hospital equipments, novelties and presentation articles.

The achievements in the metal and alloy plating have really served the task of solving some of the chronic problems of rusting, corrosion, atmospheric corrosion, chemical corrosion, and weathering processes. The various electroplating processes include several plating jobs like that of copper plating, nickel plating, chrome plating, zinc plating, tin plating, silver plating, gold plating, platinum plating, brass plating, etc. The process of electrogalvanizing and electrodeposition of rubber and resins and other process of electrocleaning, pickling, electropolishing, and electrotyping have similar commercial importance and it is desired to study the possibilities of expanding these lines in the country, where large number of electroplating workshops are engaged on good number of plating works. A large number of plating chemicals and other accessories are consumed by the various plating workshops.

The production of electroplating chemical and polishing accessories is a line of great significance, where, practically, all the plating shops are dependent on the foreign materials. the details of such products are given separately.

ELECTROMETALLURGICAL PRODUCTS : So far, the developments in electrometallurgical operations have rather been poor in India. This may be attributed to the various reasons ; firstly, it may be due to lack of technique of working of electrometallurgical furnaces ; secondly, non-availability of suitable equipments and machinery ; and thirdly, for want of cheap electric energy in the country. The electrometallurgical products require temperature higher than those obtainable by ordinary cumbustion methods. The electric heating gives higher relative efficiency but it may be more costly if cheap power is not available. The working of electric furnaces is based on the electric arcs which are operated under varied conditions. The establishment of electric furnaces in India for producing steel, ferroalloys and other non-ferrous metals can be given definite preference to ordinary combustion furnaces, on account of the fact that the fuel supplies of the country are inadequate. In fact, the mechanism and the working operations of such furnaces are very complicated and their introduction in the industrial fields would take some time. At present, the fundamental necessity for the setting up of electrometallurgical furnaces on commercial scales in India, is urgently being felt. There are several furnace designs based on different constructional and operational details and are patented individually. A broad classification of such electrometallurgical furnaces is, further, outlined as Direct Series Arc Furnaces, Direct Arc Free Hearth Electrode Furnaces, Direct Arc Buried Hearth Electrode Furnaces, Indirect Arc Furnaces, Mixed types and also the Induction Furnaces.

Scores of patents are taken for steel production furnaces and each individual design has its own merits. In general, the production of steel by electrometallurgical methods is a definite problem of present day interest, in India, when iron ores are available in plenty, whereas coal and coke are comparatively in short supply. All calculations about future plans for steel production centres in India should be based on the installation of electrothermic furnaces. In fact, there are good chances of creating several new production centres of iron and steel in the iron ore bearing regions of the country which are away from Bihar and Bengal coal reserves.

There are a large number of ferro-alloys, *i.e.*, ferrosilicon, ferromanganese, ferrotungsten, ferrovanadium, etc., which are produced by the electrometallurgical methods and are found to serve useful purposes in various industries. The prospects for the production of various alloys can, simultaneously, be considered along with the steel industry. Similarly, the production of non-ferrous metals and alloys by the electrometallurgical processes can be encouraged and suitable schemes for the same can be worked out. In fact, the production of alloys like brass and bronze are the problems of vital interest, in India, as these are in big demand for commercial and industrial purposes.

The various electrolytic reactions and processes in fused condition of products are quite technical. The commercial applications of these processes are for the production of most important elements like that of aluminium, magnesium, beryllium, calcium, lithium, sodium, potassium, barium, etc.

Production of aluminium and magnesium metals in India for which the raw materials are plentiful in the country, commands urgent attention. The importance of these elements and their alloys is very well recognised in the aircraft industry. Unlimited quantities of aluminium and magnesium ores, in India, promise bright future for the manufacture of large quantities of the metals in the element form. It may be quite insignificant to talk of production figures and the future targets as the primary job of initial planning has to be given priority and, in fact, production plans are yet under consideration. Messrs. Aluminium Corporation of India Ltd., are operating their plants, at Asansol, quite satisfactorily and it may be quite reasonable to think of maturing more production schemes. The calculations about successful working can be materialised without much difficulty. In the case of magnesium metal, any suitable production unit would be welcomed. The problems relating to the manufacture of sodium and potassium can also be studied and can be given a practical shape.

ELECTROTHERMAL PRODUCTS: A large number of commercial products like calcium carbide, calcium cyanamide, abrasives, graphite, boron carbide, fused alumina, silicon, fused quartz, carbon bisulphide, phosphorus, etc., are produced in the electrothermic furnaces. All the above products are of much commercial and industrial value but none of them is being produced in India, and, on the other hand, they are being imported into the country in fairly large quantities. There is really a good scope for the production of all of them as the raw materials are plentifully available in India. Serious attention should be paid to form suitable production units in the country and attempts must be made to secure proper equipments for the furnaces and allied machinery.

ELECTROLYTIC OXIDATION AND REDUCTION PRODUCTS: Some of the organic compounds are electrolytically prepared by the cathodic reduction or anodic oxidation processes. Sorbitol and mannitol (hexahydric alcohols) are produced by the electrolytic reduction of alkaline solution of glucose. Other products obtained by these processes are bromoform, iodoform, chloral, paramino-phenol, etc.

The production of perchlorates, persulphates and perborates is also carried out by anodic oxidation. Similarly, permanganate of potash is also produced by the electro-chemical processes. Most of these products are of commercial interest and are required to be manufactured in reasonable quantities in India, especially the perborate of soda and permanganate of potash.

ELECTROCHEMISTRY OF GASES : The fixation of atmospheric nitrogen by electrothermic process into nitric acid, nitrates, ammonia and ammonium compounds has sufficiently attracted the attention of the present day industrial interests. The quick formation of oxides of nitrogen from a mixture of nitrogen and oxygen has given successful results for the production of a large number of nitrogen compounds and fertilisers. Attempts are, however, in progress to set up a few plants for the manufacture of fertilisers in India and it may be anticipated that the importance of these processes will be soon realised in the country. The main factor of availability of cheap electric energy has to be kept in mind as this would mainly govern the cost of final products.

The production of ozone is also carried out by the electrostatic method and the atmospheric oxygen is used as a source for the same.

ELECTROCHEMICAL ENERGY : The principle on which batteries function is based on the conversion of chemical energy into electrical energy. Their classification is, further, made into primary and secondary cells. The primary cells are expensive and are of little commercial value whereas the secondary cells or the storage batteries serve manifold purposes and their manufacture is being carried out in India on a moderate scale. There is a big demand of batteries for every day use for numerous purposes, *i.e.*, telephones, telegraphs, automobiles, other small scale electrical operations, etc. The production of dry cells is also being carried out on a good scale and there is still further scope for the expansion of this industry in the country.

ELECTRONICS AND ATOMIC ENERGY: The research work in electronics is, presently, a real line of scientific interest in India. No appreciable work has so far been done in this direction and most of the experimental achievements are of theoretical character. The various equipments for producing radio-active rays, x-rays, cosmic rays, are entirely being imported. Much of the work on wireless transmitters and receivers, including emission tubes, valves and cells remains to be done as yet. In fact, the work on atomic energy in India is more or less a new problem.

The use of atom bomb during the World War II had brought home to the people the real insight of the atomic energy and it was, in fact, the first world-wide practical utility to which atom was put. Later on, considerable efforts have been made by all the nations of the world to hunt for the radio-active elements like uranium and sufficient interest is being shown by all of them in the developments of atomic research. It is also fully realized that the atomic energy can be usefully harnessed for a large number of constructive projects.

Broadly speaking, the electrochemical industries must be given priority over all other industrial projects in India. The problem of making suitable arrangements for procuring equipments and machinery must attract the immediate attention of the planning bodies and they must simultaneously look for cheap electric energy. Some of the important electrochemical industries which can be started in India are listed in the following pages, since the raw materials for them are available in large quantities. It may not be worthwhile to give statistical data about the production and consumption of the individual items as most of them have been dealt with, in other chapters, but brief hints for a few industries are as follows:

A. Major Electrochemical Industries

Products	*Raw Materials*	*Energy Consumption kWh. per lb.*	*Applications of Products*	*Remarks*
Alumina fused	Bauxite	1—1.5	Used as abrasives and in refractories.	
Aluminium metal	Bauxite	10—12	Light weight alloys for air-crafts and automobiles, electric power transmission cables, etc.	
Calcium carbide	Lime and coke	1.3—1.4	Acetylene production, (used for welding, cutting and lighting), production source for acetone, acetic acid, cyanides, etc.	Large scale production needed, raw materials in plenty in India.
Calcium cyanamide	Calcium carbide and nitrogen	1 5-3	Used as fertiliser and source for ammonia and cyanides.	
Carbon bisulphide	Coke and sulphur	0.4—0.5	Solvent for viscose (artificial silk), carbon tetrachloride, production.	Can develop with viscose industry.
Caustic soda	Salt (sodium chloride) and water	1.3—1.6	Used in soap, textile, paper, and several major industries.	Large scale production needed, raw materials plenty in India.

A. Major Electrochemical Industries—*Contd.*

Products	*Raw Materials*	*Energy Consumption kWh. per lb.*	*Applications of Products*	*Remarks*
Chlorine gas	Salt (sodium chloride) and water	1.6	Bleaching of textile and paper, war-gas, mustard gas and innumerable chloro compounds.	By-product in caustic soda production.
Copper	Copper ore	0.09—0.16	Uses in electrical industry; production of brass, and other alloys; innumerable other uses.	Raw material resources already located are quite meagre, large scale production needed.
Ferroalloys (ferrochrome, ferromanganese, ferromolybdenum, ferrotitanium, ferrotungsten, ferrovanadium)	Ores of chromium manganese, molybdenum titanium, tungsten and vanadium.	1.5—4	Special steels and structures.	
Gold	Copper and silver refining slimes.	0.15	Precious metal.	Raw materials resources are not very big. Large scale production needed.
Graphite.	Anthracite coal.	1.5—2.0	Electrodes, lubricants and paints.	

A. Major Electrochemical Industries—*Contd.*

Products	*Raw Materials*	*Energy Consumption kWh. per lb.*	*Applications of Products*	*Remarks*
Iron pig.	Iron ore.	1.8—2.0	Steel industry.	
Magnesium metal	Magnesium chloride and magnesite.	8—13 (Chloride) 14—15 (Oxide)	Flashlight powders, light-weight alloys, tracer bullets and flares.	Large scale production needed as raw materials are available in plenty, in India.
Nitric acid.	Atmospheric nitrogen and oxygen.	7—7.5	Explosives and fertilisers.	
Phosphorus	Phosphates and coke.	4—5.5	Matches, phosphorus compounds, phosphorus bronze, smoke screens.	Moderate production required. Raw materials plenty in the contry.
Silicon carbide.	Sand and Coke.	3.2—3.85	Abrasives and refractories.	
Silver.	Copper refining slimes.	0.3—0.5	Jewellery, coinage, industrial alloys and chemicals.	Raw material sources already located are not very large. Large scale production needed.
Sodium metal.	Salt (sodium chloride)	7.1—7.3	Peroxides, cyanides, explosives, organic compounds.	Presently no production, raw materials plenty.
Zinc metal.	Zinc ore.	1.4—1.56	Brass manufacture and galvanizing.	Raw materials inadqeuate, complete investigation of Jaipur source required or Burmese resources to be linked.

B. Other Electrochemical Industries (Slow Programme)

Products	*Raw Materials*	*Applications and Uses*	*Remarks*
Beryllium.	Beryl.	Light alloy.	Adequate ore supply, production can find export market or adequate researches required to find use locally.
Bismuth.	Lead refining slimes.	Alloy production.	Raw materials resources inadequate.
Cadmium.	Zinc electrowinning slimes.	Alloy production; plating work.	
Calcium.	Calcium chloride.	Radio tubes, lamps.	Cannot find much encouragement at present.
Cerium metal.	Rare earth chlorides.	Pyrophoric alloys, automatic lighters, tracer bullet and shells.	Raw materials resources to be located.
Lithium metal.	Lepidolite and lithium salts.	Light alloys.	Adequate ore supply, production can find both Indian and export markets.
Ozone.	Air.	Sterilisation of water, sanitation.	Production can be adjusted according to demand.
Palladium.	Nickel refining slimes.	Alloy production.	Little scope as raw materials not available.
Perborates.	Borax and sodium metal.	Bleaching agent for textiles and oxidizing agent.	Can be taken up on a medium scale.

B. Other Electrochemical Industries (Slow Programme)—*Contd.*

Products	*Raw Materials*	*Applications and Uses*	*Remarks*
Platinum.	Copper and nickel refining slimes.	Electrical uses; precious element.	Must be located wherever possible.
Potassium chlorate.	Potassium chloride.	Match manufacture; explosives and oxidizing agent.	Can be taken up on a medium scale: can be developed with potash industry.
Quartz fused.	Quartz rock.	Silica tubes for heat and acid resisting equipments, optical lenses.	Can be taken up on a moderate scale, raw materials available in plenty.
Rhodium.	Nickel refining slime.	Alloy production.	Little scope as raw materials not available.
Silicon.	Sand and coke.	Silicon steel, hydrogen production, silicides and silicon tetra-chloride.	Limited scope; can be encouraged for steel production.

ELECTROPLATING ACCESSORIES: The electroplating industry has gained sufficient importance in India, during the last 10 to 15 years. The number of plating shops in all parts of the country, engaged on different production jobs like that of surgical instruments, hospital equipments, electrical and hardware fittings, including novelties and presentation articles indicates the importance and usefulness of this industry. The automobile industry is popularly connected with the electroplating work, although the same is not yet developed in India.

The task of electroplating is fairly technical one whereas the working operations are quite simple. The utility of plating is realised more and more every day as the problem of corrosion is now better understood. The popularity of plating is mainly due to the fact that some of the metals get corroded and rusted under the ordinary atmospheric conditions and such metallic surfaces are protected by a better resistant metal coating. Further, there is an improvement in appearance of the articles and thus plating serves also the decorative purpose.

A large number of plating workshops in the country are engaged on various types of popular commercial jobs, *i.e.*, copper plating, brass plating, nickel plating, chrome plating, silver plating, etc. Other electroplating jobs of tin, zinc, cadmium and lead are not very popular. Gold plating is mostly done on jewellery and certain presentation articles. Copper, nickel and chrome plating on iron is a fairly popular combination and is attempted universally by good platers. The electroplating processes are simple and are more or less automatic, but command high class skill. The standard of local plating is found very poor as most of the plated articles are rarely tested for defects. Most of complaints indicate porosity and peeling off of the deposits. The reason is that the trade is mainly in the hands of non-technical persons and even the electroplating shops are mostly ill-equipped. A large number of plating shops have generating sets and plating vats and have no cleaning, pickling, polishing and degreasing equipments.

The electroplating work involves in the use of varied equipments, depending on the jobs, but common equipments are polishing mops and wheels, cleaning and pickling degreasing vats, plating vats and swill batteries. The electrical equipment comprises of meters, generators, control panels, slider resistance and electrical instruments of the type ammeters and voltmeters. The polishing compositions and the plating chemicals, including metallic anodes, may be classified as raw materials for the electroplating industry.

The electroplating industry in India has, so far, flourished on imported goods like electrical equipments and fixtures, polishing and plating materials. The most popular suppliers who have earned name in the line are Messrs. W. Canning & Co., Ltd., England, and Messrs. R. Cruickshank, Ltd., England and their patent polishing compositions and chemicals are consumed in large quantities. Some of the local producers have attempted to market similar materials but have failed to gain grounds in competition to those of Canning's materials. There are certain basic reasons for the same. The majority of consumers are so used to the foreign products that it seems to be beyond their intelligence to use new products. In fact, the foreign patent products can be handled in a fool proof manner. Some of the local producers have put dirty imitations in the market and have badly failed to establish themselves.

The various electroplating accessories may be divided into three broad heads :

(1) Electrical accessories.
(2) Mechanical accessories.
(3) Chemical accessories.

The permanent fixtures in a plating shop are electrical and mechanical equipments and such fittings are mainly of foreign make, with minor exceptions. The chemical accessories which include plating salts and chemicals, anodes, polishing and finishing compositions, cleaning, pickling and degreasing chemicals, form the basic raw materials for the industry, as these are regularly consumed for the job.

ELECTRICAL ACCESSORIES : The electroplating industry requires D. C. generators, more popularly known as dynamos, which are a specialised electrical machinery shunt wound or compound wound, giving a large volume of current at low voltage. The production of such machines is really a specialised job and the attempt to produce them in the country, have shown favourable results. The durability and accuracy of the working of such dynamos is a matter of great importance, and with the developments in the manufacture of electrical machinery in India, the imports of dynamos might totally be stopped. Further, rheostats, ammeters, voltmeters are also being produced at several centres. It might take considerable time to achieve high degree of accuracy in these instruments.

MECHANICAL ACCESSORIES : The polishing wheels and mops, including hair and wire brushes can easily be produced in the country. The plating and cleaning vats including swill batteries can be fabricated and built in India and, thus, the industry can really be independent of the imports of the mechanical equipments.

CHEMICAL ACCESSORIES : Electroplating industry consumes several chemical compounds and products which include abrasives, plating chemicals and salts, polishing compositions, cleaning and degreasing compounds, etc. The total annual value of imports of these materials exceeds several lakhs of rupees.

ABRASIVES : The abrasives required for the electroplating industry are sand paper and sand cloth, emery paper and emery cloth, emery powders, emery flour, grinding mops and wheels and are imported from abroad in huge quantities for this trade. Continuous attempts are being made by some of the producers to manufacture various grades of such abrasives but they receive little encouragement at the hands of the consumers. India has plenty of abrasives and there are resources for meeting the country's demands for all such types of abrasives and, as such, the imports should altogether be stopped.

POLISHING COMPOSITIONS: The various compositions are essentially the polishing powders like pumice powder, tripoli powder, emery, rouge, rotten stone, etc., mixed with binding agents. A good number of patent products like peerless polish, lustre tripoli composition and various grades of rouge compositions are in the market and the consumers pay fancy prices for all such commodities. Some of the local products comparable to peerless, lustre and rouge composition, have been put in the market but are discarded by the consumers on grounds of quality. The consumers are, decidedly, prejudiced about Indian products. Serious efforts must be made to do propaganda for the popularity of the locally manufactured polishing compositions as the standard of quality, comparable to imported stuff, is not difficult to be attained, if the confidence of the consumer is once built. The polishing compositions can very easily be produced and no specialised equipments are required for the same. Peerless composition is more or less a mixture of lime and magnesia powders, mixed with other similar ingredients and binding agents. The tripoli composition is produced by mixing tripoli powders with fats and waxes. Several grades of rouge compositions are also produced by the same methods. Similar compositions are used for polishing brass, copper, silver, gold, nickel and chromium surfaces. Polishes must be free from cheap and harmful ingredients. The criterion for good polishing composition is necessarily based on the fact that it must have quick cutting action, with the smallest quantity consumed. It should leave clean work and wear on mops must be minimum.

CLEANING, PICKLING AND DEGREASING COMPOUNDS: Cleanliness is of paramount importance in the electroplating jobs. The surface of the metal to be plated, must be perfectly smooth as the coat metal follows the same contours on deposition, hence the finish must be proper. Articles must completely be free from traces of rust as such points form nuclei for corrosion. They must be subjected to chemical cleaning, pickling and degreasing operations, before they are taken to the plating vats. Some of the cleaning chemicals are like soda ash, caustic soda, silicate of soda, and trisodium phosphate and they are used in different proportions in different baths and, in certain cases, electrolytic cleaning is also done. A few patent salts are in the market and the same can easily be replaced by suitable mixtures. In the case of iron and steel articles, the pickling processes are carried out in the weak acid solutions using hydrochloric acid and sulphuric acid. The degreasing chemicals are mainly organic solvents like trichlorethylene or benzene which dissolve the adhered grease and clean the article.

PLATING CHEMICALS AND ANODES: Commercially, non-ferrous metal plating is very popular. The plating bath consists of chemicals dissolved in plating vats and the suspended metal anodes help to replenish the bath concentrations. The various factors that determine the proper electrodeposition are voltage across the bath, current density, temperature of the bath and *p*H value of the solution.

A large number of electroplating chemicals are sold under different trade names in the market, *i.e.*, copper salts, brass salts, chrome salts, nickel salts, silver salts, mercury salts, cadmium salts, tin salts, zinc salts (electroplating) and zinc salts (galvanizing). Most of these salts are either single or double cyanides or compounded with potassium and sodium cyanides or, in certain cases, in the forms of sulphates or chlorides. All such salts are merely complex chemical compounds and are sold at very high prices. In case the platers exert a little, it may not be difficult to prepare their own suitable baths by adjusting the bath compositions. Brief hints about some of the plating baths are given on the next page in the form of table.

In actual practice, it has been found that all these baths work quite successfully when the current density and temperature of the bath are properly maintained. A good

Electroplating Baths

Surface Coat	*Plating Baths*	*Anode*
Copper	(i) Acid sulphate.	Copper metal.
	(ii) Alakline cyanide.	Copper metal.
Nickel.	(i) Single sulphate.	Nickel metal.
	(ii) Double sulphate.	Nickel metal.
	(iii) Sulphate, and chloride	Nickel metal.
Chromium.	Chromic acid.	Lead metal.
Brass.	Cyanide.	Copper zinc alloy.
Silver.	Cyanide.	Silver.
Gold.	Cyanide.	Gold.
Zinc.	(i) Sulphate.	Zinc metal.
	(ii) Chloride.	Zinc metal.
	(iii) Alkaline cyanide.	Zinc metal.
Tin.	(i) Alkaline stannite.	Tin.
	(ii) Alkaline stannate.	Tin.
Iron.	(i) Chloride.	Iron.
	(ii) Double sulphate.	Iron.
Cobalt.	Sulphate.	Cobalt.
Cadmium.	Alkaline cyanide.	Cadmium.
Lead.	Fluoborate.	Lead.
Platinum.	Phosphate.	Platinum.

many practical formulæ have been evolved to replace the various patent plating salts. In fact, more attention should be paid to produce plating chemicals than patent plating salts. There is no denying the fact that the use of plating patent salts is advocated in a fool proof manner whereas the use of the plating chemicals have the advantage of cheapness as well as easy availability. The plating salts are really produced out of plating chemicals by adding special ingredients which may be useful in increasing conductivity, quick throwing power of solution and certain other favourable factors. A thorough study of such factors can make each and every plater an independent unit, and the use of patent salts can be replaced. Scope for producing such patent salts in India definitely exists and the only way to popularise them is to discourage imports of foreign patent salts. Some of the basic plating chemicals are cyanides of potash and sodium; and from them, all other cyanides are produced, *i.e.*, copper, brass, silver, gold, cadmium, etc. A few of the

Plating Salts

Metal	*Plating Chemicals*	*Products of W. Canning & Co., Ltd.*	*Products of R. Cruickshank Ltd.*
Copper.	Copper cyanide (single). Copper cyanide (double). Copper pink salt.	Copper pink salt. Zonax copper salt.	Kuprit. Rochelle copper salt.
Nickel.	Nickel sulphate. Nickel ammonium sulphate. Nickel chloride. Nickel carbonate.	Albo nickel salt. Nivo nickel salt. Zonax double nickel salt.	Minerva nickel salt. "Blacknick" salt. "Britenick" salt. "Hardnick" salt.
Chromium.	Chromic acid.	Chromic acid. Chromax chrome salts. Zonax bright chrome salt.	Silvachrome. Hardchrome.
Brass.	Copper cyanide. Zinc cyanide.	Zonax brass salt.	Brassit.
Silver.	Silver nitrate. Silver cyanide.	Zonax silver salt.	Argentum.
Cadmium.	Cadmium cyanide. Cadmium oxide.	Zonax cadmium salt.	Cadmas. Cadmium bright dip.
Tin.	Sodium stannate. Stannous sulphate.	Stannic tin salt. Artax tin salt.	Sodium stannate sol. Acid tin solution. Tinnit tin salt.
Zinc.	Zinc sulphate. Zinc cyanide.	Galvanax zinc salt. Zonax zinc salt. Ajax zinc salt.	Zincus salt. Brizinc salt. Azincid salt.
Lead.	Lead fluoborate. Lead perchlorate. Lead acetate.	Zonax lead solution.	Lead fluoborate solution.

patent salts manufactured by Messrs. W. Canning & Co., Ltd., England, and Messrs. R. Cruickshank Ltd., England, can easily be replaced by the basic plating chemicals and such compounds are given in the chart on page 257.

Apart from the above patent salts, there are a good many other types of patents for striping nickel, chromium from the articles for reprocessing, barrel plating compounds, oxidising salts, quicking salts, passivating solutions and chromating solutions and innumerable other compositions which need thorough study before the same can be taken up for manufacture in India.

BRONZING SOLUTIONS : Besides the electroplating chemicals, there are other sets of compounds and solutions which help in acquiring thin films of varying shades and colours on metal surfaces and are more permanent in atmospheric conditions. They are known as bronzing solutions. The formation of such films is achieved by several methods *i.e.*, mechanical, thermal, electrolytic and chemical processes. The mechanical process is comparable to spray painting or dipping and is of a temporary nature. The thermal process is carried out at high temperatures, *i.e.*, blue steel formation, and is not workable when high temperature is injurious. The electrolytic method is more or less the anodic oxidation process and has a limited scope. On the other hand, the chemical process is carried out by the immersion of metals in certain chemical solutions and desired results are attained under controlled conditions.

A large number of bronzing solutions are put in the market, *i.e.*, steel bronze, blue bronze, dark steel bronze, ebony black bronze, iridescent bronze for brass, florentine bronze, brown bronze, green bronze, golden bronze, etc. These solutions are simple mixtures of chemicals in certain definite proportions and all of them can be prepared quite easily. Efforts must be made to produce such compositions in the country and they should not be imported from abroad any more.

CHAPTER VIII

THE INDUSTRY OF PHOTOGRAPHIC CHEMICALS

THE photographic industry today occupies first place amongst the various top rank industries of the world. There has practically been very little development in this line, in India, except that the raw films are annually imported in huge quantities. The production of raw films in India must be considered as one of the urgent problems. It must also attract the attention of the Government.

The working and processing of such a large quantity of raw films and imports of other photographic equipments and accessories, involve huge sums of Indian capital which is being drained out of the country. The imports of such commodities are very essential. This chapter would, primarily, deal with the various chemicals required for the photographic trade in general. The classification for them is as under :

A. CHEMICALS EMPLOYED IN THE MANUFACTURE OF PHOTOGRAPHIC FILMS AND PLATES :

(i) Celluloid ;
(ii) Gelatine ;
(iii) Photo-sensitive salts ;
(iv) Sensitizer ;
(v) Desensitizer ;
(vi) Filters and colour filters.

B. CHEMICALS EMPLOYED FOR PROCESSING :

(i) Developing agents :

(*a*) Reducing agents ;
(*b*) Accelerators ;
(*c*) Restrainers ;
(*d*) Preservatives ;

(ii) Fixing agents ;
(iii) Reducing agents ;
(iv) Intensifiers ;
(v) Toning agents.

C. CHEMICALS EMPLOYED IN THE MANUFACTURE OF PHOTOGRAPHIC PAPERS :

(i) Sensitive salts ;
(ii) Emulsions.

D. MISCELLANEOUS PURPOSES CHEMICALS, INCLUDING FLASH-LIGHTS :

India has no photographic industry. The present position regarding photography, as it stands today, is that all the requirements for this trade are fulfilled through imports. Most of the processing chemicals are also obtained from abroad except that a few simple products like thiosulphate, bisulphate and sulphite and metabisulphite of sodium, are being manufactured here to a certain extent. The line of photographic chemicals has all along remained undeveloped in India. The basic reason for such a slow and steady progress may be attributed to the fact that the technique of photography is a highly skilled job and involves in the use of extremely delicate and scientific equipments to which very little attention has been paid. The various delicate and scientific equipments include cameras, optical lenses and apparatus, projectors, cine cameras and movies and other photophone equipments.

The industry of photographic chemicals has failed to receive advancements in the country because the job of developing the production of basic equipments is initially very difficult. The production and applications of photo-sensitive products which are effected by light, are the jobs of highly technical nature. Besides these difficulties, most of the photographic chemicals are very complex organic compounds and are required in extremely high standards of purity before they can actually be taken up for application and for practical utility in the trade. There are, however, innumerable specifications that have to be technically followed before the task of production of photographic chemicals can be taken in hand. In fact, the right way to begin with this industry is by starting the production of photographic equipments and accessories, on commercial scales. The basic requirements of this trade are, primarily, associated with the procurements of optical lenses which form the fundamental parts of the photographic equipments. It may not be out of place to consider the question of the production of optical glass, although it may rather be too early to lay the foundations on this assumption.

Attempts may, however, be made to produce the various developers and reducing agents but the manufacture of raw films can only be taken up by stages. In the initial stages, the raw film base may be imported and the coating and processing may be done here in India. Secondly, the raw film base may be produced in India using imported chemicals. Thirdly, the necessary chemicals may be produced here in India.

CHEMICALS EMPLOYED IN THE MANUFACTURE OF PHOTOGRAPHIC FILMS AND PLATES: It is a recognised fact that film production has more importance than the manufacture of plates as the requirements of former are much on account of the large scale developments in the film trade. The ordinary plate production is merely for retail trade. Some of the basic raw materials for the film production are celluloid, gelatine, photosensitive salts, etc.

Celluloid is used for the manufacture of films and cinematographic pictures and is produced from nitrated cellulose which is known as pyroxylin. Pyroxylin and camphor are compounded to yield celluloid. On the other hand, production of cellulose acetate (a non-inflammable product) can equally serve the purpose for the raw film production. This would be absolutely a new industry for India if plans for production really get matured. The production of plates is also a highly technical job and their manufacture is carried out on plane glass sheets with the help of photo-sensitive chemicals, gelatine, sensitizers and desensitizers, etc. Some of the silver salts are very photo-sensitive and find applications in the photographic industry. The manufacture of all such products has to be taken up quite seriously. A good number of dyes are used as optical sensitizers, a few are Erythrosin, Eosin, Pinacyanol, Cyanines, etc., and the desensitizers are Chrysodin, Pheno-safrinin, Pina-kryptol green and yellow. None of these products have been attempted for manufacture in India and should, therefore, be of great future production interest.

CHEMICALS EMPLOYED FOR PROCESSING: Film processing is sufficiently complicated job and involves in the developing, fixing, reducing, intensifying and toning processes. Large number of chemicals are used for film processing and a good variety of agents like reducing salts, restrainers, accelerators and preservatives are required for different operations.

Developers: Photographic film developing is a fairly tedious operation and involves in the use of various reducing agents. Most of these are complex organic monohydric, dihydric and trihydric phenols. Some of the compounds are given popular trade names, *i.e.*, amidol, para-amidophenol, metol, hydroquinone, ortho and para phenylenediamine, pyrocatechol and pyrogallol, etc. The use of sulphite and bisulphite of soda is also made. Besides the use of such reducing agents, accelerators and restrainers are also added. The various accelerators are alkaline solution of carbonates and hydroxides of soda or potash and also the biborate of soda or borax, aided by the use of restrainers like bromide of potassium. Preservatives like metabisulphite, bisulphite and acetic acid are recommended in the developing processes. A large number of other reducers are employed which are really known as oxygen rich compounds, like persulphates of ammonia, permanganate of potash and dichromates of sodium or potassium. Apart from the above compounds, other chemicals like ferric chloride, iodine, cyanides, oxalate and ferricyanide of potassium also act as good reducing agents. There is no production of the organic photographic compound in India and present requirements are fulfilled only through imports. Some of the inorganic salt like soda bisulphate and soda sulphite, which are already being produced in the country, are of desirable quality and even the production is quite adequate. It is, however, desired that attempt must also be made to produce other developing compounds in the country.

Fixing Agents: The fixing process is carried out to dissolve unexposed part of silver salts and the same is done with the sodium thiosulphate solution, commercially known as "Hypo." The production of hypo is carried out on an elaborate scale in India and the standard of final product is acceptable to the photographic trade and, as such, the country is self-sufficient in her supplies of hypo, although raw materials for the manufacture of the same are imported.

Intensifiers: The use of intensifiers helps to increase the density of the negative and assists in getting better contrasts. Some of the mercury salts like chloride and iodide are fairly popular for the purpose. The uranium salts are also employed. Further, the use of other metallic salts like that of nitrate of lead, sulphate of copper and dichromate of potash is recommended in the presence of citric acid and citrates. Most of such salts are inorganic and can be produced here in India, but attention towards standards of purity must properly be paid so that they may be acceptable to photographic industry.

Toners: A large varieties of toning baths are recommended in the photographic industry and most important of them are gold toning solutions. The various chemicals required in the toning operation for different baths may be quite good in number, but a few common are the chlorides of gold, platinum, palladium and vanadium and such are used in suitable baths along with other chemicals like citrates of soda or potash, tartarates, sulphides of sodium, potassium or barium, formic acid, phosphoric acid, gallic acid, ammonium sulphocyanide, etc. No attempt has so far been made by any of the Indian manufacturers for producing such delicate and expensive chemicals. All of them can be produced in the country.

Preservatives : There are large number of preservatives which are used in this industry and the most important amongst them is chrome alum which is produced in India in adequate quantities and is of satisfactory quality, but the imports are also pouring in small quantities. Other preservatives are phenol, chloral hydrate, oil of cloves and oil of wintergreen. All of these products are presently being imported from abroad.

CHEMICALS EMPLOYED IN THE MANUFACTURE OF PHOTOGRAPHIC PAPERS : The use of photographic papers is not quite popular for the motion pictures industry but the same is quite important for getting prints on papers. The various types of papers that are required for printing are, silver chloride gelatin papers, silver chloride collodion papers, silver chloride casein papers, silver bromide papers, silver chlorobromide papers, silver phosphate papers and various other sensitive types of papers. It is clear from names, that the silver halides are largely required for the production of printing papers for photographic industry. The developing processes are also employed on photographic prints. The production of bromide papers has been attempted by certain interested parties in India, but the results have not been much encouraging. It is, however, expected that this industry can be successfully developed in India, if specific attention is paid.

MISCELLANEOUS PURPOSES CHEMICALS INCLUDING FLASH-LIGHTS: Large number of chemicals are required in bulk while others are consumed in minor quantities in this industry. It may not be worthwhile to write about the ordinary chemicals that are consumed in this but, in general, these are various mineral and organic acids of the type: sulphuric, hydrochloric, nitric, hydrobromic, phosphoric, formic, acetic and citric and all of them are required in a very pure state. Amongst the solvents are acetone, alcohols (ethyl and methyl) and some of the other chemical compounds are that of iodides, bromides, chlorides, cirates and thiocyanates of sodium, potassium and ammonium. Other miscellaneous types of chemicals are ammonia aqueous, glycerine, phenols, formaline and also distilled water. All such chemicals are ordinary reagents and it may not be difficult to produce them locally and attain the desired standard of purity.

The flash-lights are ordinary mixtures of magnesium metal powder mixed with oxidising agents *i.e.*, permanganate of potash, chlorate of potash and with other compounds like antimony sulphide. The smokeless powders are found to contain mixture of magnesium and aluminium, mixed with nitrates of rare elements. The use of flash-lights in photography has become quite popular. The flash-light powders, including time light powders, can easily be produced in India.

Correctly speaking, India is very backward in the photographic industry and entire demand of photography and film industry is fulfilled through imports. The detailed figures of imports of the individual items may not be available, as separate statistics for them are not being maintained. The figures of import of cinematographic films, both exposed and unexposed, for the last few years may be referred to from the Appendix " B."

There are large numbers of cine laboratories, established in Bombay and Calcutta, which are regular customers of photographic materials and chemicals. Film industry has got to be encouraged in India as it has really gained much importance in the present days.

As regards photographic chemicals, some of the foreign manufacturers have fairly established their products in this country, and the same can be replaced by the Indian products, if immediate steps are taken in this direction. With further developments in this industry, it may be quite essential to consider the establishment of the industry for producing photographic equipments, including cameras, projectors and other accessories of interest to the trade.

CHAPTER IX

CHEMICALS IN DYESTUFFS AND TEXTILE AUXILIARIES

THE importance of dyes and colours has been realised in India for long as this country is known for the use of natural colours and dyes, like the extracts from natural flowers, tree barks, fruits, etc., which were used as colouring materials in the textile industry. Dyestuff industry is a very vast line. It may be classified as one of the important groups of chemicals and allied products. The manufacture and application of dyes involves in large number of chemical reactions and processes.

The introduction of synthetic dyes has, definitely, revolutionised the dyestuffs industry and the various colours and tints obtained from such dyes are very popular in the textile industry. These colours and dyes are very prominently used in the production of coloured, printed and designed cotton, silk, woollen and rayon fabrics. The application of dyes and colours in paper industry, jute industry and in leather tanning industry is also well recognised at present. Every day researches and developments in the colours and colouring matters are affording quite successful results. Applications and uses of colours and pigments in paints, rubber, plastic, and in the linoleum industry are quite popular.

The manufacture of synthetic dyes has not been taken up in India so far, although, plans for their production are in progress. It is understood that official committees appointed by the Government of India are exploring the possibility of starting this industry. Dyestuff industry is very much connected with heavy chemicals, fine chemicals, pharmaceuticals, coal tar distillates, organic chemicals, and other innumerable products as these form raw materials for the manufacture of dyes and their intermediaries. The developments in dyes industry must necessarily depend on the progress of basic heavy chemicals industry. It is an admitted fact that the heavy chemicals industry has so far not attained stage of self-sufficiency and most of the chemicals are imported in large quantities every year.

The consumption of dyes in India has, rather, been on a progressive scale. The fundamental reasons for such bigger demands are that the number of consuming industries have sufficiently increased. There are various sub-groups of dyes and colours, *i.e.*, acid colours, basic colours, direct colours, vat dyes, sulphur dyes, chrome colours, alizarines, indigos, naphthols, etc., and other innumerable groups which have gained sufficient importance. Classifications of these colours are further extended to the percentages of colour strength which are also quite large in number. Apart from the varieties of colour shades, there are countless grades which are consumed by the mills and other trades.

So far as the imports of dyes in India are concerned, German dyes were very popular in India before the World War II and there had been a terrible competition in the dyes trade. German make dyes and colour were found to give best results at the cheapest cost and a cut-throat competition, just before the World War II, threatened almost all dyes producers of the world who failed to stand German dyes in competition. The imports of German dyes and colours were stopped immediately after the World War II broke out. The dyes market was, later, captured by certain leading suppliers of dyes like Messrs. Imperial Chemical Industries, Ltd., Ciba Ltd., and Volkart Brothers, during the war period, who managed to procure supplies from the various countries of the world. Monopoly of dyestuff supplies into the Indian market has long been held by all these foreign firms. English, American and Swiss dyes had gained sufficient field, and even after World War II, such imports of colours and dyes from the U.S.A. have been in tremendous quantities. The figures of imports of coal tar dyes during the past few years are tabulated below. Detailed information regarding the imports of various groups and sub-groups of dyes and colouring matters, can be sought from Appendix "B."

IMPORTS OF COAL TAR DYES

Year			*Lbs.* (*Thousands*)	*Rupees* (*Thousands*)
1937-38	...	...	20,888	34,276
1938-39	...	...	12,023	26,035
1939-40	...	...	12,830	28,706
1940-41	...	...	13,330	45,549
1941-42	...	...	11,727	50,409
1942-43	...	...	6,564	39,781
1943-44	...	...	9,385	70,685
1944-45	...	...	8,813	64,136
1945-46	...	...	14,309	97,762
1946-47	...	...	12,873	87,959
1947-48	...	...	20,531	154,089
1948-49	...	...	14,934	122,990

The above figures of imports clearly indicate the extent of the country's annual requirements of dyes and the amount of Indian capital that is being drained out of the country. The relative importance of dyestuff industry in India must be judged from the ever increasing demands for dyes and colour.

The scope for the production of dyes in India has got to be considered after ascertaining the primary factors of the availability of raw materials and scope for the marketability of the products. There are various other factors which help to determine the same. The industry can certainly be developed in stages and can be adopted in ranges if efforts towards production and marketability are centralised. Some of the basic raw materials, classified as inorganic and organic are required in ton lots, if the industry is to be started on an initially elaborate scale. A list of chemicals required in very large quantities, is appended below. It may, however, be specified that raw products of minor interest are too many to be included in the following list :

Acetic Acid, Acetic Anhydride, Ammonia, Anthracene, Bauxite, Benzene, Bromine, Carbazole, Chlorine, Chromite, Copper, Ethyl Alcohol, Ethyl Chloride, Fluorspar, Formaldehyde, Glycerine, Iodine, Iron, Lead, Limestone, Magnesium Carbonate, Manganese Dioxide, Mercury, Methyl Alcohol, Naphthalene, Phosphorus, Potassium Chloride, Potassium Nitrate, Pyridine, Selenium, Sodium Chloride, Sodium Sulphate, Sulphur, Toluene, Turkey Red Oil, Zinc.

A detailed list of chemical compounds and products required for the manufacture of dyes and intermediates, are given in Appendix " A." Scope for the availability of raw materials has to be investigated and efforts should be made to exploit the existing resources. The developments in the coal tar distillation in India have rather been poor so far. Apart from the distillation of coal tar, the metallurgical coke industry which is allied with the progress of the iron and steel industry can yield suitable chemical products for the dyestuff industry. As regards the procurement of the above raw materials, it may be essential to depend on imports in the case of a few items like copper, fluorspar, lead, mercury, selenium, sulphur and zinc while other products are more or less available either in natural crude forms or can be produced by setting up independent plants or subsidiary units. The recovery plants of some of the coal tar, coal and wood distillation products have got to be supplemented by the purification units as most of the fine and heavy chemicals for the dyes industry, are desired to be of a pure standard. The production of some of the important organic chemicals has yet to be taken up before dyestuffs manufacture could be encouraged in the country. It may be a matter of great importance to give due consideration to the manufacture of certain basic ingredients, at reasonable cost of production. Most of the intermediates and dyes are very easy to produce but high skill and manufacturing technique is demanded. It may be considered absolutely essential to have certain trained personnel for giving a start to the line. Further training can be imparted by actual trials.

There are a large number of chemical processes which should be specialised in if the dyestuff industry is desired to be put on sound footings. A few of such processes are as under:

(i) Oxidation.
(ii) Reduction.
(iii) Sulphonation.
(iv) Nitration.
(v) Amination.
(vi) Halogenation.
(vii) Diazotization.
(viii) Coupling.
(ix) Alkylation.
(x) Acylation.
(xi) Estrification.
(xii) Saturation.
(xiii) Unsaturation, etc.

It is understood that sometimes back high level talks were in progress and were more or less in the melting pot for the establishment of a dyes manufacturing concern in India and joint efforts of Messrs. Imperial Chemical Industries Ltd., and Messrs. Tata Sons Ltd., were hoped to be materialised but, till this day, no specific announcement to its effect has come to the notice of the industrial circle. Some of the renowned foreign sales offices of a few of the world's dyes producers of popular trade marks like "CIBA," "DUPONTS," "MONSANTO," "SANDOZ," are also offering most of the basic dyes to the trade and, besides these, there are a large number of foreign exporters who have varied ranges of dyes and colours to feed the Indian markets.

The correct judgment for the adaptability of new enterprises is difficult to be given, unless the State interference to protect the Indian producers from foreign competition is considered on sound lines.

There may be other means and ways to encourage Indian dyestuff industry, but before any decisive steps are taken, it may be quite essential to locate and tap the necessary resources. The biggest drawback in the dyestuff marketability is that a large number of malpractices like adulteration and addition of inert materials exist in the trade and, as such, the standardisation and maintenance of proper strengths of dyes is very important. Strictly speaking, the standardisation of products is very essential for the Indian dyes trade.

MORDANTS AND TEXTILE AUXILIARIES : The utility of mordants and auxiliaries in the textile industry is very well recognised. In textile industry, a large set of chemical products are needed for the treatment of yarn and finished fabrics before they are sent to the market. Such treatments are carried out through the agency of certain specific products and the processes are like wetting out, sizing, desizing, softening, bleaching, gumming, finishing, kier boiling, weighting, cleaning, calendering, dyeing and printing, etc., and they involve in good number of chemical and physical operations. A large number of patent products are in the market which find utility as suitable agents.

The production of mordants and textile auxiliaries in India can be planned on several lines, as there is a good scope for marketability of the same and there is a constant demand for them. The various textile chemicals are grouped as heavy chemicals, fine chemicals, starches and starch derivatives. The production of starches in India has rather been on a meagre scale and developments in the line need a serious consideration as the present capacity of the existing starch manufacturers is, comparatively, small and even their working is not very efficient.

There are a large number of chemicals and auxiliaries required for the textile industry, but a few important chemicals are listed below :

> Acetic Acid, Antimony Salt, Aluminium Sulphate, Aniline Salt, Boric Acid, Bleaching Powder, Borax, Calcium Chloride, Chromic Acid, Copper Sulphate, Cresylic Acid, Formaldehyde, Formic Acid, Glauber's Salt, Glue, Glycerine, Hydrogen Peroxide, Hydrochloric Acid, Hydrosulphite of Soda, Lead Acetate, Magnesium Chloride, Magnesium Sulphate, Potassium Bichromate, Potassium Chloride, Potassium Ferrocyanide, Potassium Permanganate, Soft Soap, Soda Ash, Soda Caustic, Sodium Bisulphite, Sodium

Chlorate, Sodium Chloride, Sodium Ferrocyanide, Sodium Nitrate, Sodium Perborate, Sodium Peroxide, Sodium Silicate, Sodium Sulphide, Sodium Thiosulphate, Turkey Red Oil, Tallow, Zinc Chloride, etc.

As regards auxiliaries, a large number of patent products are sold in the market, under different trade names. For the various agents, broad classification may be given below :

(1) Sizing agents.
(2) Desizing agents.
(3) Bleach aids and wetting out agents.
(4) Sulphonated oils and soaps.
(5) Emulsions and emulsifiers.
(6) Antiseptic agents.
(7) Kier boiling assistants.
(8) Level dyeing agents.
(9) Finishing agents.
(10) Mercerizing agents.
(11) Softening agents.
(12) Solvents for printing, etc.

The subject of auxiliaries and other allied products is sufficiently vast and needs elaborate investigations and is one of the various easy lines that can be developed in the country. It may be difficult to throw much light on the figures of import for auxiliaries but it is believed that fairly large quantities of the same are being imported. Ultimately it may not be difficult to produce all such products in the country, as the processes of manufacture are quite simple. The imports of textile auxiliaries may, however, be discouraged.

The following list of a few patent products, imported under different trade names, would more or less give rough idea of the same :

Agents	*Products and Trade Names*
(1) Sizing	Maize starches.
	Wheat starches.
	Tamarind seed powder.
	Tapioca root powder.
	Gums (natural).

Agents	*Products and Trade Names*
(2) Desizing	Enzymol.
	Entlein E.
	Viveral E, conc.
	Polysine.
	Novo farmasol.
(3) Bleach aids and wetting out agents	Igepon T & T powder.
	Lisapol T & T powder.
	Igepol C.
	Pentrone T.
	Gardinal, WA, CA.
(4) Sulphonated oils and soaps	Turkey red oil.
	Monopol soap.
	Senol super.
	Pearlaxol.
	Servoline soap.
(5) Emulsion and Emulsifiers.	Paranol.
	Paraffin.
	Stearin and Stearates.
(6) Antiseptic agents	Salicylic acid.
	Carbolic acid.
	Cresylic acid.
	Benzoic acid.
	Zinc chloride.
	Perventol liquid and solid.
(7) Kier boiling agents	Soda ash.
	Caustic soda.
	Soda silicate.
	Pine oil.
	Mineral turpentine.
	Laventine KB.
	Perminol KB.
	Trivapol KB.
(8) Level dyeing agents	Glue and gelatine.
	Peregol O.
	Dekol.
	Leovatine.

	Agents	*Products and Trade Names*
(9)	Finishing and softening agents	Gums. Ewasol. Softnol. Stearin. Soaps.
(10)	Mercerizing agents	Mercerol. Perminal merc. Sulph mercerol.
(11)	Solvents for printing	Pine oil. Glycerine. Turpentine.

Evidently, it may not be difficult to produce the various textile auxiliaries in the country. The mills' departments must themselves develop the technique for the production of such products and need not buy cheap imitations, because sometimes, the cost of using such auxiliaries is very uneconomic and is prohibitive.

CHAPTER X

EXPLOSIVE CHEMICALS

THE term "Explosive Chemicals" appears to be vague in the days of atomic age, when individual atoms of elements can be exploded. This chapter would not be touching the subject of atomic research and possibility of the developments thereon, but would, briefly, refer to a few of the explosives which hold some importance for the industrial purposes, besides their utility for producing military explosives. It will have to be admitted that the subject is very vast and the information available, for the same is quite insignificant, as most of the details about production of explosives in India and their procurements from abroad are supposed to be the secrets.

Explosives can be classified under the following heads depending on their utility :

(1) Explosives for Military Operations :
- (*a*) Offensive.
- (*b*) Defensive.

(2) Blasting Explosives :
- (*a*) Mining.
- (*b*) Industrial.

(3) Smoke Screens and Harmless Explosives.

(4) Miscellaneous Explosives.

EXPLOSIVES FOR MILITARY OPERATIONS: It is not possible to refer to any of the attempts made by the Government of India by way of production and imports of the explosives for use by the country's forces on land, sea and air. The different types of offensive and defensive weapons are put into use by all these forces. Explosives are also utilised by the police at the time of emergency for the maintenance of law and order. It may, however, be clarified that the figures of import of such chemicals and machinery are not meant for public information. The various raw materials required by the government explosive factories are being produced in India, besides their adequate imports from other countries. The progress made by the local factories for producing explosives during the World War II had really been quite appreciable. It is, however, anticipated that the country would make adequate efforts for producing explosives as soon as the economic conditions have improved. Exhaustive researches must, however, be carried out on an elaborate scale for investigating the production and application of explosives in the country. The latest developments in the atomic energy in other countries have made India realise that the matters must earnestly be pursued for researches in the radio-active elements like uranium which is located in India, especially in the Travancore State.

BLASTING EXPLOSIVES : The blasting explosives for mining and industrial purposes are too many and almost all of them are imported from abroad. The mining industry has flourished a good deal on account of the use of explosives as, otherwise, there would not have been possible to make so much advancement in the mining line. Different explosives are recommended for different minerals, depending on their hardness. Further, the net work of communication services like rails and roads on hilly tracts and also the working of tunnels is carried out by the use of mild and suitable explosives.

The most commonly known varieties of blasting explosives are gunpowders, nitro-glycerine, gun cotton, dynamite, blasting gelatine, gelatine dynamite or gelignite, picric acid, T.N.T., smokeless powders, solenite, ballistite, perchlorate explosives, cheddites, detonators and blasting fuses, etc. Besides these, there are a few hundred more varieties of the explosives. The imports of these explosives, during the past years, are given in the later pages of this Chapter.

Gunpowders : Gunpowders are the simplest type of explosive mixtures, prepared out of varying proportions of charcoal powder with nitrates of soda or potash or ammonia, and certain percentage of sulphur. A good many patents for the same are taken by the foreign producers of explosives and different trade names are given to them. The use of various nitrates like saltpetre (potassium nitrate) or chile saltpetre or ammonium nitrate, makes the explosive powders of different qualities, with varying intensity. The basic advantages which the gunpowders possess over other explosives are that (i) the mixtures can immediately be prepared at the spot, (ii) the raw materials can separately be transported, hence the danger of transporting explosives is eliminated, (iii) the uniformity of burning operation for gunpowders is remarkable. The raw materials for producing gundpowders can be made available in plenty in the country. Presently, most of the gunpowders are locally produced at the mine pits and major parts of the requirements are fulfilled through Indian production. It is, however, estimated that the pre-war annual production of gunpowders in India was approximately 10 to 15 million lbs. per year, whereas, such production had later gone up considerably. The use of gunpowders is bound to increase, if further advancements are made in the mining operations.

Nitro-glycerine : Nitro-glycerine is another blasting explosive and is produced by the nitration of glycerine. The various nitro-derivatives of glycerine like dinitro-glycerine, trinitro-glycerine and the nitrate of polymerised glycerine are all explosives with varying blasting intensity. All these are termed as esters of glycerine.

The processes for the manufacture of all these nitro explosives are merely the result of controlled nitration of glycerine which is achieved by careful technical skill. The various raw materials for these explosives are glycerine, nitric acid and sulphuric acid and all of them are plentifully available in the country. These nitro-glycerines are further compounded with other products to give different explosives *e.g.*, dynamite, gelatine dynamite, etc.

Strictly speaking, the transportation of nitro-glycerine is very dangerous; hence by mixing with inert materials, its mixtures are safely transported.

Presently, there are no statistics in hand revealing the production and imports of nitro-glycerine. It is, however, certain that planned production of nitro-glycerine is not being carried out in the country except that for military purposes and the details of such productions are not known.

The importance and utility of nitro-glycerine and other nitro explosives is very well realised and it is anticipated that with the advanced requirements of industrial and mining operations, its production should be to the tune of nearly 1,500 to 2,000 tons per year which may, further, require raw materials to the extent of nearly 1,000 to 1,500 tons of glycerine, 3,000 to 4,000 tons of nitric acid and 5,000 to 6,000 tons of sulphuric acid. The import figures of nitro-compounds and other explosives can be seen from the attached tables. The requirements in these explosives have considerably gone up during the war days and, lately, one may calculate it to more than two times of the pre-war figures.

Dynamite, Blasting Gelatine, Gelatine Dynamite and Gelignite: Dynamites are, in fact, mixtures of some inert materials mixed with nitro-glycerine for the purpose of safe transportation. The various inert materials are of the type of kieselguhr to the extent of about 25 per cent. Another variety containing burnt cork and charcoal is named as "carbo-dynamite". Wood meal along with some nitrates are added in varying proportions to some of the mixtures. The blasting gelatine, however, contains about 90 to 93 per cent of nitro-glycerine mixed with 7 to 10 per cent of collodion cotton which keeps the mass in plastic form and thus there are less chances for accidents. A colloidal solution containing 96 to 97 per cent of nitro-glycerine and 3 to 4 per cent collodion cotton, on being mixed with saltpetre and wood meal, yields gelatine dynamite or gelignite. The proportions of these additives vary considerably, depending upon the quality of the products. The production of all such blasting explosives has to be carried out in carefully worked mixing machines and operated in low temperature atmosphere. The homogeneity of final product is a criterion for good explosives.

Gun Cotton : It is really a nitrated product of cellulose, produced from cotton waste, sulphuric and nitric acids. Other cellulose materials like paper shreds, tissue papers are also recommended in place of cotton waste. If intended for use in mines, torpedoes or other demolition work, the gun cotton is moulded into suitable shapes.

Picric Acid and Trinitro-toluene : Picric acid, the trinitrophenol, is produced by nitrating phenol with nitrate of soda or potash and sulphuric acid. It is extensively used for filling shells and its salts are used in certain compositions for producing propellant. The trinitro-toluene is one of the most powerful explosives, produced by the nitration of toluene. The production of the same is carried out in stages, giving mono and dinitro-toluene. Good many complex nitro compounds of these series, are produced and are given different trade names.

Presently, most of the blasting explosives and detonators are being imported and the figures of imports, during the last few years, are given overleaf. Detailed figures of imports of individual items are given in Appendix "B".

It may not be difficult to visualise the importance of industrial explosives from the above figures of imports. The raw materials for most of such explosive are available in India whereas it is a matter of having requisite machinery and adequate technical skill. No time should be wasted in delaying the installation of such projects as, apart from industrial value, these explosives have great national importance. In fact, remarkable progress has been made by some of the countries of the world in the production of high intensity explosives, bombs and war weapons.

IMPORTS OF BLASTING EXPLOSIVES AND DETONATORS

Year	Blasting Gelatine		Gelignite or Gelatine Dynamite		Nitro Compounds		Detonators	
	Lbs. (Thousands)	Rupees (Thousands)	Lbs. (Thousands)	Rupees (Thousands)	Lbs. (Thousands)	Rupees (Thousands)	Lbs. (Thousands)	Rupees (Thousands)
1937-38 ...	450	379	1,219	868	816	507	9,033	255
1938-39 ...	439	347	996	706	398	237	8,748	227
1939-40 ...	207	174	1,451	1,066	409	249	10,718	278
1940-41 ...	32	27	1,702	1,322	421	310	6,773	184
1941-42 ...	..	..	972	723	1,219	939	6,410	160
1942-43 ...	..	..	1,625	1,357	436	224	10,990	261
1943-44 ...	..	..	1,266	1,011	163	90	6,020	109
1944-45 ...	..	..	2,024	1,530	254	152	10,858	348
1945-46 ...	10	12	2,168	1,781	420	335	6,838	375
1946-47 ...	96	112	3,362	2,785	400	344	12,488	662
1947-48 ...	106	123	3,278	2,855	500	452	6,832	613
1948-49 ...	89	108	3,971	3,559	1,018	933	6,950	705

SMOKE SCREENS AND HARMLESS EXPLOSIVES: These are the class of explosives which include fireworks, smoke screens and other military training explosives. There may not be much information available about the smoke screen explosives and other military training explosives. The fireworks which are largely consumed for festival celebrations in the country are both imported and locally produced. The Chinese crackers and other miscellaneous items are being imported from abroad. The production of sparklers and certain other fireworks was taken up in the country in pre-war days and the same was more seriously handled during the war period. The imports in the past few years have been of the following order:

IMPORTS OF FIREWORKS

Year			*Lbs.* (*Thousands*)	*Rupees* (*Thousands*)
1937-38	...	...	2,061	811
1938-39	...	...	2,926	952
1939-40	...	...	1,610	563
1940-41	...	...	1,001	492
1941-42	...	...	711	501
1942-43	...	...	2	3
1943-44	...	...	5	8
1944-45	...	...	1	3
1945-46	...	...	2	6
1946-47	...	...	321	912
1947-48	...	...	864	1,834
1948-49	...	...	400	683

Fireworks are mainly used on the celebration of ceremonial rites and, hence, are classified as luxury items. The imports of the same should be prohibited while, on the other hand, the local production of various items must be carried out on planned scale although the manufacture of most of the items is already in progress.

IMPORTS OF GUNPOWDERS AND OTHER EXPLOSIVES

Year	Gunpowder Black		Smokeless Gunpowder		Gunpowders Others		Cartridges for Shotguns and Rifles	
	Lbs. (Thousands)	*Rupees (Thousands)*	*Lbs. (Thousands)*	*Rupees (Thousands)*	*Lbs. (Thousands)*	*Rupees (Thousands)*	*Lbs. (Thousands)*	*Rupees (Thousands)*
1937-38 ...	39	26	16	26	44	28	16,297	1,083
1938-39 ...	28	23	9	10	52	23	14,984	986
1939-40 ...	26	20	2	9	63	32	13,088	870
1940-41 ...	20	17	4	17	40	26	9,556	714
1941-42 ...	13	15	4	22	78	44	11,899	992
1942-43 ...	2	2	..	..	..	..	1,836	185
1943-44 ...	11	10	..	..	10	26	1 820	179
1944-45 ...	19	21	4	10	9	9	3,547	362
1945-46 ...	19	26	11	26	25	20	10,645	1,094
1946-47 ...	23	41	8	13	109	98	16,079	1,809
1947-48 ...	8	14	5	14	67	60	24,681	2,994
1948-49 ...	17	25	7	21	62	62	5,101	870

MISCELLANEOUS EXPLOSIVES: There are a good many varieties of explosives which are covered under this head. The explosives and ammunitions for sporting purposes include gunpowders, smokeless powders, cartridges filled for shot guns, rifles and revolvers, etc., and are all classified under this group. All the requirements of these explosives are presently being met through imports. The figures of imports are as given in Appendix "B".

It will be interesting to note that the subject of explosives and their operative details are somewhat new to our countrymen. Strictly speaking, very little chance has been offered to the people of commercial interests for handling these lines. The reason for such slack attitude has been due to the fact that the Government had not encouraged any such enterprises in the country. Now that the national assets have to be fortified the country's requirements in explosive must, necessarily, be fulfilled through local production and a large number of such centres need to be opened in various commercial and official circles. Further researches in this direction must vigorously be followed. The latest developments in pursuing the atomic research must be given a practical shape. Attempts must be made to see that the country takes necessary steps in building up her military and industrial strength and establishing a standard of supremacy over the other nations.

CHAPTER XI

ROLE OF CHEMICALS AND MINERALS IN PAINTS AND VARNISHES INDUSTRIES

PAINT and varnish industry had its origin on scientific lines in India, since the beginning of the 20th century. The importance of this industry is very well realised, as there are plenty of resources of raw materials in the country.

This industry has received a great advancement in India during the recent years, especially during the period of World War II. These are quite vast industries and a large number of products fall under the various broad heads :

(1) Pigments and dry colours.
(2) Paints: ready mixed and dry.
(3) Varnishes and lacquers.
(4) Enamels.
(5) Distempers.
(6) Miscellaneous paint products; namely: electric insulation varnishes, synthetic enamels, nitro-cellulose lacquers, leather finishes, tin can lacquers, antifouling compositions, marine paints, etc.

The various raw materials required in the paint and varnish industry, are grouped as under :

(*a*) Pigments and colours.
(*b*) Drying oils.
(*c*) Resins and gums.
(*d*) Solvents and thinners.
(*e*) Driers and plasticizers.

PIGMENTS AND COLOURS: Pigments are classified according to the shades, colours and grades. India is extremely rich in natural pigments which are, primarily, available as oxides of elements. Natural pigments are fairly stable in atmospheric conditions. Superior grade pigments are produced by chemical reactions and the various grades and shades are adjusted according to the requirements.

NATURAL PIGMENTS: Amongst the natural pigments, are included the various ochres like yellow ochre, red ochre; red, yellow, brown and black oxides of iron. Besides these cheap oxide pigments, there are other white minerals like whiting, gypsum, barytes, china clay, mica, quartz, silica, etc., which can also be classified as natural white pigments. All these pigments are found in large quantities and inexhaustible reserves are located in different parts of the country. The utility of the various pigments and ores in the paints industry can make India not only self-sufficient in her requirements of paints but there are also bright prospects for exports. The following chart will indicate the use of the various kinds of pigments.

NATURAL PIGMENTS

Pigments	*Uses*	*Remarks*
Barytes.	White paints and lithophone.	Barytes are obtainable in snow white and off colour shades, and are very cheaply available. India has huge reserves.
Whiting.	Putties, paints and as fillers.	Whiting is quite cheaply available. Proper gradations and refining is required.
Gypsum.	Suitable as base for water paints and distempers and for cheap grades of lake pigments.	Gypsum is available in large quantities in various parts of India but West Punjab reserves have now been eliminated after the partition. Cement industry requirements are more prominent, hence good quality material is scarce.

Pigments	*Uses*	*Remarks*
Bauxite.	White paints.	Huge reserves of bauxite are available in the country. Certain deposits contain titanium which gives high grade white paints.
China clay.	Cheap grade paints.	Extremely white shades of china clay are scarce but plentiful natural varieties are available.
Mica.	Heat resistant, fireproof paints and also other decoration paints.	Very large quantities of mica are available in India. It is also exported in very large quantities.
Red Ochres. Red oxide of iron.	Red and coloured paints.	Huge quantities of raw materials are available in India.
Yellow ochres. Yellow oxide of iron.	Yellow coloured paints.	Huge quantities of raw materials are available in India.
Brown and black oxides and umbers and sienna	Various shades and grades of paint.	
Green earth.	Green and coloured paints and distempers.	
Graphite.	Black and grey paints.	
Black and red manganese.	Black, grey and other coloured paints.	

It may not be worthwhile to estimate the quantities of these natural pigments that could be made available as, in most of the cases, unlimited reserves are located in India. It is observed that the natural pigments are extremely cheap. The cost of raising the natural minerals at mine pits is somewhat very nominal. Further operations of gradation, packing transportation and ore dressing increase the basic costs and later the cost of disintegrating, crushing, grinding and pulverising make them more costly.

CHEMICAL OR ARTIFICIAL PIGMENTS : There are a large number of chemical pigments which find use in the paints industry, on a commercial scale. A few of them are detailed hereunder :

CHEMICAL PIGMENTS

Pigments	*Uses*	*Remarks*
Lithophone.	White paints and as white pigment in rubber industry.	There is no production of lithophone being carried out in India. Present requirements range from 1,000 to 2,000 tons annually. There is no production in India.
Zinc oxide.	White and coloured paints, wide applications in rubber industry.	Present requirements range from 7,500 to 8,000 tons. Production plants, at Calcutta, yields insufficient quantities.
White lead.	White paints.	Present lead pigment production is insufficient. It is manufactured from imported lead.
Red lead.	Red and other coloured paints.	Production 4,000 to 5,000 tons ; it should be doubled.
Litharge.	Yellow and coloured paints and also as drier.	
Titanium dioxide.	High grade white paints, and has important use in rubber industry.	Ilmenite ore reserves are available in Trivandrum. It should not be exported, and instead, recovery should be carried out here.
Mercury oxide.	Antifouling compositions.	No production. Can be manufactured in India.
Cuprous oxide.		
Yellow chrome.	Yellow and other coloured paints and distempers.	Production is being carried out on a fairly satisfactory scale. It can go up with demand.
Chrome orange.	Orange and other coloured paints and distempers.	
Chrome green.	Green and other coloured paints and distempers.	
Ultramarine blue.	Blue and other coloured paints and enamels and distempers.	Ultramarine blue is entirely imported ; no production carried out in India.

CHEMICAL PIGMENTS—*contd.*

Pigments	*Uses*	*Remarks*
Prussian blue.	Blue and other coloured paints and enamel and distempers.	Small scale attempts for production are being made.
Lake pigments.	Various grades and shades of paints and other products.	Lake pigments are being produced in fairly good quantities in the country.
Carbon black.	Black and grey paints and enamels, etc.	Presently there is no production of carbon black in India. Annual consumption for paint trade is comparatively small but it is largely consumed by rubber industry. Requirements are satisfied through imports.
Metal powders (aluminium and bronze powders)	Various shades and grades of paints.	Very little developments. Planning for production can be done, except that minor production of aluminium powder is attempted at Asansol by Aluminium Corporation of India.
Organic pigments.	Various shades and grades of paints.	No production in this country so far; very little developments. All requirements are presently covered through imports.

It is clear from the above that a large number of natural as well as artificial pigments are obtainable in the country and there are bright prospects for paint industry in India.

DRYING OILS : Amongst the various types of drying oils that are required for the paint and varnish industry, the most popular ones are linseed oil, tung oil, dehydrated castor oil, soya bean and poppy seed oil, etc. India is the biggest producer of linseeds and same are also exported in very large quantities to other countries. Out of 500,000 tons of linseeds produced annually in India, about 50 per cent are exported and nearly 200,000 tons are crushed for oil. It is, however, estimated that nearly 15,000 to 20,000 tons of drying oils are consumed by the paint industry and, as such, there is wide scope for the expansion in this direction as linseed oil production can be increased to cope up with the requirements.

This industry can easily capture world market as the availability of linseed oil in India is in unlimited quantities. The use of dehydrated castor oil is an additional asset to the paints manufacturers, as the production of castor oil in India is quite satisfactory. It is estimated that nearly 150,000 tons of castor seeds are produced per year. The use of tung oil can also be encouraged as attempts for tung cultivation are already in progress. As regards other synthetic drying oils, there is a lot of scope for researches and, thereby, having advancements in the line. Innumerable substitutes for drying oils have been tried with successful results.

RESINS AND GUMS: There are several grades of resins and gums required for the paints and varnishes industries. A good number of synthetic resins are also in the market for the production of large varieties of useful varnishes and lacquers. A few of the natural varieties are lac resin, known as shellac resin, gum copal and many other varieties of gums.

Shellac is really an important Indian product and is finding a very good export market. Crude lac is produced to the tune of nearly 40,000 tons per year, but a limited quantity is used in the country for the manufacture of French polish and other types of furniture polishes and varnishes.

Rosin is obtained by the distillation of some of the oleoresins obtained from the coniferous trees of the type *pinus palustris* and other species. Production of various grades of rosin, along with turpentine oil, is already being carried out at a few centres in India and products of satisfactory quality are sent to the market.

India is definitely deficient in her supplies of some of the gums like copal gum which is, presently, being obtained from Belgian Congo. Gum copal is largely required for varnish manufacture and, therefore, it is absolutely essential to look for some Indian substitutes. Synthetic resins like cellulose nitrate are finding quite a vast use in the production of important lacquers and this industry, however, needs serious attention to be developed on sound lines in the country.

SOLVENTS AND THINNERS: Some of the low boiling organic liquids are playing a very important role for acting as solvents. Their importance has been very well realised in the various chemical and pharmaceutical industries, especially the biochemical processes where the task of extraction with the help of solvents is of great importance. Some of these solvents are largely used as thinners in the paint and varnish industry. These solvents and thinners are indispensable for the paints, varnishes, lacquers and enamels industries and are also used in the production of oil and leather cloths.

There are innumerable solvents and thinners, but the common varieties are acetone, alcohols, turpentine, white spirit, coal tar naphtha, petroleum ether, benzene, ethyl acetate, butyl acetate, amyl acetate, etc. The annual consumption of such solvents for paint and varnish industry is roughly estimated to be nearly two and a half million gallons and such requirements are presently fulfilled through imports as well as through local productions. It is earnestly desired that imports of solvents and thinners should be discouraged and provisions for production in India may be made as all these solvents can safely be produced on a large scale, in the country.

DRIERS AND PLASTICIZERS: It is understood that most of the driers are already being produced in India. Driers accelerate the drying properties of oils and some of them are lead compounds like litharge, red lead, borate of lead; and manganese compounds, *i.e.*, manganese dioxide, sulphate and borate, and other organic complexes of cobalt, lead and manganese of the type linoleates, rosinates, naphthanetes and also oxalates and acetates, etc. These driers, though used in minor quantities have their due importance in the paint and varnish industry. A large number of plasticizers are recommended for this industry and good many patent products are being obtained from abroad. The use of plasticizers has not been well realised in this country as the advancement in this direction has rather been slow. The scope for the production of plasticizers in the country must also be investigated.

It is a recognised fact that paint and varnish industry in India can have splendid prospects if expansion targets are scientifically taken up in hand and due importance is attached to the exports since India has adequate resources of the raw materials. Paints and painters' materials and other allied materials are being imported in huge quantities. During the recent years, such imports have been on the decline as the indigenous production has greatly been encouraged. The following figures of imports and exports of paints and painters' materials, during the past few years, would indicate the relative trend of trading in paints with foreign countries.

IMPORTS AND EXPORTS OF PAINTS AND PAINTERS' MATERIALS

Year	*Imports Rupees (Thousands)*	*Exports Rupees (Thousands)*
1937-38	10,186	1,449
1938-39	8,899	1,301
1939-40	10,265	1,781
1940-41	10,316	2,158
1941-42	11,457	2,316
1942-43	7,926	546
1943-44	5,736	701
1944-45	8,335	1,018
1945-46	10,370	630
1946-47	14,510	2,616
1947-48	18,475	4,285
1948-49	22,483	6,175

It is estimated that roughly 50,000 tons of paints and 250,000 gallons of varnishes of all types are produced in this country and it is hoped that the production figures will go up with the rapid industrialisation. The effects of the partition of the country are not much marked on the paints and varnishes industries.

CHAPTER XII

PLASTICS AND CHEMICALS

PLASTICS and synthetic resins have a direct origin from chemicals and are, in fact, some of the polymerised complexes obtained from certain simple chemical compounds. This industry has made a marked progress during the recent years and, in India, this is one of the post-war industries. The utility of the plastics and synthetic resins had been fully realised during the war days as these could satisfy some of the important war requirements. The wartime researches carried out in the foreign countries, had, considerably, helped in establishing this industry on sound lines. The World War II had, really, accelerated the maturity of several unexplored problems in plastics. Commendable achievements have been made in plastics by the countries like U.S.A., Germany, U.K., U.S.S.R. Some of the natural resins are also found to be used for good many products.

Plastics have gained world-wide recognition on account of the several reasons. They have, in fact, offered certain very useful and cheap substitutes of materials of construction and, in certain cases, have successfully replaced some of the metals and alloys, wood, bricks and cements, glass, porcelain, leather and rubber. The basic properties of electrical resistivity and heat insulating, lightness, fineness and smoothness have created a unique place for plastics in the electrical and mechanical industries. Products can be moulded into desired shapes and forms and, in a few cases, they possess fairly high compression strength. The additional advantages of the plastic products are that they are quite cheap and sufficiently attractive, plain and multi-coloured shades can be prepared out of them. Besides their great importance in the electrical line, plastics are found to serve a good deal in the basic problems of transport and communications, *i.e.*, telephones and telegraphs parts and accessories ; automobile and aircraft industries ; and in several industrial and domestic equipments. A large number of novelties and presentation articles including toys are also made out of plastics.

Plastic industry has really a poor record in India, and in fact, it was carried out on a very minor scale before the war. A few varieties of products were moulded out of the imported quality moulding powders. During the war period, this industry had a slow and progressive move and it is after the World War II that the real advancement had started. The bakelite powders, more popularly known as phenol-formaldehyde and urea-formaldehyde powders, were used for producing articles by compression moulding or injection moulding or by extruding methods. The introduction of transparent plastic powders have given further advancement to the industry. The number of plastic moulding presses was very small, in India, during war days but the same has gone up to nearly a hundred now and large varieties of plastic products are manufactured from imported powders.

The film and photographic industries which had also their birth from the plastics like cellulose nitrates and cellulose acetates have developed to a little extent in India. Large amounts of raw films including photographic equipments are imported into the country every year and the real technique of the industry of film making is lacking.

The natural resins of the type lac resins, lignin resins and cashew-nut shell liquid, are successfully utilised to produce some of the plastic products. Considerable research work has been carried out at the Indian Lac Research Institute, Namkum in Bihar, and innumerable products are prepared out of natural resins. Combinations of natural lac and synthetic resins have been successfully tried and a good number of commercial products are made out of them. Bleached lac also finds several uses. Some of the vegetable oils, if added to the natural resins modify their character and they exhibit better properties.

Resins and plastic moulding powders which form the basic raw materials of the modern plastic industry are graded according to the nature of powders. A few of them are as under :

1. SYNTHETIC RESINS :
   (A) *Moulding Plastics :*
      (1) Phenol-formaldehyde.
      (2) Urea-formaldehyde.
      (3) Melamine Resins.
      (4) Polyethylene Resins.
      (5) Polystyrene Resins.
      (6) Vinyl Resins.
      (7) Oragno-Silicon Polymers.
      (8) Alkyd Resins.
      (9) Acrylic Resins.
      (10) Nylon Resins, etc.
   (B) *Cellulose Derivative Plastics :*
      (1) Cellulose Acetate.
      (2) Cellulose nitrate and other derivatives, etc.

2. NATURAL RESINS :
      (1) Lac Resins.
      (2) Cashew-nut shell liquid and other Resinous oils and extracts, etc.

3. MISCELLANEOUS RESINS :
      (1) Synthetic Rubber Plastics.
      (2) Casein Plastics.
      (3) Cold Setting Glues.
      (4) Varnishes and Lacquers, etc.

Moulding powders are further graded according to the physical properties which they exhibit under different conditions. Resins are also graded in thermosetting and thermoplastic qualities. Such gradations are purely based on the fact that the products manufactured out of thermosetting powders are heat resisting and remain unaltered in structure and shape if subjected to further heat treatment, whereas the thermoplastic products are greatly effected by heat.

Apart from the moulding powders, there are also other additives which have considerable importance in the plastic industry and these are as under :

(i) Fillers,
(ii) Pigments and colours,
(iii) Plasticizers,
(iv) Lubricants, etc.

Some of the thermosetting resins do not produce satisfactory moulded articles unless some suitable filling agents are added to such compositions. Fillers have a marked effect on the moulded articles and, in fact, they modify the mechanical strength, electrical properties, resistance to chemicals, heat and moisture and even, in certain cases, entirely change the character of the resins. These are cheap additives and considerably help in cutting down the cost of production of the finished products. A few of the industrial fillers are wood flour, graphite, cotton waste, cotton linters, jute waste, mica, asbestos, carbon black, whiting and other mineral ochres. In fact, the demand for fillers can be easily satisfied from the country's resources as and when plastics industry is properly organised.

The various plasticizers which are really the complex solvents, considerably help in modifying the character of resins and their various derivatives. In fact, the line of plasticizer is unexplored in India and the imported varieties are used by certain industries. The use of lubricants is quite popular in the plastic industry and the most popular type of lubricants are stearic acid and certain stearates of zinc and aluminium.

SYNTHETIC RESINS: Phenol-formaldehyde : Phenols and cresols when condensed with formaldehyde in the presence of suitable catalysts under specific conditions of temperature and pressure, produce suitable quality of thermosetting resins. These resins are also termed under the trade name of bakelite and the powders obtained from them can be usefully moulded. The production of phenols and cresols in India is a matter of primary interest if these resins have got to be produced on a commercial scale. The coal tar distillation products which also include the benzol production, can provide for the manufacture of phenol in sufficiently good quantities in the country. Similarly, the production of formaldehyde has its prime importance and reference about the same has already been made in the previous chapters. Besides the production centre at Bhadravati, a plant for manufacture of the same is also under planning at Sindri in Bihar where the construction of fertiliser factory is already in progress.

These are thermosetting resins and can be easily moulded to good shape and appearance. These resins are specifically useful when electrical insulation and high mechanical strength is desired. These are water resistant and are inert to many solvents. These resins can be suitably moulded in the presence of fillers like wood flour, paper, fabric or asbestos.

Urea-formaldehyde : These resins are of similar importance like that of the phenolic resins and, in fact, the actual production is carried out by the condensation of urea and formaldehyde. It is anticipated that the production of urea is also to be taken up at the Sindri fertiliser factory, Urea-formaldehyde resins are thermosetting and are hard, transparent, fast to light and resistant to all inert solvents. They can be easily produced at a low cost. These resins have a sufficiently hard surface finish and are quite resistant to corrosive products and chemicals. The mechanical properties of these resins do not alter within the temperature range up to 180°F. and even show high electrical resistivity.

Melamine Resins : Melamine-formaldehyde resins are prepared from calcium cyanamide. These resins have been found to be thermosetting in character. They have largely been used in the treatment of paper and textile as they are water resistant materials. Certain plywood glues which are heat-resistant, are also prepared out of these resins. The cellulose-filled melamine-formaldehyde resins show high strength and hardness and are quite shock resistant. Mineral filled resins of this series show excellent electrical properties. These resins are fairly hard in general and can stand wear and tear very well.

Polyethylene Resins : These are the characteristic type of polymerised resins obtained from ethylene. They are the thermoplastic resins and are, chemically, the most resistant type and possess high insulating properties. They have also served some of the urgent problems of electrical insulation especially in that of electronics where high frequency cables have to be insulated. These resins can be moulded by compression or injection and can be readily formed into films, sheets, tubes, rods, tapes and filaments. These are tough materials and show flexibility over a wide range of temperatures. These are also resistant to moisture and to the action of chemicals and possess very good electrical properties.

Polystyrene Resins : These are the copolymers of hydrocarbons with nitrogen base resins and also the halogen derivatives and offer chemically resistant, light weight, heat and electrically resistant plastics which had found immense uses in several of the wartime requirements. The principal uses of these resins are in the electrical field in the aircraft industry, wireless and radio parts, refrigerator parts, telephone equipments and several other allied products.

Vinyl Resins : These resins include the vinylchloride-acetates, polyvinyl-butyral, polyvinyl-chloride and vinylidene-chloride polymers. These were largely used in flexible film materials and for the cable insulation purposes. Some of the vinyl polymers have been successfully used for coating textiles for the production of water proofs, and are also used for the manufacture of gramophone records. Useful varieties of lacquers are also prepared from the vinyl polymers. Further, unbreakable and safety glass is prepared out of these series.

Polyvinyl-butyral being an important resin is successfully used for the production of laminated, flexible and rubber like products. Modified with the use of plasticizers it acquires higher tensile strength and flexibility and also exhibits good adhesive properties. In fact, it is found suitable to be calendered on to cloth for waterproof fabric. It is very useful thermoplastic adhesive for leather, rubber, paper, wood, plastics and glass. Further, it is found useful for coating fabric raincoats, tarpaulins and hospital sheetings. A large variety of modified powders with variable properties of elasticity, flexibility, degree of insulation and of different coating thickness, are produced out of polyvinyl chloride resins. Even the working range of temperature is altered by the use of different plasticizers, and with a change in water permeability and chemical resistance, these resins can be graded differently.

The vinyl-chloride-acetate resin possesses high strength and chemical inertness. They are resistant to most of the chemicals and are non-inflammable. These are odourless, tasteless and non-toxic and are largely used for the aircraft industry for the manufacture of navigation instruments. The vinylidene-chloride plastics are resistant to most inorganic and organic solvents *i.e.*, acid and alkaline solutions (except ammonia) and alcohols, esters, ketones nitroparaffins with the exception of aromatic hydrocarbons. These resins are non-inflammable and are tough and mechanically strong.

Organo-Silicon Polymers: These are typical resins which are obtained as a result of the polymerisation of inorganic and organic compounds of silicon, *i.e.*, silicon tetrachloride is converted into organo-silicon chloride which is ultimately polymerised into silicon resins. These resins possess unusual heat resistance and electrical insulation properties and are sufficiently recommended for reducing the weight and size of the electrical equipments that are produced out of them.

Alkyd Resins: Technically speaking, alkyd resins are prepared by the chemical combination or reaction between a polyhydric alcohol and a polybasic acid, in the presence of modifying agents like fatty acids. Some of the suitable combinations are obtained by the use of glycerine and phthalic anhydride. The important uses of these series of resins are in their application on the surfaces of wood, metals, leather, paper, and cloth, Alkyd resins also form the basic enteric coating on pill tablets, capsules and similar medical products. Alkyd resins are noted for their toughness and durability and, hence, attempts to produce films and sheets have been made in different grades in foreign countries. Unbreakable watch glasses are also prepared out of them. On account of its bonding properties, several laminated products are prepared out of it including safety glasses. Some such products are electrical insulation materials, linoleum, gaskets, break lining, etc. Alkyd resins have successfully offered a scope for the production of more hygroscopic water repellant match that lights even when it is wet. These resins are found to be insecticide in character. Suitable lubricants, which are insoluble in water and petroleum products, are obtained from alkyd resins. Some of the varnishes and protective coatings are also produced out of them.

Acrylic Resins: These resins are the thermal polymers of acrylic esters and are produced by the catalytic action of benzoyl peroxide. Acrylic resins are sufficiently popular because of their specific properties of toughness, light weight and transparency. These are found to be chemically resistant and also water resistant. These are stable to heat and light and have high softening point. Windows and cockpit enclosures of aeroplanes are made out of acrylic resin sheets. A large variety of novelties and presentation articles can be produced out of these resins.

Nylon Resins: These resins are the condensation products obtained from adipic acid and hexamethylene-diamine and belong to the polyamide group. These are popularly used for the manufacture of films and filaments. Nylon-bristled toilet brushes, tooth brushes, rotary brushes, and paint brushes are quite popular products of such resins. Nylon filaments have also offered a good scope for the production of ropes of exceptional strength and tennis strings for sports goods.

CELLULOSE DERIVATIVE PLASTICS: Amongst the various cellulose derivatives, the important plastics are cellulose nitrate, cellulose acetate, cellulose acetate-butyrate, cellulose propionate, etc., and all of them occupy a unique position in the plastic industry. In fact, the film industry has its birth from the cellulose plastics. India is today importing all sorts of films in the form of raw photofilms, *i.e.*, motion picture films, photographic films, x-Ray films and several other cellulose derivative plastic-wares. The annual rate of imports of raw cinematograph films can be seen from the Appendix " B."

Cellulose nitrate plastics are manufactured by the nitration of high cellulose containing materials especially of high alpha-cellulose contents, *i.e.*, dried cotton linters or wood cellulose. Nitration is carried out with the mixture of nitric acid and sulphuric acid. After the elimination of free acid, the product is bleached. dehydrated and, later mixing with plasticizers, can be converted into sheets of desirable width and thickness. The process of seasoning and maturing is very important before such sheets are sent for industrial uses. Cellulose nitrate plastics are tough and thermoplastic in character. They can be easily cut, punched, drilled, turned, drawn and embossed. Further, they can be readily cemented and can be polished and are highly inflammable. These resins cannot be used for moulding purposes. Some of the important uses of the cellulose nitrate plastics are in the production of drawing and calculating instruments, identification plates. labels, index forms, engraved and printed objects, transparent containers, film base, optical frames, brush handles, tool handles, pens and pencils, etc.

Cellulose acetate plastics are produced by the estrification of alpha cellulose, with acetic acid and acetic anhydride. The process is carried out under controlled conditions. By the use of suitable plasticizers, the products obtained are tough and possess high impact strength. Moulded articles can be easily cut, punched and drilled. The degree of transparency can be adjusted according to requirements. These plastics have application in the aircraft control knobs, flashlights, valve handles, buttons, gas masks valves, etc.

Cellulose-acetate-butyrates are prepared by the estrification of cellulose with acetic acid and butyric acid. These plastics are tough and possess high impact strength. The moulding behaviour of these plastics depend on the type and amount of plasticizers used. These are used for the production of tooth brushes, telephones, toilet float bulbs, pistol grips, gas mask valves and guards, blackout lenses, steering wheels and a large variety of similar products.

NATURAL RESINS: Indian lac industry is one of the oldest industries in the plastics and resins. Huge amounts of Indian lac are exported out of the country in the form of raw and refined lac sticks and buttons and in the form of shellac. Shellac has suitably been used for the manufacture of varnishes and furniture polishes. The Indian Lac Research Institute, Namkum in Bihar, has carried out considerable research work in lac and lac products and have established certain important facts about the bright and prospective utility of lac on the lines of plastics and even the experiments have been tried to produce combined plastics out of natural and synthetic resins. Lac has other applications in the manufacture of insulating varnishes for the electrical industry and has wide utility in the radio and wireless industry. A few of the laminated products manufactured out of pulp and jute waste in combination with the lac resin have yielded very suitable products for the construction of panels, tea chests and other packing materials. Lac resins have offered useful adhesives which are suitable for binding abrasive wheels and micanite products. Water proofing of inks and other products is successfully done with lac. Lac resins are also found to be used in the manufacture of anti-gas fabrics and oil cloth. Sealing wax and lac bangles are other products of interest which are produced out of lac.

Other natural resins are of the type cashew-nut shell liquid which is obtained from cashew-nuts grown in South India. In fact, by series of experiments carried out in the country, it is observed that these resinous liquids have great value in the production of insulating varnishes. This liquid has so far been finding export market and the same could evidently be used here in India in the production of industrial lacquers. There are several other natural resins that are available in plenty in India.

MISCELLANEOUS RESINS : There are large varieties of miscellaneous resins that can be described in this chapter. In fact, the researches in the synthetic rubber are more or less on similar lines and the same can be grouped under the heading of resins or plastics.

Butadiene is the most important starting raw material for the manufacture of synthetic rubber. There are several sources which can yield this raw material, *i.e.*, petroleum, coal and certain carbohydrates. Treatments of certain vegetable oils also yield synthetic rubber. Butadiene is obtained from the cracking operation of petroleum. Chloroperene is another raw material for the production of neoprene synthetic rubbers. Chloroperene is produced from acetylene. There are several compounds like isoperene, styrene, etc., which also go into the composition of some of the varieties of synthetic rubber. These are all polymerised products and certain copolymers are also produced under different conditions. This subject is, however, very vast for this chapter.

There are also other resinous products obtained from casein and such adhesive products are finding vast applications in the plywood industry and in several other industrial products like varnishes and lacquers.

APPLICATIONS OF PLASTICS : Plastics have very wide applications and it may not be out of place to mention some of the interesting products manufactured out of them.

(1) *Electrical Accessories :* Adapters, bell push, bullet tips, ceiling roses, condensers, crash helmets, cut outs, fan bushes, fan components, fuse cut out, fuses, insulating bushes, insulator, joint cut outs,

junction boxes, knobs, lampholders, transit plugs, plugs, smoke boxes, switches, switch gears, socket and switch combined.

(2) *Domestic and General Household Items :* Ash trays, bangles, bottles, bottle caps, bowls, boxes, boxes with lids, caps for all containers, cigarette cases, combs, containers, cups, desk pads, eye-glasses, gumpots with lid, inkstands, lampshades, lens holders, note blocks, pepper and salt bottles, pin trays, plates, pots, safety razors, saucers, shaving block containers, shaving cups, shaving stick containers, shaving sets, soap boxes, spoons, spools, stands for calendars, stands for bottles, sugar pots, tobacco box covers, tooth brush handles, trays, tumblers, tea strainers, washers, whistles, and other innumerable similar products.

(3) *Cold Setting Ahdesives :* Wood glue for plywood industry, abrasives, furniture, aeroplane constituents.

(4) *Varnishes and Lacquers :* Low temperature hardening lacquers, wood protective coats, metal covering, insulating varnishes, food containers lacquers, oil soluble resins for paints, varnishes and enamels.

(5) *Cellulose Products :* Photo films, cine films, eye-shields, window shields, electrical dials, aircraft and automobile parts, acetate rayon industry, electrical parts, x-ray films, graphic art films, packings.

(6) *Chemical Resistant Materials :* Chemically resistant resins as materials of construction for reaction chambers and vessels, storage tanks, packing materials for miscellaneous purposes ; materials for transport ; conveying channels and pipes.

(7) *Miscellaneous Industrial Products:* Radio cabinets, knobs and other parts ; telephone parts, motor car fittings, electrical meters, camera cases, gramophone records, mill parts, display and

decoration articles, buttons, buckles, knife and cutlery handles, kitchen utensils, structural components, desk and table tops, counter tops, partitions, industrial machinery, name plates, packing materials, toys, spectacle frames, pens and pencils, fountain pens, household and office furniture, filing cabinets, raincoats, waterproof hospital equipment, suitcases, lightweight air travel kits, shoes, hats, textiles and fabrics, belts, straps, pulleys, gear wheels, bearings, brake lining, clutch lining, bathroom fittings, sanitary fittings, drawing-room accessories, stationery, crockery and tableware and glassware substitutes. There are numberless other industrial products which are available in the market.

Plastic industry has not, so far, much developed in India. The fundamental reason for being backward in this line is the lack of basic researches in the field of plastics and the production of various resins. A large number of moulding presses are engaged, in India, in the production of different novelties and presentation articles and the various moulding powders are imported in huge quantities.

Efforts have, therefore, to be made to properly organise this industry and the real chemical aspects of plastics must be thoroughly tackled, although the methods of mechanical moulding are quite known. The film industry, however, must attract the attention of the Government immediately.

CHAPTER XIII

MATERIALS OF CONSTRUCTION AND LABOUR WELFARE IN CHEMICAL INDUSTRIES

THE subject of materials of construction is too vast to be dealt with, in this chapter. It would, however, be possible to outline some of the points. The importance of the materials of construction in all industries has to be judged from the fact that the initial cost for laying out building, machinery, plant equipments and reaction vessels is always included in the production cost in the form of depreciation. Similarly, the cost of replacement of complete units or parts thereof and the period required for such replacements have also to be taken into consideration. The more the depreciation, the higher goes the cost. Normally, there are certain rough standards of depreciation costs laid down for certain specific industries and it is observed that in the chemical industries such figures are very high. Machinery parts and vessels need replacement even after a few months.

The selection of materials of construction for chemical factories has to be very carefully made. Factory buildings also need definite protections from corrosion. A broad classification of materials of construction for chemical industries may roughly be mentioned under the following heads :

(1) Materials used for building and structural work.

(2) Materials used for reaction chambers, absorbing vessel and collection vessels.

(3) Materials used for furnaces, ovens and drying chambers.

(4) Materials used for physical operations: grinding, filtration, distillation, evaporation, crystallisation, etc.

(5) Materials used for packing :
  (i) absorption towers for gases.
  (ii) absorbants,
  (iii) catalysts.

(6) Materials used for storage and transportation.

The chief materials of construction that are used in various industries are iron, steel, mild steel, cast iron, aluminium, copper, lead and other alloys like duriron, stainless steel, monel metal, bronze; fused quartz, cements, stone slabs, wood, etc. It may be difficult to go into the deep details of individual groups. The selection of suitable materials of construction is further based on various factors, mentioned hereunder :

(1) Mechanical strength.
(2) Physical conditions and other specific properties.
(3) Resistance to atmospheric conditions, corrosion, weathering and rusting.
(4) Resistance to chemicals corrosion.
(5) Resistance to mechanical use.
(6) Initial cost of materials and replacement expenses.
(7) Source and availability of materials and parts.
(8) Substitutes and their scope for use.

There is not much work done on this subject in India. Blue prints along with the mechanised equipments are, right through, being imported from abroad and no efforts are made to manufacture the same in India. Most of the basic materials are available in plenty but little is known about the technique of producing suitable alloys, synthetic resins and special cements. Little is known about the use of the substitutes in place of specific constructional materials.

It may not be out of place to mention about the utility of some of the materials of construction, either for chemical industries or for some of the chemical processes in certain other industries.

MILD STEEL : It is mechanically strong and is malleable. It contains carbon to the extent of 0.3 to 0.5 per cent. It is used for the storage of alcohol, oils, sulphuric and mixed acids, ammoniacal liquors, oleum and other countless liquids. Further as a reaction vessel, it is used for the construction of liquor ammonia equipments for the recovery of ammonia and is also utilised in the soda ammonia process plants. Further, it is used for the industrial distillation stills of alcohol and methanol. In the paper industry, mild steel is used for the construction of soda wood pulp digesters. Large settling and reaction tanks in soap industry are also made out of it. There are innumerable other uses of mild steel in different industries. Apart from this, glass lined mild steel vessels find a great utility in the chemical industry. Mild steel is being produced to a certain extent, in the country but the production is not adequate to meet the real requirements of the various industries. It is, therefore, desired that serious efforts may be made to investigate the scope for the increased production of mild steel in India.

CAST IRON : Cast iron is tough and hard, having high compression strength. It is not as strong as steel but the main advantage is that it can be cast into any desired curved shape which may be free from joints. It is extensively used in chemical industries as the same is very strong and cheap. Cast iron is used for the construction of fusion pots for caustic soda industry, in the manufacture of nitric acid retorts and is also used for the equipments of nitration and sulphonation processes. It resists the action of alkaline solutions and fused alkalis and also stands the strong acids. It is also used for the purpose of casting grate bars of furnaces. Filter presses for various industries are made out of cast iron. A large number of cast iron foundries are operating on progressive scale in the country for producing small machines and machine parts and other miscellaneous equipments. Further, it may be desired to implement the existing organisations, as more and more developments in the engineering field would command large production of cast iron.

WOOD : There are good many varieties of wood which find wide industrial applications. Apart from the use of wood as the building material, it has really an important utility in the chemical industry. It is useful in the construction of parts which come in contact with dilute mineral acids. Storage tanks in the factories are often made out of wood. In textile mills, the dyeing vats, tanks, crystallisers, and tanks for washing and cleaning purposes are made out of it. Storage tanks for weak solutions of inorganic acids and for other innumerable solutions are constructed out of wood. Lead lined wooden tanks are used for the storage of sulphuric acid. Many chemical reactions are carried out in lead lined wooden tanks where steam can be used. Wood exhibits more resistant properties on treatment and, in certain cases, chemical and physical treatments are necessary. Treatment of wood is carried out in various ways, depending on the requirements.

(1) Treatment is given by heating wood to remove moisture.

(2) Treatment is given by burning off the surface waxes and volatiles.

(3) Treatment is given either by spraying chemical solutions or by giving protective coatings.

A good many patents have been taken for such processes of wood treatment. The application of pitch and bitumen coats, creosote treatments, acid and chemicals resistant paint coats are a few important examples. The carbonised surface of wood resists strong acids. Wood used for building structure requires protection from moth and, hence, preservatives are applied to them. Paint coatings on wood give surface protection and also serve the decorative purpose. Wood gets softened when it comes in contact with alkaline solutions. Iron, calcium and magnesium salts also tend to attack wood.

The forest wealth of India is really very vast and a large number of species of wood are obtained from them. The wide range of climatic conditions in the country are responsible for such growth of various qualities of wood. In fact, some of the hilly forests yield best quality of timber and teak wood. A good deal of research work has been carried out at the Dehra Dun Forest Research Institute for the examination of various species of wood yielding plantations. It is, however, anticipated that the developments in this direction are fairly successful. Serious efforts are needed for better utility of wood for the chemical industry.

STONE SLABS : Stone slabs are largely used for the construction of acid gas absorption towers. The gases directly come in contact with the acid resistant stone. There occur some constructional handicaps when stone slabs are used for this purpose, but by the application of suitable jointing materials, such difficulties are overcome. Various kinds of firestones are used in the construction of boiler flue and furnace parts. Some of the stone slabs are primarily complex silicates and are found in plenty in the country. Stone slabs are available at extremely cheap rates and it is, therefore, necessary to make further investigations to find out the suitability of the same for other useful purposes.

BRICKS : Bricks are made for various purposes, *i.e.*, constructional bricks, fire bricks, acid resisting bricks, vitrified bricks, porous bricks and other varieties depending on their requirements. The art of ordinary brick making was known to the people even during the primitive ages. The process is simple wherein the ordinary pond mud is moulded into brick and then burnt.

The common red bricks of the normal size $9'' \times 4\frac{1}{2}'' \times 3''$ are made from the naturally occurring clays which possess the necessary properties of plasticity and the bricks get hardened on having been put to fire at a high temperature. The size and style of bricks can be made in accordance with the requirements. Building bricks are indispensable item of construction jobs as all fixtures, external and internal, for the industries are necessary to be rested on brick works. The advancement in the cement building technique has today replaced much of brick work, but it may not be possible to completely replace bricks for all purposes. Brick making is presently being carried out on an extensive scale in the country but the fuel shortage is one of the major problems for the industry.

The acid resisting properties of bricks are mainly due to the porosity, texture and the degree of vitrification. Acid resisting bricks are largely required for the construction of acid absorption towers. They serve the purpose of packing materials and lining materials for acid chambers although, in certain cases, special cements made from litharge and glycerine are used for giving such linings. Equipments like concentration basins, seating for acid concentrators, jet blowers, nozzles and drainage tiles are also made from acid resisting bricks. Glazed bricks are quite suitable for this purpose, and cheap glazing can be done with the help of common salt. The process of vitrification also helps in making the surface as acid-proof. Highly vitrified bricks are quite acid resistant and even, the surface vitrification produces suitable results. Vitrification at surface can be done either by polishing or by heating and fusing the external surface or by inducing some foreign matter like silicate of soda and after the surface absorption, it reduces the porosity. Vitrified bricks are largely used for the construction of acid storage containers but they do not stand the action of alkaline solutions. The production of acid resisting bricks is being carried out in the country on a moderate scale but the quality of the same is reported to be very poor. It may be desired to attend seriously to the production of suitable quality of acid proof bricks.

Porous bricks are largely used for the construction of filtration equipments for corrosive liquids where other mediums of filtration fail. Porous vessels are also used as diaphragms for the electrolytic cells.

Refractory bricks are used for the construction of structures which stand high temperature, *i.e.*, furnaces, cupolas, kilns, flue channels, fire boxes, etc. Refractory bricks are further classified as acidic, basic and neutral types, depending on qualities. Further gradation of refractory bricks is based on the temperature limits. There are good many varieties of such bricks, *i.e.*, chromite bricks, magnesite bricks, high alumina bricks, etc. There are large number of industries like glass, ceramics, pottery, cement furnaces, reverberatory and reduction furnaces, electrothermic and metallurgical furnaces which require refractory materials.

Chemically resistant bricks may either be heat conductors or heat insulators. It is found that the vitrified bricks are good conductors whereas porous bricks are good insulators. A large number of refractory materials are being produced in India and major requirements of iron and steel, ceramics, cement, glass, and chemical industries are fulfilled through the local production.

CEMENTS : Ordinary Portland cement is a very good building material but it is attacked by acidic solutions. Alkaline solutions can be stored in cement tanks.

Acid proof cement composition is prepared by mixing asbestos powder with sodium silicate. It is also fire proof. Mixture of asbestos, silicate of soda and tar are also applied for acid proofing. Finely powdered flint, if mixed with sodium silicate, gives suitable acid proof cement. Mixture of fireclay and asbestos is used as jointing material for acid proof bricks. Sulphur containing cements, melt at about 1,000°C. and are used as lining or coating in the cast iron vessels for the storage of cold acids. The various acid proof cements of such compositions can easily be produced in India and it is, therefore, desired that further investigations should be made to procure cheap substitute of fire proof and chemically resistant cements.

FUSED QUARTZ AND CHEMICAL GLASSWARES: Fused quartz can be shaped into all desired forms. It stands high temperature but its main defect is that it is fragile. It is resistant to acid gases. Fused quartz equipments are very costly and are not very commonly used for general industrial purposes and are very scarce. Fused quartz is attacked by strong alkaline solutions. The receivers and condensers of acid plants are prepared out of fused quartz. Equipments of fused silica are entirely imported from abroad and there are no local productions of the same in India. The technique of production of fused quartz equipments must be developed, on a commercial scale, in the country, as the requisite raw materials are plentifully available. Chemical glassware of the type "Pyrex", "Borosil" and other varieties are much used for organic chemical reactions. The sizes of the plants are of limited dimensions and can be produced in the country if developments in the production of heat resistant glass are matured. Glass lined vessels are also used for chemical reactions which find sufficient use in the chemical and pharmaceutical industries.

CHEMICAL STONEWARE: Chemical stonewares have a complex composition and are made out of naturally occurring clays, quartz and felspar. These are also sintered from inside. Stonewares are generally given hard glaze which stand the action of acid and preferably salt glazing is done. Chemical stonewares are generally used for the construction of parts which come in contact with acid vapours, and acid liquors and also for the absorption, collection and storage vessels. The normal thickness of stoneware equipments should not be more than half an inch especially where the temperature changes are quite sudden as stoneware does not stand thermal shocks.

Stoneware jars are important acid storing containers and their real value is realised only by the mineral acid manufacturers. Stoneware jars do not stand the action of alkaline solutions. Tiles made out of stoneware are cemented with acid proofing cements. The manufacture of chemical stoneware jars and other equipments is already being carried out in India. The stoneware Jar industry will have to expand in due course and such expansions will correspondingly depend upon the progress of mineral acid industry.

RUBBER : Rubber is a very useful material of construction, especially the hard rubber. Hard rubber is used for the manufacture of piping, pumps and pistons, particularly for resisting acids. It can easily be threaded and such pipes can be joined with the help of sleeves and elbows. It can be softened by hot water and, thereafter, it can be bent. Its special advantage is that it can stand the action of all acids. Soft rubber lining on steel is also used for acid storage purposes. Rubber lining is not much expensive and can easily be renewed. The progress of rubber industry in India, during the last 4 to 5 years, has really been quite appreciable. With further developments, it is anticipated that rubber is bound to play an important role in the Indian chemical industry.

METALS AND ALLOYS : Some of the basic metals and alloys are found chemically resistant and are largely used as materials of construction for various industrial purposes. Metals like lead, copper, aluminium are finding good use in the construction of various chemical plants and machinery. A few of the ferroalloys like monel metal, stainless steel, duriron and chrome alloys are found suitable materials of construction for some of the acid plants. However, there has not been much development in the production of the various alloys in India. There is really a large demand for the various alloys, therefore due importance should be given to have adequate productions of the same.

LEAD : Lead finds an important use in the sulphuric acid industry. It is used in large quantities in the construction of lead chambers, Glover's towers, Gay-Lusac towers, storage tanks, channels and conveying pipes for gases and acids. Lead lined vessels are also finding important uses for the storage of acidic solutions. Hard lead, containing element like antimony, is used for the construction of centrifugal acid pumps. Copper and zinc in small quantities also form suitable alloys for this purpose. As already mentioned in the chapter on minerals, lead is in short supply in the country and needs further prospecting to locate more and more supplies of ores. Possibilities must, therefore, be sought for using substitutes of lead.

COPPER : The various uses of copper have already been mentioned in one of the previous chapters. Copper finds use for the construction of distillation still for organic liquids like alcohol, methanol, acetalaldehyde redistillation, etc. Copper is also used for making the fractionating columns and steam coils of distillation stills. Organic liquids slightly react with copper and form a sort of protective coating. The electrolytic cells for the manufacture of fluorine are made out of copper. Copper is used for the manufacture of varnishes and for rosin melting containers. The equipments like shell column and trays for liquid air are also constructed out of copper. The vacuum concentrators (tinned copper) for vacuum drying of mango pulp and lemon juice are also built out of copper. The uses of copper for household utensils for cooking food stuffs are well known but, in actual use, they are either tinned or plated with nickel or chromium. Acids and ammonia attack this metal. It is also slowly attacked by air. Apart from these uses, the main utility of copper is very well recognised in the electrical industry.

DURIRON : Duriron is a kind of cast iron containing high percentage of silica. Duriron casting can very easily be obtained. It can also bear thermal shocks as the co-efficient of conductivity is fairly high. It has the passivity of stoneware, combined with the strength of cast iron. The thermal conductivity of duriron is more than that of stone-ware and approaches that of cast iron. Duriron resists the action of sulphuric acid and nitric acid, oxidising agents and other acid solutions. Hydrochloric acid attacks it very slightly. Duriron can be very well used for the production of pipe lines for conveying acids. Complete plants for the manufacture of oxidising agents can be constructed out of it. Concentrators for sulphuric acid can be built from it. Duriron is extremely hard but brittle. The main defects of this alloys are that it cannot be machined, drilled, polished and threaded.

Tantiron and Corrosiron are similar alloys with slightly different compositions. These are also used as suitable materials of construction and are quite resistant to the action of chemicals.

MONEL METAL : Monel metal is essentially a nickel copper alloy with small percentage of iron, manganese, silicon and carbon. It has high melting point, *i.e.*, 1,360°C. and has sp. gr. 8.87. It is uneffected by brine solution and is inert to the action of most of the chemicals, although it cannot stand well the action of acids. It can be drilled, threaded and can be handled in the machine shop like steel. It can also be cast. It has a good ductility and can be drawn into wires. It is, however, more expensive than steel. Monel metal is resistant to the action of alkalis and commercial acids (not all). It can stand high temperatures and pressures. Monel metal wire can be woven into screen for filtrating alkaline slurries. Rotary driers for salt are lined with monel metal. All parts of ice refrigeration equipments that come in contact with salt solution are also made out of this alloy. Pumps and pipes, for handling sea water on ship board are all made out of monel metal. The propellers of ships are either made of monel metal or lined with this alloy.

CHROMIUM STEELS : There are several chrome steel alloys of different compositions ; the most popular of the type are stainless steel and nichrome. These alloys are chemically resistant and stand the action of water, salt water and a good number of other chemicals. Autoclaves and other reaction chambers for chemical purposes are made out of chrome steels. Their popularity has considerably increased, as stainless steels are largely required for the manufacture of surgical instruments and cutlery. These are also demanded for the manufacture of food containers.

Various steel compositions which contain varying amounts of chromium and other constituents like carbon, nickel, manganese, etc., are also known. A large number of patents for such steel alloys are taken by some of the foreign producers.

Stainless steel resists the action of water, sea water, steam, foodstuffs, alkali solution, carbon dioxide, nitric acid, nitrous acid, alcohol, ammonia, mercury, soap, sugar and oils, etc. The concentration and distillation plants for nitric acid manufacture can also be constructed out of it. Certain varieties of stainless steel can stand the action of several organic compounds, fused salts, molten metals, and practically all inorganic acid accept hydrochloric and hydrofluoric acid. Stainless steels can also stand temperature up to 2,300°F.

Nichrome, the nickel iron and chromium alloy, is a high class heating element. It possesses a high electrical resistance and also stands corrosion. Nichrome finds a wide application in the manufacture of large number of electric instruments and appliances.

SYNTHETIC RESINS : A good number of synthetic resins are found to resist the action of a large number of chemicals and are also mechanically strong. Some of such resins can be used to build commercial reaction tanks and other plants equipments.

It is quite important to think of making earnest efforts to manufacture certain materials of construction required for various chemical and allied industries as the problem of selecting and building suitable constructions out of proper materials is rather a matter of serious consideration.

B. LABOUR WELFARE IN CHEMICAL INDUSTRIES :

The machine age today commands the use of modern labour saving appliances which are, however, required for increasing the efficiency of processes and assist in cutting down the cost of production of the manufactured articles. The uses of hand labour is discouraged in almost all the industrially advanced countries of the world. The position is somewhat different in the case of India.

India possesses plenty of manpower and the population of the country has increased at a very rapid rate during the last few years. The economy of India does not permit the elimination of hand labour as more and more hands need employment. The labour movements which are gaining importance day by day, need attract the attention of the Government and the industrialist to solve the labour problems in such a way as to benefit the masses and the country. In view of the absence of an understanding between the capitalists and the labour, it is desired to find out a harmonious solution so that the progress of the country may not be hindered.

Labour conditions in chemical factories are not much different from those of the other industries except that the employers should pay particular attention to the conditions under which the labourers work. Apart from chemical factories, almost all the industries have got chemical sections where either the chemical processing is done or the chemicals enter into composition of the products. The use and application of chemicals must be carried out through skilled labour as, in most of the cases, chemicals are corrosive and poisonous. In the factories where acids are handled, workers must be guarded from burns and protection must be provided for from hazardous products. Acid resisting gloves or other coverings for hands and feet should be given. Adequate protection to eyes and other limbs must be afforded. Compulsory use of aprons and other guarding equipments, may be advocated. Corrosive chemicals like acids, alkalis and other miscellaneous chemicals are, invariably, consumed by all industries. Specifically, one may mention the chemicals like mineral acids, alkalis, chrome and lead salts and compounds, poisonous chemicals like cyanides, etc., for use in the industries. First-aid in the factories must be available at all times. There are good many precautions that are to be observed in respect of the protections of workers. The use of antidotes in the case of poisons have to be recommended.

In certain chemical industries especially that of lead salts, cases of slow poisoning are reported. In the mineral grinding work, dust effects the lungs of the worker where a lot of dust is inhaled by them. Further in paper and textile mills, the bleaching operations involve the evolution of chlorine which, if inhaled in excess, proves to be injurious or might sometimes be fatal. ' The electroplating works where cyanide baths are commonly used need careful attention. Besides protection required from chemicals, safety from electrical and mechanical dangers must be well afforded. The use of first-aid equipments has been made compulsory by the Factory Act. Chemical poisoning must necessarily be attended to on scientific lines. Medical aid must be given in the first instance. There are a large number of antidotes used for several chemical poisons.

Chemical factories where different chemical processes are involved, need skilled labourers who should be conversant with the various operations and must also be in a position to handle the materials at all stages, starting from raw materials to the finished products. The handling and storage of raw materials may sometimes be quite important. Further stages of crushing and grinding, sieving, filtration, lixiviation, leaching, evaporation, distillation, crystallisation and packing have to be very carefully attended to. For other chemical processes like chlorination, sulphonation, diazotization, carbonation, hydrogenation, sulphitation, oxidation and reduction, highly skilled labour is required.

The labour wages in chemical factories must be somewhat at advanced scales as compared with that of the workers in other mills and factories. Labour engaged on high temperature furnaces, *i.e.*, reverberatory and blast furnaces, metallurgical cupolas, reduction furnaces, glass and pottery furnaces, need special salaries and privileges.

CHAPTER XIV

INDUSTRIAL TRAINING AND TECHNICAL EDUCATION

INDUSTRIAL progress of a country must be calculated in terms of the correct estimates of its resources and, further, the achievements made to utilise beneficially such resources. It may be essential to note that the presence of technically qualified staff in the industrial and manufacturing organisations is as important as the use of machinery and raw materials, required for the production of finished materials.

The industrial training and technical education in India is, presently, in an infant stage. Strictly speaking, the literate population of the country is not more than 15 per cent which, apparently, shows that a big majority of people in India are illiterate and there are several unfavourable factors which hinder the country's progress. The problem relating to the furtherance of education in India is too vast for this chapter.

There are a very few training centres in the country that impart technical education to quite a limited number of people. The number of such institutions, is, practically, negligible as compared to the vastness of the country. There is no denying the fact that the various Indian Universities are conducting elaborate courses on the technical subjects and most of them are also maintaining research laboratories but some of them are so poorly equipped that their results are far from satisfactory.

The technical institutions, as they exist today, are very few and can easily be counted on finger tips. Some of the important ones are the Indian Institute of Science, Bangalore; Institutes of Sugar Technology and Glass Technology, Kanpur; Victoria Jubilee Technical Institute, Bombay; Harcourt Butler Technological Institute, Kanpur; Indian School of Mines, Dhanbad. The various Universities have got the attached laboratories where researches are being conducted on scientific lines. The number of engineering and technical colleges and other training institutes in the country are very few and, on the whole, progress is very slow.

India had made great scientific progress during the period of World War II. In the year 1940, Government of India had set up the Scientific and Industrial Research Board and this was, decidedly, a bold step taken by the authorities. In fact, some of the urgent problems which commanded certain strategic investigations, made the Government to take an initiative in this direction. The main function of the board in the beginning was to pay immediate attention to the various problems relating to the country's defence.

A large number of the personnel were absorbed in war-time private industrial projects, and in the various Ordnance Factories controlled by the Government. The Defence and Supply Directorates also employed a large number of technical hands. The Inspectorate-General of Explosives, Ammunitions, Gun and Shell production centres engaged technical staff and such services were classified as essential ones and, in most cases, were requisitioned for Defence purposes. The employment of the Engineering Corps which included Miners and Sappers, Wireless Operators, Motor Mechanics, trained people for war services and thus, on the whole, the technical training was imparted to people on an official scale.

The Scientific and Industrial Research Board, in fact, made slow and steady progress and also helped in realising the utility of the scientific work carried out under the guidance of the able personnel. In general, people had developed better inclination towards gaining technical knowledge. Further, it is well understood that the present wars are really wars of industrial supremacy and are based on industrial resources of the countries. They are, in fact, calculated in terms of capacity to produce war weapons. The introduction of atomic bomb as a war weapon, has considerably changed the world-wide outlook of all the nations and has opened new avenues for further struggle in future.

The Government of India had, however, decided to make the Scientific and Industrial Research Board as a permanent body after the war. Further, the establishment of the National Institute of Science, with sub-centres at nearly a dozen places in the country, have given another favourable jerk towards scientific progress in India. Some of the important laboratories are already under construction, *i.e.*, laboratories for chemicals, physics, metallurgy, fuels, glass and ceramics, drugs and medicines, food, electroplating, leather tanning, atomic research, etc.

During the recent years, the people of the country have given encouraging response to the Government's schemes for the promotion of advanced technical studies. The Government launched a scheme to send the scholars to foreign countries for higher studies on State expenses. There was a general awakening all round and the people had become industrial minded. The Government's scheme of sending the trainees abroad had also been supplemented by the private enterprises and even the industrialists had sent their own technicians for specialisation in the particular lines.

The various subjects for which scholars were sent abroad, provided training on all possible lines including all scientific subjects *i.e.* chemistry, chemical technology and all industries (fertilisers, paper, textile, sugar, cements, plastics, glass, food and fruit products, paints and varnishes, etc.), physics, zoology, botany, medicine, pharmacy, astronomy, agriculture; power and fuel, fermentation, metallurgy (ferrous and non-ferrous), machinery manufacture, heavy structural, civil, electrical and mechanical engineering and also economics and politics, etc. The schemes for sending nearly 1,500 to 2,000 scholars every year to U. K. and U. S. A. were formulated and several batches were admitted in foreign universities in the year 1946-47. Most of those trainees have now completed their courses and have returned to the country. The various schemes had provisions to employ all those scholars and they were to serve the Government for a period of 3 to 5 years and necessary bonds for such agreements were taken from all of them.

These schemes, at their face value, appear to be very extravagant as huge sums from the Indian budget were set apart to meet the expenses of the trainees which amount to a few crores of rupees. It may be true that such democratic methods are too prospective but the real significance of higher technical education appears to be missing. The Government's initiative to look for such programme should have particularly been based on the fact that she had an intention to promote certain industrial organisations and institutes and utilise the services of the experts in the nation building departments. Since the Government of India was unable to chalk out any solid scheme to absorb the foreign trained experts, the Education Department had to withdraw all further steps of sending the scholars abroad.

Such liberal schemes had diverted the huge sums of hard earned revenues to foreign countries, notwithstanding the fact that the resources for exchanges being quite limited. The major expenses of scholars go as a part of their livings. The usual mode of life of an average Indian in countries like U. S. A. and U. K., is not unknown and, thus one may estimate that 80 to 90 per cent of the allocated budget expenditures go to train the scholars for a standard of foreign living. A critical analysis shows that these lavishly planned schemes to train students abroad are really very expensive and do little good.

It may be true to imagine that these schemes will enable the students to have a broader outlook of scientific and technical knowledge and, at the same time, they will be in a position to personally get practical first hand knowledge of massive industrial plants and factories ; and, from these, they shall carry ideas of the planning in India. These arguments are, too convincing, but the reality is not too far to be known. Correctly speaking, very little importance is attached to the real training work. In fact, the foreign manufacturers who offer practical training courses to the trainees have got to guard their trade secrets carefully.

The huge sums of money which are being channelised in such fashions, should, on the other hand, be utilised in importing heavy machinery and also securing the services of skilled technical staff to set up technical institutions in India. Services of foreign technical personnel could be borrowed and thus larger number of students could be trained in India. Provisions can also be made to set up experimental plants and instal other equipments out of the same budget.

Countries like U. S. A., U. K., Russia, Germany and Japan had never sent scholars to other countries for this purpose, but at the same time, they had greatly advanced industrially as well as scientifically through their own efforts and researches. It is hard to believe that one could get training in the art of making atom bomb from the countries like U. S. A., U. K. and Russia.

Advanced industrial training is of little value when the basic standard of technical education in India is so poor. The mode of teaching in schools, colleges and universities is, fundamentally unsatisfactory. The usual way of limitation of education through text courses is too defective and the results are most unhappy. One may attribute such shortcomings to the lack of proper medium of instruction. The imparting of scientific education through a national language is presently, a matter of great controversy in the country and this has led to the unbalanced state of affairs, but, however, it will have to be admitted that English, is, decidedly a reasonable language at this stage and, therefore, should be preferred as a medium to impart technical and scientific knowledge. Further, special emphasis should be laid on the practical training to be given to the children even from the tender age at schools. It is not at all difficult to widen the outlook of youngsters at their early age. The trend of children for a particular line of profession or technique should be studied and they must be imparted education in the line in which they have inborn tendencies. The children who show their mental attitude for mechanical or scientific training would do well if they are made to study on right lines. However, the standard of their parents' financial conditions must also be examined.

Presently, the students who leave their schools to join colleges get theoretical training and are quite incompetent to handle industrial units unless they undergo a thorough practical training. In the beginning, a raw graduate having high degrees in Science is often found to be worse than the illiterate factory labourer who has picked up better practical knowledge of operations through years of experience. There are a few institutions in India where practical training is given on a standard of diploma courses in certain lines like textile, sugar, glass, engineering and mining. It may be worthwhile to have a large number of such institutions where training on theoretical and practical scales could be given to the students and such specialised courses must be offered for training them after they leave their schools. The duration of such courses must range to several years to enable them to master over the subjects, both practically as well as theoretically. This would ultimately help in producing better technicians.

It is absolutely essential that the technical personnel must be trained in all the aspects of the various problems. A chemical engineer must not be considered as perfect technician until he is fully conversant with the economic aspects of the industrial processes. The methods of arriving at the correct cost of production must be known to him to find out whether a particular industry is running at profit or at loss. However, this involves the knowledge of high class cost accountancy. Apart from the full information of cost of basic raw materials and process cost, the correct judgment of overhead expenses and their proper allocation is absolutely essential.

The economy and efficiency of individual processes must draw the attention of the technical personnel and efforts should be made at all stages to reduce wastage in all the processes and attain the maximum degree of efficiency.

These efforts would help in cutting down the cost of manufacture and assist in getting better returns. The proper utilisation of by-products must also be attempted, wherever it is possible. It is invariably found that a by-product in one process of an industry or in one industry is, sometimes, a raw material for the other process of industry or another industry and, usually, by-products are assets to certain industries.

The allotment of jobs is done rather in peculiar fashion in India. The industrialists and capitalists engage their own people in their organisations, irrespective of merits. The key posts in the various departments of the Government services are usually distributed in a similar way. Jobs are secured through recommendations and other social ways. It is found that some of the finest brains are allowed to rot, whereas nepotism is observed in all departments of the Government and also in private organisations.

It may be considered essential that mills and factories of certain limited investments should maintain research and testing laboratories attached to their works and thus supplement their own work and assist the Central Scientific institutions in co-ordinating matters of common interest. The Board of Scientific and Industrial Research would normally require huge amounts of capital for the maintenance of various laboratories at different centres. Private research laboratories could also afford effective results with reduced and distributed expenditures over the particular problems. Such attached laboratories might assist to increase the efficiency of plants and processes, connected with the mills. These laboratories can also co-ordinate and assist in building and assessing the progress of the country and avoid the duplication of research work. In any case, private big factories are, decidedly, in a position to maintain testing and research laboratories which can give them direct or indirect gains.

There is hardly any standard and grades of products laid down in Indian trade except that most of the products manufactured in the country are based on certain foreign standard specifications. The B.P. products in the case of medical preparations are supposed to be governed by the Drug Acts. Other products do not have specified standards of these types. Such standards of the specifications of the products must be laid down by Government and must be enforced in the form of an Act. These standard specifications must also be known to the public, consumers and producers. Any deviation from such standards must be punishable under the provisions of the Act. It is understood that the Indian Standards Institute is already functioning and the matter pertaining to such standards are under consideration and, in due course, the necessary regulations are bound to be enforced.

There is no doubt that the fixation of Indian Standard Specifications would need a specialised knowledge of production methods and it may not be difficult to get guidance from the British Standard Specifications or other similar standards. A special attention need be paid to the tropical climatic conditions of the country in the case of certain products especially the perishable goods and other materials which are effected by improper storage and get spoiled by the change in temperature and atmospheric humidity.

It is a well-known fact that the Provincial Department of Industries are assisting the various cottage and small scale Industries by way of affording certain facilities. It has, however, to be analysed if any practical assistance is given to the manufacturers. In fact, some of the Government departments are acting like record offices for maintaining statistics. In some of the provinces, industrial loans on long term basis are also being advanced to some of the manufacturing industries but there is not much money that could be separately laid down for these purposes.

Small scale cottage industries have little protection from bigger machine operated industries. The position of handloom and powerloom cloth was quite unsatisfactory just before the World War II. Mill cloth was always becoming popular and even it attracted the attention of the consumers in small villages on account of its fineness, soft texture, attractive designs and the cheap prices. Later on when the war broke out, the Government enforced controls over yarn and cloth, thus handloom and powerloom cloth was again in demand as the mill cloth was being rationed and supplies were much restricted. The lifting of textile control in the beginning of 1948 worsened the position for powerloom and handloom cloth producers, but later on with the reimposition of textile controls in the end of the year 1948 the situation again improved for them. Similar attempts were being made to produce hand made paper and that also could not stand the mill made paper in competition. There are innumerable examples of this type. The economy of cottage industry is yet a matter of vital consideration and the question as to how far it could be followed as had been done in countries like Japan, and is in fact of paramount importance. It, however, requires planning to decide matters in a way beneficial to the workers whose fate is connected with cottage industries.

The advancement of loans to the various industries must be based on all types of considerations and in the event of local competitions, the Government must provide the assistance by way of pooling methods. The position regarding the allocation of industrial loans had really become very important after the partition of the country, *i.e.*, after 15th August, 1947, when Government were faced with the problem of resettlement and rehabilitation of refugees who had been forced to migrate from Pakistan. A large number of such displaced people who had originally settled in trades and industries in Pakistan, had got urgent problems of bread and shelter and had been considered for the grant of industrial loans. The Central Government have offered loans to various people who are in a position to set up industries. In fact, this problem is really vast and is beyond the scope of this cpapter. It may, however, be mentioned that all the provinces of the country should advance loan to those who are competent to start certain industries.

In nutshell, the task of industrial training and technical educations is of acute importance as this lays the foundation stone for the industrial advancements of the country.

APPENDIX "A"

CHEMICALS REQUIRED IN INDUSTRIES

List of the chemicals required in the following industries.

(1) Adhesives and Cements.
(2) Agriculture and Fertilisers.
(3) Chemicals and Dyestuffs.
(4) Cosmetics, Perfumes and Toilet Preparations.
(5) Food Products and Beverage Industry.
(6) Glass, Ceramics, Porcelain and Pottery.
(7) Inks, Pencils and Lithography.
(8) Leather and Tanning Industry.
(9) Linoleum and Oil Cloth.
(10) Matches, Explosives, Pyrotechnics and Fireworks.
(11) Metal Industry.
(12) Paints, Varnishes and Lacquers.
(13) Paper and Pulp Industry.
(14) Petroleum Industry.
(15) Pharmaceutical Industry.
(16) Photographic Industry.
(17) Plastics and Synthetic Resins.
(18) Rubber Industry.
(19) Soaps and Detergents.
(20) Sugar Industry.
(21) Textile Industry.
(22) Water Treatment.

I. ADHESIVES AND CEMENTS

Acetone
Agar
Albumen, Blood
Alum Ammonia
Aluminium Sulphate
Ammonia Aqua
Ammonium Benzoate
Ammonium Carbonate
Barium Sulphate
Barytes
Benzol
Blanc Fixe
Blood Dried
Borax
Calcium Hydroxide
Carbolic Acid
Carbon Bisulphide
Carbon Dioxide
Carbon Tetrachloride
Casein
Chlormetacresol
Copper Sulphate
Cresol
Diethylene Glycol
Ethyl Alcohol
Formaldehyde
Furfural
Hydrochloric Acid
Hydrofluosilicic Acid
Isinglass
Litharge
Magnesium Oxide
Magnesium Stearate
Manganese Resinate
Montan Wax
Nitrobenzene
Oxalic Acid
Ozokerite Wax
Paraformaldehyde
Phenol
Polyvinyl Alcohol
Potassium Bichromate
Pyridine
Soda Caustic
Sodium Bichromate
Sodium Lactate
Sodium Molybdate
Sodium Phosphate
Sodium Silicate
Starch
Stearin
Sulphur
Sulphur Monochloride
Sulphuric Acid
Talc
Toluol
Turpentine
Vinyl Acetate
Xylol
Zinc Chloride
Zinc Oxide
Zinc Sulphate
Zinc Sulphide

II. AGRICULTURE AND FERTILISERS

Aluminium Sulphate
Ammonium Chloride
Ammonium Nitrate
Ammonium Phosphate
Ammonium Sulphate
Ammonium Thiocyanate
Arsenic Acid
Arsenic Trichloride
Arsenic White
Barium Chloride
Barium Fluosilicate
Beta Naphthol

Bleaching Powder
Blood Dried
Bone Ash
Bordeaux Mixture
Calcium Arsenate
Calcium Carbide
Calcium Chloride
Calcium Cyanamide
Calcium Nitrate
Calcium Phosphate
Calcium Sulphate
Carbolic Acid
Carbon Bisulphide
Chlorine
Chloropicrin
Copper Acetoarsenite
Copper Arsenite
Copper Carbonate
Copper Nitrate
Copper Oxide
Copper Sulphate
Creosote
Cresol
Cresylic Acid
Cryolite
Cyclohexanol
Dianisidine
Dibutyl Phthalate
Dichloro-diphenyl-trichlore-
thane
Dichlorobenzene
Epsom Salt
Ethyl Formate
Fatty Acids
Ferric Chloride
Ferrous Sulphate
Formaldehyde
Furfural
Glycol Oleate
Hydrocyanic Acid
Lead Arsenate
Lime
Magnesium Carbonate
Magnesium Oxide
Magnesium Sulphate
Manganese Acetate
Manganese Carbonate
Manganese Chloride
Manganese Dioxide
Manganese Sulphate
Meta Cresol
Methyl Salicylate
Mineral Oil
Naphthalene
Nicotine Sulphate
Nitric Acid
Orthodichlorbenzene
Para Cresol
Paradichlorobenzene
Paraformaldehyde
Paris Green
Phenol
Phosphoric Acid
Phosphorus Red and Yellow
Pine Oil
Potassium Bichromate
Potassium Carbonate
Potassium Cyanide
Potassium Ferricyanide
Potassium Fluoride
Potassium Muriate
Potassium Nitrate
Potassium Phosphate
Potassium Prussiate, Red
Potassium Xanthate
Prussic Acid
Sodium Arsenate
Sodium Arsenite
Sodium Chloride
Sodium Chlorate
Sodium Cyanide
Sodium Fluoride

Sodium Flusoilicate
Sodium Nitrate
Sodium Silicofluoride
Sodium Sulphate
Sodium Sulphide
Sodium Sulphocyanide
Sulphur
Sulphur Monochloride
Sulphuric Acid
Superphosphate
Tar Oil
Thallium Sulphate
Thiourea
Turpentine
Urea

III. CHEMICALS AND DYESTUFFS

Acetaldehyde
Acetanilide
Acetamide
Acetic Acid
Acetic Anhydride
Acetaocentanilide
Acetone
Acetophenone
Acetyl Chloride
Acetylene Tetrachloride
Alizarin
Allyl Alcohol
Alphanaphthol
Alphanaphthylamine
Alphanitronaphthalene
Alum Ammonia
Alum Potash
Aluminium Acetate
Aluminium Chloride
Aluminium Fluoride
Aluminium Hydroxide
Aluminium Stearate
Aluminium Sulphate
Aminoazobenzene
Aminoazotoluene
Ammonia Anhydrous
Ammonia Aqua
Ammonium Bicarbonate
Ammonium Bichromate
Ammonium Bromide
Ammonium Carbonate
Ammonium Chloride
Ammonium Fluoride
Ammonium Formate
Ammonium Iodide
Ammonium Molybdate
Ammonium Oxalate
Ammonium Perchlorate
Ammonium Persulphate
Ammonium Sulphate
Ammonium Thiocyanate
Ammonium Vandate
Amyl Acetate
Amyl Alcohol
Amyl Chloride
Aniline Oil
Aniline Salt
Aniline Sulphate
Anthracene
Anthranilic Acid
Anthraquinone
Antimony Chloride
Antimony Oxide
Antimony Sulphide, Black
Arsenic Trisulphide, Yellow
Arsenic White
Barium Acetate
Barium Carbonate
Barium Chloride
Barium Chlorate
Barium Hydroxide
Barium Nitrate

Barium Oxide
Barium Peroxide
Barium Sulphide
Barytes
Bauxite
Benzal Chloride
Benzaldehyde
Benzidine
Benzidine Sulphate
Benzoic Acid
Benzoic Anhydride
Benzol
Benzophenone
Benzoyl Peroxide
Benzyl Alcohol
Benzyl Chloride
Beta-Naphthol
Blanc Fixe
Bleaching Powder
Boric Acid
Bromine
Butane
Butyl Acetate
Butyl Alcohol
Butyl Lactate
Cadmium Acetate
Cadmium Chloride
Cadmium Hydroxide
Cadmium Oxide
Cadmium Tungstate
Calcium Acetate
Calcium Carbide
Calcium Carbonate
Calcium Chloride
Calcium Cyanide
Calcium Ferrocyanide
Calcium Hydroxide
Calcium Nitrate
Calcium Phosphate
Calcium Pyrophosphate
Calcium Sulphate
Carbolic Acid
Carbon, Activated
Carbon Bisulphide
Carbon Dioxide
Carbon Tetrachloride
Carbonyl Chloride
Caustic Potash
Cetyl Alcohol
Chlorine
Chlormetacresol
Chloroform
Chloropicrin
Chromic Acid
Chromium Chloride
Chromium Oxide
Cinnamic Acid
Cobalt Carbonate
Cobalt Nitrate
Cobalt Sulphate
Copper Carbonate
Copper Cyanide
Copper Hydroxide
Copper Nitrate
Copper Oxide
Copper Sulphate
Cresol
Cresylic Acid
Cyclohexane
Diacetone Alcohol
Dibutoxy Methane
Dibutyl Ether
Dibutyl Oxalate
n-Dibutylamine
Dichloraniline
Dichlorethyl Ether
Dichlorethylene
Dichloromethane
Diethanolamine
Diethyl Oxalate
Diethylamine
Diethylene Glycol

Diethylene Triamine
Dinitraniline
Dinitrobenzene
Dinitrochlorobenzene
Dinitrophenol
Dinitrotoluene
Ether
Ethyl Acetate
Ethyl Acetoacetate
Ethyl Alcohol
Ethyl Carbamate
Ethyl Lactate
Ethyl Oxalate
Ethylene Dichloride
Ethylene Glycol
Ferric Chloride
Ferric Sulphate
Ferrous Chloride
Ferrous Sulphate
Formaldehyde
Formic Acid
Fusel Oil
Gallic Acid
Glauber's Salt
Guanidine Carbonate
Guanidine Nitrate
Heptane
Hexachlorethane
Hexane
Hydriodic Acid
Hydrobromic Acid
Hydrochloric Acid.
Hydrocyanic Acid
Hydrofluoric Acid
Hydrogen Peroxide
Hydroquinone
Indol
Iodine
Isoamyl Alcohol
Isobutyl Alcohol
Isopropyl Acetate
Isopropyl Alcohol
Isopropyl Ether
Lactic Acid
Lead Acetate
Lead Nitrate
Lead Oxide, Red
Lead Peroxide
Lime
Litharge
Magnesium Bromide
Magnesium Carbonate
Magnesium Chloride
Magnesium Hydroxide
Magnesium Stearate
Maleic Acid
Maleic Anhydride
Manganese Carbonate
Manganese Chloride
Manganese Dioxide
Manganese Nitrate
Manganese Sulphate
Mercuric Oxide, Red
Mercury Bisulphate
Mercury Nitrate
Metanitroaniline
Metanitroparatoluidine
Metatolulenediamine
Methyl Bromide
Methyl Chloride
Methyl Ethyl Ketone
Methyl Salicylate
Methylene Chloride
Molybdic Acid
Monochlorbenzene
Monoethylaniline
Monoethanolamine
Naphthalene
Naphthylamine
Nickel Carbonate
Nickel Oxide
Nickel, Salts, Single and Double

Nitric Acid
Nitrobenzene
Octyl Alcohol
Orthoaminophenol
Orthoanisidine
Orthochloro-Acetoacetanilide
Orthochloro Aniline
Orthochloro Paranitraniline
Orthochlorphenol
Orthochlortoluene
Orthodichlorbenzene
Orthonitroaniline
Orthotoluidine
Oxalic Acid
Palladium Chloride
Para-Amidophenol
Paraamidophenol Hydrochloride
Para-Aminoacetanilide
Para-Amino Benzoic Acid
Para-Chlorophenol
Para-Chlor-Ortho-Nitraniline
Para-Cresol
Paradichlorobenzene
Paraldehyde
Paranitraniline
Paranitraniline, Red
Paranitrophenol
Paraphenetidine
Paraphenylenediamine
Paratoluidine
Pentaerythritol
Pentane
Perchlorethylene
Perchloric Acid
Phenol
Phenolphthalein
Phenol Sulphonic Acid
Phosphate Rock
Phosphoric Acid
Phosphoric Anhydride
Phosphorus, Red and Yellow
Phosphorus Oxychloride
Phosphorus Pentachloride
Phosphorus Pentasulphide
Phosphorus Pentoxide
Phosphorus Sesquisulphide
Phosphorus Trichloride
Phthalic Acid
Phthalic Anhydride
Picramic Acid
Picric Acid
Potassium Acetate
Potassium Bicarbonate
Potassium Bichromate
Potassium Bisulphate
Potassium Bisulphite
Potassium Carbonate
Potassium Chlorate
Potassium Chloride
Potassium Chromate
Potassium Cyanide
Potassium Ferricyanide
Potassium Ferrocyanide
Potassium Hydroxide
Potassium Iodide
Potassium Metabisulphite
Potassium Muriate
Potassium Nitrate
Potassium Oxalate
Potassium Permanganate
Potassium Prussiate, Red
Potassium Prussiate, Yellow
Potassium Sulphate
Potassium Tartrate
Potassium Thiocyanate
Propyl Alcohol
Propylene Diamine
Prussic Acid
Pyridine
Pyrogallic Acid
Pyroligneous Acid

Quinaldine
Quinoline
Quinone
Resorcin
Ricinoleic Acid
Salicylaldehyde
Salicylic Acid
Soda Ash
Soda Caustic
Sodium Acetate
Sodium Aluminate
Sodium Aluminium Sulphate
Sodium Arsenate
Sodium Benzoate
Sodium Bichromate
Sodium Bifluoride
Sodium Bisulphate
Sodium Bisulphite
Sodium Borate
Sodium Bromide
Sodium Carbonate
Sodium Chloride
Sodium Chromate
Sodium Cyanide
Sodium Ferricyanide
Sodium Ferrocyanide
Sodium Fluoride
Sodium Formate
Sodium Hypochlorite
Sodium Hyposulphite
Sodium Iodide
Sodium Nitrate
Sodium Nitrite
Sodium Perborate
Sodium Peroxide
Sodium Phosphate
Sodium Prussiate, Red
Sodium Prussiate, Yellow
Sodium Salicylate
Sodium Silicate
Sodium Sulphate
Sodium Sulphide
Sodium Sulphite
Sodium Thiosulphate
Sodium Tungstate
Starch
Stearic Acid
Strontium Carbonate
Strontium Oxide
Succinic Acid
Succinic Anhydride
Sulphanilic Acid
Sulphur
Sulphur Monochloride
Sulphuric Acid
Sulphurous Acid
Tannic Acid
Tartaric Acid
Tetrachlorethylene
Thallium Sulphate
Thioglycollic Acid
Thiourea
Thymol
Tin Chloride
Tin Oxide
Titanium Dioxide
Titanium Tetrachloride
Tolidine
Toluidine
Toluol
Triacetin
Trichlorethylene
Tricresyl Phosphate
Triethanolamine
Triethylene Glycol
Triethylene Tetramine
Tungstic Acid
Turpentine
Urea
Vanadium Pentoxide
Vinyl Acetate
Xylol

Zinc Acetate
Zinc Carbonate
Zinc Chloride
Zinc Chromate
Zinc Dust
Zinc Oxide
Zinc Sulphate

IV. COSMETICS, PERFUMES AND TOILET PREPARATIONS

Acetone
Acetophenone
Alphanaphthol
Ammonia Aqua
Ammonium Bichromate
Ammonium Carbonate
Ammonium Chloride
Amyl Acetate
Amyl Alcohol
Anethol
Aniline Oil
Anthranilic Acid
Antimony Potassium Tartrate
Barium Carbonate
Bentonite
Benzalehyde
Benzidine
Benzidine Sulphate
Benzoic Acid
Benzol
Benzophenone
Benzoyl Chloride
Benzyl Acetate
Benzyl Alcohol
Benzyl Chloride
Borax
Boric Acid
Butyl Acetate
Butyl Alcohol
Butyl Lactate
Butyl Propionate
Calcium Carbonate
Calcium Peroxide
Calcium Phosphate
Calcium Pyrophosphate
Calcium Resinate
Carbolic Acid
Carbonyl Chloride
Castor Oil
Caustic Potash
Ceresin Wax
Cetyl Alcohol
Cinnamic Acid
Cinnamic Alcohol
Cochineal
Coumarin
Cresol
Dibutyl Phthalate
Diethyl Phthalate
Dinitrochlorobenzene
Epsom Salt
Ether
Ethyl Acetate
Ethyl Acetoacetate
Ethyl Alcohol
Ethyl Benzoate
Ethyl Formate
Ethyl Oxalate
Ethylene Glycol
Eugenol
Fuller's Earth
Fusel Oil
Glycerine
Glyceryl Monoricinoleate
Glyceryl Monostearate
Glyceryl Tristearate
Guanidine Carbonate
Hydriodic Acid

Hydrobromic Acid
Hydrochloric Acid
Hydrogen Peroxide
Ionone
Isobutyl Alcohol
Lanolin
Lecithin
Lithium Stearate
Lithophone
Magnesium Carbonate
Magnesium Oxide
Magnesium Sulphate
Menthol
Mercury Oxide, Red
Mercury Nitrate
Methyl Acetate
Methyl Acetone
Methyl Benzoate
Methyl Chloride
Methyl Salicylate
Methylene Chloride
Mineral Oil
Monoethanolamine
Octyl Alcohol
Oleic Acid
Ozokerite Wax
Paraffin Wax
Petrolatum
Phenol
Phosphoric Acid
Phosphorus Trichloride
Phthalic Anhydride
Pine Oil
Potassium Bichromate
Potassium Carbonate
Potassium Hydroxide
Potassium Permanganate
Potassium Sulphate
Propyl Alcohol
Propylene Glycol
Pyrogallic Acid
Resorcin
Resorcinol Monoacetate
Salicylic Acid
Saponin
Silver Nitrate
Soda Ash
Soda Caustic
Sodium Benzoate
Sodium Bichromate
Sodium Bisulphite
Sodium Borate
Sodium Perborate
Spermaceti Wax
Starch
Stearic Acid
Succinic Acid
Sulphuric Acid
Talc
Tartar Emetic
Tetrapotassium Pyrophosphate
Tetrasodium Pyrophosphate
Thymol
Tin Peroxide
Titanium Dioxide
Toluol
Triacetin
Trichlorethylene
Triethanolamine
Turpentine
Zinc Carbonate
Zinc Oxide
Zinc Stearate

V. FOOD PRODUCTS AND BEVERAGE INDUSTRY

Acetic Acid
Agar
Albumen, Blood
Albumen, Egg

Alum Ammonia
Alum Potash
Alum, Sodium
Aminoazobenzene
Ammonia Anhydrous
Ammonium Benzoate
Ammonium Bicarbonate
Ammonium Carbonate
Ammonium Fluoride
Ammonium Gluconate
Ammonium Phosphate
Ammonium Silicofluoride
Amyl Acetate
Amyl Alcohol
Anethol
Bentonite
Benzaldehyde
Benzoic Acid
Benzyl Benzoate
Benzyl Para Hydroxy Benzoate
Borax
Boric Acid
Butane
Butyl Para Hydroxybenzoate
Calcium Bromide
Calcium Carbide
Calcium Carbonate
Calcium Chloride
Calcium Hypochlorite
Calcium Lactate
Calcium Sulphate
Calcium Phosphate
Calcium Pyrophosphate
Carbolic Acid
Carbon Dioxide
Casein
Charcoal
Citric Acid
Cochineal
Corn Sugar
Corn Syrup
Coumarin
Cream of Tartar
Dipentene
Epsom Salt
Ethyl Acetate
Ethyl Alcohol
Ethylene Dichloride
Formaldehyde
Formic Acid
Gelatin
Glauber's Salt
Glycerine
Hydrogen Peroxide
Isinglass
Isobutyl Alcohol
Lactic Acid
Lactose
Lecithin
Linseed Oil
Lithium Carbonate
Lithium Chloride
Lithium Citrate
Lithium Nitrate
Magnesium Chloride
Magnesium Oxide
Magnesium Sulphate
Menthol
Methyl Acetate
Methyl Salicylate
Milk Sugar
Mineral Oil
Para-Coumarone
Paraffin Wax
Pectin
Phenol
Phosphoric Acid
Potassium Bicarbonate
Potassium Bisulphate
Potassium Bitartrate
Potassium Carbonate
Potassium Metabisulphite

Potassium Muriate
Potassium Nitrate
Potassium Permanganate
Potassium Phosphate
Potassium Sodium Tartrate
Propylene Glycol
Pyroligneous Acid
Rochelle Salt
Saccharine
Salicylic Acid
Saponin
Sodium Acetate
Sodium Acid Pyrophosphate
Sodium Aluminium Sulphate
Sodium Benzoate
Sodium Bicarbonate
Sodium Bifluoride
Sodium Bisulphate
Sodium Bisulphite
Sodium Borate
Sodium Chloride
Sodium Citrate
Sodium Fluoride
Sodium Gluconate
Sodium Hypochlorite
Sodium Metaphosphate
Sodium Nitrate
Sodium Nitrite
Sodium Perborate
Sodium Phosphate
Sodium Silicate
Sodium Sulphate
Sodium Sulphite
Spermaceti Wax
Starch
Sulphur
Sulphur Dioxide
Sulphuric Acid
Sulphurous Acid
Tannic Acid
Tartaric Acid
Thymol
Vanillin

VI. GLASS, CERAMICS, PORCELAIN AND POTTERY

Alum Ammonia
Alum Potash
Alum Sodium
Aluminium Chloride
Aluminium Fluoride
Aluminium Hydroxide
Aluminium Oxide
Aluminium Powder
Aluminium Silicofluoride
Aluminium Sulphate
Aluminium Sulphocyanide
Ammonia Aqua
Ammonia Bifluoride
Ammonium Carbonate
Ammonium Fluoride
Ammonium Vanadate
Antimony Fluoride
Antimony Oxide
Antimony Sulphide, Black
Arsenic Acid
Arsenic Trichloride
Arsenic White
Barium Carbonate
Barium Chromate
Barium Fluoride
Barium Hydroxide
Barium Nitrate
Barium Oxide
Barium Sulphate
Barytes
Bentonite
Borax
Boric Acid
Butyl Acetate

Cadmium Nitrate
Cadmium Oxide
Cadmium Sulphide
Calcium Carbonate
Calcium Phosphate
Calcium Resinate
Carbonyl Chloride
Cellulose Acetate
Chlorine
Chromic Acid
Chromium Oxide
Chromium Sulphate
Cobalt Carbonate
Cobalt Nitrate
Cobalt Oxide
Cobalt Sulphate
Copper Acetate
Copper Oxide
Cryolite
Epsom Salt
Ferrous Sulphate
Ferrous Sulphide
Formaldehyde
Gold Chloride
Gold Cyanide
Gold Sodium Chloride
Hydrochloric Acid
Hydrofluoric Acid
Hydrofluosilicic Acid
Iron Oxide
Lead Carbonate
Lead Chromate
Lead Oxide, Red
Lead Sulphate Basic
Litharge
Lithium Fluoride
Lithium Nitrate
Magnesium Carbonate
Magnesium Chloride
Magnesium Fluoride
Magnesium Oxide
Magnesium Silicate
Magnesium Silicofluoride
Magnesium Sulphate
Manganese Dioxide
Manganese Nitrate
Manganese Oxide
Manganese Sulphate
Mercuric Oxide, Red
Mercurious Chloride
Methylene, Blue
Molybdic Acid
Nickel Carbonate
Nickel Oxide
Nickel Salts Single and Double
Palladium Chloride
Phosphoric Acid
Potassium Acetate
Potassium Bichromate
Potassium Carbonate
Potassium Fluoride
Potassium Nitrate
Potassium Silicate
Potassium Sulphate
Selenium
Silver Nitrate
Soda Ash
Soda Caustic
Sodium Aluminate
Sodium Aluminium Sulphate
Sodium Antimoniate
Sodium Bicarbonate
Sodium Bifluoride
Sodium Borate
Sodium Chloride
Sodium Fluosilicate
Sodium Phosphate
Sodium Silicate
Sodium Silicofluoride
Sodium Stannate
Sodium Sulphate
Strontium Carbonate

Strontium Oxide
Strontium Sulphate
Sulphuric Acid
Talc
Thallium Sulphate
Tin Chloride
Tin Oxide
Tin Peroxide
Tin Tetrachloride
Titanium Dioxide
Titanium Tetrachloride
Turpentine
Ultramarine Blue
Uranium Oxide
Vanadium Pentoxide
Vanadium Sulphate
Vinyl Acetate
Zinc Carbonate
Zinc Chloride
Zinc Oxide
Zinc Sulphate
Zinc Sulphide

VII. INKS, PENCILS AND LITHOGRAPHY

Acetic Acid
Alum Potash
Alum Potash Chrome
Alum Sodium
Aluminium Hydroxide
Aluminium Sulphate
Ammonia Aqua
Ammonium Bichromate
Ammonium Bromide
Ammonium Perchlorate
Ammonium Vanadate
Amyl Acetate
Aniline Oil
Barium Chloride
Barium Sulphate
Barytes
Benzol
Blanc Fixe
Borax
Butyl Lactate
Cadmium Bromide
Cadmium Iodide
Calcium Carbonate
Carbolic Acid
Carbon Black
Carbon Tetrachloride
Caustic Potash
Ceresin Wax
Charcoal
Chlorine
Chlormetacresol
Chromic Acid
Chromium Oxide
Chromium Sulphate
Citric Acid
Cobalt Acetate
Cobalt Chloride
Cobalt Nitrate
Cochineal
Collodion
Copper Acetate
Copper Sulphate
Cresol
Cyclohexanol
Epsom Salt
Ethyl Alcohol
Fatty Acids
Ferric Chloride
Ferrous Sulphate
Gallic Acid
Glauber's Salt
Glycerine
Gum Rosin
Hydrocholoric Acid
Hydrogen Peroxide
Iodine

Iron and Ammonium Citrate
Iron and Ammonium Oxalate
Iron and Potassium Oxalate
Iron and Sodium Oxalate
Iron Oxide
Isinglass
Lead Acetate
Lead Linoleate
Lead Nitrate
Lead Oxide, Red
Lecithin
Linseed Oil
Litharge
Lithophone
Magnesium Carbonate
Magnesium Sulphate
Mineral Spirits
Mineral Turpentine
Monoamyl Naphthalene
Nickel Chloride
Nitric Acid
Oxalic Acid
Ozokertite Wax
Palladium Chloride
Phenol
Phosphoric Acid
Potassium Bichromate
Potassium Bitartrate
Potassium Carbonate
Potassium Chlorate
Potassium Chromate
Potassium Cyanide
Potassium Ferrocyanide
Potassium Hydroxide
Potassium Iodide
Potassium Metabisulphite
Potassium Prussiate, Yellow
Prussian Blue
Pyrogallic Acid
Rosin
Silver Nitrate
Soda Ash
Soda Caustic
Sodium Aluminium Sulphate
Sodium Arsenate
Sodium Bichromate
Sodium Borate
Sodium Chromate
Sodium Ferricyanide
Sodium Ferrocyanide
Sodium Prussiate, Red
Sodium Prussiate, Yellow
Sodium Sulphate
Sodium Sulphide
Sodium Sulphite
Sulphuric Acid
Tannic Acid
Tin Chloride
Tributyl Phosphate
Turpentine
Ultramarine, Blue
Vanadium Pentoxide
Wood Rosin
Xylol
Zinc Oxide
Zinc Stearate

VIII. LEATHER AND TANNING INDUSTRY

Acetic Acid
Acetone
Albumen, Blood
Albumen, Egg
Alum Ammonia
Alum Ammonia Chrome
Alum Potash
Alum Sodium
Aluminium Nitrate
Aluminium Sulphate
Ammonia Aqua
Ammonium Carbonate

Ammonium Chloride
Ammonium Lactate
Amyl Acetate
Antimony Potassium Tartrate
Barium Chloride
Barium Sulphate
Barytes
Benzol
Bleaching Powder
Borax
Boric Acid
Butyl Acetate
Butyl Alcohol
Calcium Hypochlorite
Calcium Resinate
Carbolic Acid
Carbon, Black
Carbon Tetrachloride
Casein
Castor Oil
Cellulose Acetate
Chlorophyll
Chromium Acetate
Chromium Chloride
Collodion
Copper Sulphate
Cresol
Cyclohexanol
Dichloromethane
Epsom Salt
Ethyl Acetate
Ethyl Alcohol
Ethylene Glycol
Ferric Sulphate
Ferrous Sulphate
Formaldehyde
Formic Acid
Furfural
Gallic Acid
Glauber's Salt
Glycerine
Glyceryl Monoricinoleate
Glyceryl Monostearate
Hydrochloric Acid
Hydrogen Peroxide
Iodine
Iron Oxide
Lactic Acid
Lanolin
Lead Nitrate
Lime
Linseed Oil
Litharge
Lithophone
Magnesium Sulphate
Manganese Acetate
Methyl Acetate
Mineral Spirits
Mineral Turpentine
Monoamyl Amine
Montan Wax
Naphthalene
Oleic Acid
Oxalic Acid
Ozokerite Wax
Petrolatum
Phenol
Phenol Sulphonic Acid
Picric Acid
Potassium Bichromate
Potassium Bisulphite
Potassium Carbonate
Potassium Chromate
Potassium Ferricyanide
Potassium Permanganate
Potassium Prussiate Red
Potassium Titanium Oxalate
Salicylic Acid
Soda Ash
Soda Caustic
Sodium Aluminium Sulphate
Sodium Arsenite

Sodium Bichromate
Sodium Bisulphate
Sodium Bisulphite
Sodium Borate
Sodium Chlorate
Sodium Chloride
Sodium Chromate
Sodium Ferrocyanide
Sodium Hypochlorite
Sodium Hyposulphite
Sodium Metaphosphate
Sodium Nitrate
Sodium Oxalate
Sodium Phosphate
Sodium Prussiate Yellow
Sodium Silicate
Sodium Sulphate
Sodium Sulphide
Sodium Thiosulphate
Stearin
Sulphur
Sulphur Dioxide
Sulphuric Acid
Sulphurous Acid
Talc
Tannic Acid
Tartar Emetic
Tartaric Acid
Titanium Potassium Oxalate
Toluol
Trichlorothylene
Turkey Red Oil
Turpentine
Ultramarine Blue
Vinyl Acetate
Xylol
Zinc Oxide
Zinc Sulphide

IX. LINOLEUM AND OIL CLOTH

Aluminium Sulphate
Amyl Acetate
Barium Carbonate
Barium Chloride
Barium Sulphate
Barytes
Calcium Carbonate
Carbon Tetrachloride
Copper Acetate
Ethyl Acetate
Iron Oxide
Linseed Oil
Litharge
Lithophone
Magnesium Carbonate
Pine Tar
Potassium Bichromate
Rosin
Talc
Ultramarine Blue
Zinc Chromate
Zinc Oxide
Zinc Stearate
Zinc Sulphide

X. MATCHES, EXPLOSIVES, PYROTECHNICS AND FIREWORKS

Alum Potash
Alum Sodium
Aluminium Powder
Ammonium Bichromate
Ammonium Nitrate
Ammonium Oxalate
Ammonium Perchlorate
Amyl Acetate

Aniline Oil
Anthracene
Antimony Sulphate
Antimony Sulphide, Black
Antimony Sulphide, Golden
Barium Carbonate
Barium Chlorate
Barium Chloride
Barium Chromate
Barium Nitrate
Cadmium Sulphide
Calcium Carbide
Calcium Nitrate
Carbolic Acid
Carbon Bisulphide
Carbon Black
Carbon Dioxide
Caustic Potash
Cellulose Nitrate
Chromium Oxide
Copper Carbonate
Cresol
Diethylene Glycol
Dinitrotoluene
Epsom Salt
Ether
Ethyl Acetate
Ethyl Alcohol
Formaldehyde
Fusel Oil
Glycerine
Hexachlorethane
Hydrochloric Acid
Iron Oxide
Lead Chromate
Lead Nitrate
Lead Oxide, Red
Lead Peroxide
Litharge
Lithium Chloride
Lithium Nitrate
Magnesium Nitrate
Magnesium Sulphate
Manganese Dioxide
Mercurous Chloride
Meta Cresol
Methyl Ethyl Ketone
Naphthenic Acid
Nitrobenzene
Nitrocellulose
Oxalic Acid
Perchloric Acid
Phenol
Phosphoric Acid
Phosphorus, Red and Yellow
Phosphoric Pentasulphide
Phosphorus Sesquisulphide
Picric Acid
Potassium Bichromate
Potassium Carbonate
Potassium Chlorate
Potassium Ferrocyanide
Potassium Hydroxide
Potassium Nitrate
Potassium Oxalate
Potassium Perchlorate
Potassium Prussiate, Yellow
Prussian Blue
Sodium Aluminium Sulphate
Sodium Bichromate
Sodium Chlorate
Sodium Nitrate
Sodium Oxalate
Sodium Sulphocyanide
Sodium Thiocyanate
Stearic Acid
Strontium Chloride
Strontium Nitrate
Strontium Oxalate
Strontium Oxide
Strontium Peroxide
Strontium Sulphate

Sulphur
Talc
Toluol
Ultramarine Blue
Urea
Zinc Oxide

XI. METAL INDUSTRY

Ammonia Aqua
Ammonium Chloride
Ammonium Persulphate
Ammonium Sulphide
Ammonium Thiocyanate
Antimony Sulphide Black
Barium Carbonate
Barium Chloride
Barium Peroxide
Barium Sulphate
Barytes
Bauxite
Bentonite
Borax
Butane
Calcium Carbide
Calcium Chloride
Calcium Cyanide
Calcium Molybdate
Calcium Sulphate
Carbon Black
Carbon Dioxide
Charcoal
Chlorine
Chromic Acid
Chromium Oxide
Copper Carbonate
Copper Cyanide
Copper Oxide
Copper Sulphate
Cresylic Acid
Diamylamine
Fatty Acids
Ferric Sulphate
Ferrous Chloride
Hydrofluoric Acid
Iron and Ammonium Sulphate
Iron Oxide
Lead Oxide, Red
Lead Peroxide
Lime
Linseed Oil
Magnesium Oxide
Manganese Dioxide
Molybdic Acid
Nickel Carbonate
Nickel Cyanide
Nickel Salts Single and Double
Nitric Acid
Ozokerite Wax
Phosphoric Acid
Potassium Bisulphate
Potassium Cyanide
Potassium Ferricyanide
Potassium Ferrocyanide
Potassium Muriate
Potassium Nitrate
Potassium Prussiate, Red
Potassium Prussiate, Yellow
Rosin
Silver Cyanide
Soda Ash
Soda Caustic
Sodium Bichromate
Sodium Bisulphate
Sodium Borate
Sodium Chloride
Sodium Cyanide
Sodium Ferrocyanide
Sodium Nitrate
Sodium Phosphate
Sodium Prussiate, Yellow

Sodium Silicate
Sodium Sulphide
Sulphur
Sulphuric Acid
Sulphurous Acid
Tetra Sodium Pyrophosphate
Thioglycollic Acid
Tin Chloride
Tin Peroxide
Tungstic Acid
Vinyl Acetate
Zinc Ammonium Chloride
Zinc Chloride
Zinc Cyanide
Zinc Dust

XII. PAINTS, VARNISHES AND LACQUERS

Acetanilide
Acetic Acid
Acetic Anhydride
Acetone
Acetylene Tetrachloride
Alum Potash
Alum Sodium
Aluminium Acetate
Aluminium Oleate
Aluminium Oxide
Aluminium Powder
Aluminium Stearate
Aminoazobenzene
Amyl Acetate
Amyl Alcohol
Amyl Chloride
Aniline Oil
Antimony Oxide
Antimony Sulphide, Black
Antimony Sulphide, Golden
Arsenic Dissulphide, Yellow
Asphalt
Barium Carbonate
Barium Chloride
Barium Chromate
Barium Sulphate
Barium Sulphide
Barytes
Bauxite
Benzol
Benzyl Acetate
Benzyl Alcohol
Blanc Fixe
Bone Black
Borax
Butane
Butyl Acetate
Butyl Alcohol
Butyl Lactate
Butyl Oleate
Butyl Phosphate
Butyl Propionate
Butyl Stearate
Cadmium Oxide
Cadmium Sulphide
Cadmium Tungstate
Calcium Bromide
Calcium Carbonate
Calcium Chloride
Calcium Hydroxide
Calcium Linoleate
Calcium Oleate
Calcium Resinate
Calcium Sulphate
Carbolic Acid
Carbon Bisulphide
Carbon Black
Carbon Tetrachloride
Casein
Castor Oil
Cellulose Acetate
Cellulose Nitrate

Ceresin Wax
Charcoal
Chromium Oxide
Chromium Sulphate
Cobalt Acetate
Cobalt Blue
Cobalt Carbonate
Cobalt Chromate
Cobalt Hydrate
Cobalt Linoleate
Cobalt Naphthenate
Cobalt Nitrate
Cobalt Oleate
Cobalt Oxide
Cobalt Resinate
Cobalt Sulphate
Copper Acetate
Copper Acetoarsenite
Copper Arsenite
Copper Carbonate
Copper Cyanide
Copper Hydroxide
Copper Nitrate
Copper Oxide
Copper Sulphate
Cresol
Cyclohexane
Cyclohexanol
Cyclohexanone
Diacetone Alcohol
Diamyl Phthalate
Diamylamine
Dibutyl Ethyl Phthalate
Dibutyl Ether
Dibutyl Oxalate
Dibutyl Phthalate
Dichlorethyl Ether
Dichloro - diphenyl—trichlorethane
Dichloromethane
Diethyl Carbonate
Diethyl Oxalate
Diethyl Phthalate
Diethylene Glycol
Dimethyl Phthalate
Ether
Ethyl Acetate
Ethyl Alcohol
Ethyl Cellulose
Ethyl Lactate
Ethyl Oxalate
Ethylene Glycol
Fatty Acid
Ferric Chloride
Ferric Hydroxide
Ferric Sulphate
Ferrous Sulphide
Formaldehyde
Fuller's Earth
Furfural
Fusel Oil
Glyceryl Phthalate
Heptane
Hexane
Hexone
Hydrofluosilicic Acid
Iron Oxide
Isobutyl Acetate
Isobutyl Alcohol
Isobutyl Propionate
Isopropyl Acetate
Isopropyl Alcohol
Isopropyl Ether
Lead Acetate
Lead Carbonate
Lead Chromate
Lead Linoleate
Lead Naphthenate
Lead Nitrate
Lead Oleate
Lead Oxide, Red
Lead Stearate

Lead Resinate
Lead Sulphate, Basic
Lecithin
Lime
Linoleic Acid
Linseed Oil
Litharge
Lithophone
Magnesium Carbonate
Magnesium Oxide
Magnesium Silicate
Magnesium Stearate
Maleic Anhydride
Manganese Acetate
Manganese Carbonate
Manganese Chloride
Manganese Dioxide
Manganese Linoleate
Manganese Naphthenate
Manganese Oxide
Manganese Sulphate
Mercuric Oxide, Red
Mercury Sulphide, Red
Methyl Acetate
Methyl Acetone
Methyl Cyclohexane
Methyl Cyclohexanone
Methyl Ethyl Ketone
Methyl Isobutyl Ketone
Methylene Chloride
Mineral Oil
Mineral Spirits
Mineral Turpentine
Montan Wax
Naphthalene
Naphthenic Acid
Nickel Salts Single and Double
Nitrocellulose
Octyl Alcohol
Oleic Acid
Orthodichlorbenzene
Ozokerite Wax
Para-Coumarone
Paris Green
Perchlorethylene
Petrolatum
Phenol
Phthalic Anhydride
Pine Oil
Pine Tar
Polyvinyl Alcohol
Potassium Bichromate
Potassium Chromate
Potassium Ferrocyanide
Potassium Prussiate, Yellow
Potassium Silicate
Potassium Thiocyanate
Propyl Alcohol
Proplene Dichloride
Prussian Blue
Pyridine
Rosin
Soda Ash
Soda Caustic
Sodium Aluminium Sulphate
Sodium Bichromate
Sodium Borate
Sodium Chromate
Sodium Ferricyanide
Sodium Ferrocyanide
Sodium Fluoride
Sodium Molybdates
Sodium Nitrate
Sodium Phosphate
Sodium Prussiate, Red
Sodium Prussiate, Yellow
Sodium Silicate
Sodium Stearate
Strontium Oxide
Sulphur
Sulphur Monochloride
Talc

Tetrachlorethylene
Tin Peroxide
Titanium Dioxide
Toluol
Triacetin
Tributyl Citrate
Tributyl Phosphate
Trichlorethylene
Tricresyl Phosphate
Triethyl Phosphate
Triethelene Glycol
Triphenyl Phosphate
Turpentine
Ultramarine Blue
Vinyl Acetate
Xylol
Zinc Chloride
Zinc Chromate
Zinc Linoleate
Zinc Naphthenate
Zinc Oleate
Zinc Oxide
Zinc Palmitate
Zinc Stearate
Zinc Sulphate
Zinc Sulphide

XIII. PAPER AND PULP INDUSTRY

Alum Ammonia
Alum Potash
Alum Sodium
Aluminium Hydroxide
Aluminium Powder
Aluminium Sulphate
Ammonia Aqua
Ammonium Vanadate
Amyl Acetate
Barium Carbonate
Barium Sulphate
Barytes
Blanc Fixe
Bleaching Powder
Borax
Butyl Acetate
Butyl Phosphate
Cadmium Sulphide
Calcium Carbonate
Calcium Chloride
Calcium Hypochlorite
Calcium Resinate
Carbon Black
Caustic Potash
Ceresin Wax
Chlorine
Copper Arsenite
Copper Carbonate
Copper Hydroxide
Copper Oxide
Diethylene Glycol
Epsom Salt
Formaldehyde
Glauber's Salt
Glycerine
Glyceryl Monoricinoleate
Glyceryl Monostearate
Glyceryl Tristearate
Hydrofluoric Acid
Iodine
Iron Oxide
Lead Chromate
Lime
Magnesium Carbonate
Magnesium Chloride
Magnesium Oxide
Magnesium Sulphate
Manganese Oxide
Monoamylamine
Montan Wax
Ozokerite Wax
Paraffin Wax

Pine Tar
Polyvinyl Alcohol
Potassium Chlorate
Potassium Cyanide
Potassium Ferricyanide
Potassium Prussiate, Red
Prussian Blue
Rosin
Salicylic Acid
Soda Ash
Soda Caustic
Sodium Aluminate
Sodium Aluminium Sulphate
Sodium Borate
Sodium Chloride
Sodium Hypochlorite
Sodium Hyposulphite
Sodium Metasilicate
Sodium Silicate
Sodium Sulphate
Sodium Sulphide
Sodium Sulphite
Sodium Thiosulphate
Starch
Stearin
Strontium Sulphate
Sulphuric Acid
Talc
Tannic Acid
Titanium Dioxide
Triphenyl Phosphate
Ultramarine Blue
Vinyl Acetate
Zinc Chloride
Zinc Hydrosulphite

XIV. PETROLEUM INDUSTRY

Acetone
Alphanaphthylamine
Alphanitronaphthalene
Aluminium Chloride
Aluminium Hydroxide
Aluminium Oleate
Aluminium Stearate
Aluminium Sulphate
Ammonia Aqua
Bauxite
Bentonite
Benzol
Bone Black
Calcium Carbonate
Calcium Chloride
Carbon Activated
Carbon Bisulphide
Carbon Tetrachloride
Charcoal
Chlorine
Copper Oxide
Cresol
Cresylic Acid
Cyclohexanol
Ethyl Alcohol
Fatty Acids
Fuller's Earth
Lead Naphthenate
Lime
Litharge
Naphthenic Acid
Nitrobenzene
Oleic Acid
Ozokerite Wax
Palmitic Acid
Petrolatum
Phenol
Phosphoric Acid
Rosin Oil
Selenium
Soda Caustic
Sodium Bichromate

Sodium Metaphosphate
Sodium Silicate
Sulphur
Sulphuric Acid
Sulphurous Acid
Talc
Tannic Acid
Turpentine
Zinc Chloride

XV. PHARMACEUTICAL INDUSTRY

Acetamide
Acetanilide
Acetic Acid
Acetic Anhydride
Acetone
Acetophenone
Acetophenetidine
Acetyl Chloride
Agar
Allyl Alcohol
Aluminium Chloride
Ammonia Aqua
Ammonium Acetate
Ammonium Benzoate
Ammonium Bicarbonate
Ammonium Carbonate
Ammonium Bromide
Ammonium Chloride
Ammonium Phosphate
Ammonium Silicofluoride
Aniline Oil
Anthranilic Acid
Arsenic Trichloride
Arsenic White
Bentonite
Benzaldehyde
Benzidine
Benzoic Acid
Benzoic Anhydride
Benzol
Benzoyl Chloride
Benzyl Alcohol
Benzyl Benzoate
Benzyl Chloride
Benzyl Para Hydroxy Benzoate
Beta-Naphthol
Borax
Boric Acid
Bromine
Butyl Alcohol
Butyl Para Hydroxy Benzoate
Calcium Bromide
Calcium Phosphate
Carbolic Acid
Carbonyl Chloride
Castor Oil
Citric Acid
Cochineal
Collodion
Cream of Tartar
Cresol
Cresylic Acid
Diethyl Oxalate
Dipentene
Ether
Ethyl Acetate
Ethyl Acetoacetate
Ethyl Alcohol
Ethyl Carbamate
Ethyl Formate
Ethyl Lactate
Ethylene Dichloride
Fatty Acids
Ferric Chloride
Ferric Hydroxide
Ferric Nitrate
Formaldehyde
Gallic Acid

Gelatin
Glauber's Salt
Glycerine
Hexamethylenetetramine
Hydriodic Acid
Hydrobromic Acid
Hydrochloric Acid
Hydrocyanic Acid
Hydrogen Peroxide
Hydroquinone
Indol
Iodine
Iron and Ammonium Citrate
Iron and Ammonium Sulphate
Isoamyl Alcohol
Lactic Acid
Lactose
Lanolin
Lecithin
Linseed Oil
Lithium Carbonate
Lithium Chloride
Lithium Citrate
Magensium Bromide
Magnesium Peroxide
Manganese Dioxide
Menthol
Mercuric Oxide, Red
Mercurous Chloride
Mercury Bisulphate
Mercury Nitrate
Mercury Sulphide, Red
Methyl Bromide
Methyl Chloride
Methyl Salicylate
Methylene Blue
Methylene Chloride
Milk Sugar
Mineral Oil
Molybdic Acid
Monoethylamine
Nitric Acid
Oleic Acid
Ozokerite Wax
Paramidophenol
Paraamidophenol Hydrochloride
Parachlor Meta Cresol
Par Chlorophenol
Para Cresol
Paraffin Wax
Paraformaldehyde
Paraldehyde
Paranitrophenol
Paraphenetidine
Petrolatum
Phenol
Phenolphthalein
Phenol Sulphonic Acid
Phosphoric Acid
Phosphorus Trichloride
Phthalic Acid
Phthalic Anhydride
Picric Acid
Potassium Acetate
Potassium Bicarbonate
Potassium Bitartrate
Potassium Bromide
Potassium Chloride
Potassium Iodide
Potassium Metabisulphite
Potassium Permanganate
Potassium Persulphate
Potassium Sodium Tartarate
Potassium Sulphocyanide
Potassium Thiocyanate
Propylene Diamine
Propylene Glycol
Prussic Acid
Pyridine
Resorcin
Rochelle Salt

Rosin
Saccharine
Salicylic Acid
Silver Nitrate
Soda Ash
Soda Caustic
Sodium Acetate
Sodium Benzoate
Sodium Bicarbonate
Sodium Bichromate
Sodium Borate
Sodium Bromide
Sodium Carbonate
Sodium Chloride
Sodium Citrate
Sodium Gluconate
Sodium Iodide
Sodium Nitrate
Sodium Nitrite
Sodium Peroxide
Sodium Phosphate
Sodium Salicylate
Sodium Sulphate
Sodium Sulphocyanide
Sodium Thiocyanate
Spermaceti Wax
Stearic Acid
Strontium Carbonate
Succinic Acid
Succinic Anhydride
Sulphur
Sulphur Monochloride
Sulphuric Acid
Talc
Tannic Acid
Tar Oil
Tartaric Acid
Tetrasodium Pyrophosphate
Thiocarbanilide
Thiourea
Thymol
Tin Tetrachloride
Trichlorethylene
Urea
Zinc Oxide

XVI. PHOTOGRAPHIC INDUSTRY

Acetaldehyde
Acetic Acid
Acetone
Acetylene Tetrachloride
Agar
Alizarin
Alphanaphthalamine
Alum Potash Chrome
Aluminium Chloride
Aluminium Powder
Aminoazobenzene
Ammonia Aqua
Ammonium Bromide
Ammonium Chromate
Ammonium Iodide
Ammonium Persulphate
Ammonium Sulphide
Ammonium Thiocyanate
Amyl Acetate
Barium Chloride
Benzaldehyde
Benzol
Benzyl Chloride
Blanc Fixe
Butyl Acetate
Cadmium Bromide
Cadmium Chloride
Cadmium Iodide
Cadmium Sulphide
Carbolic Acid
Cellulose Acetate
Cellulose Nitrate

Collodion
Copper Nitrate
Cresol
Ethyl Acetate
Ethyl Alcohol
Ferrous Sulphate
Formaldehyde
Gallic Acid
Glycerine
Gold Chloride
Gold Sodium Chloride
Hydrobromic Acid
Hydroquinone
Iodine
Lead Nitrate
Linseed Oil
Meta Cresol
Nitrocellulose
Palladium Chloride
Para Amidophenol
Paraamidophenol Hydrochloride
Paraffin Wax
Paranitrophenol
Phenol
Potassium Bichromate
Potassium Bromide
Potassium Ferricyanide
Potassium Iodide
Potassium Metabisulphite
Potassium Muriate
Potassium Oxalate
Potassium Permanganate
Potassium Persulphate
Potassium Prussiate Red
Potassium Sulphocyanide
Pyrogallic Acid
Silver Nitrate
Sodium Acetate
Sodium Bromide
Sodium Carbonate
Sodium Chloride
Sodium Citrate
Sodium Ferrocyanide
Sodium Hyposulphite
Sodium Iodide
Sodium Nitrite
Sodium Phosphate
Sodium Prussiate, Yellow
Sodium Sulphite
Sodium Thiosulphate
Sulphuric Acid
Tartaric Acid
Thallium Sulphate
Thiourea
Vanadium Pentoxide

XVII. PLASTICS AND SYNTHETIC RESINS

Acetic Acid
Acetone
Ammonia Aqua
Amyl Chloride
Benzoic Acid
Benzoyl-chloride
Benzyl Benzoate
Butyl Acetate
Butyl Alcohol
Butyl Stearate
Calcium Stearate
Carbolic Acid
Cellulose Acetate
Cresol
Cresylic Acid
Cyclohexanol
Diacetone Alcohol
Diamyl Phthalate
Diamylamine
Dibutoxy Ethyl Phthalate
Dibutoxy Methane
Dibutyl Phthalate

Dichlormethane
Diethyl Phthalate
Diethylene Glycol
Diethylene Triamine
Dimethyl Phthalate
Ethyl Acetate
Ethyl Cellulose
Fatty Acid
Formaldehyde
Furfural
Glycerine
Hexamethylenetetramine
Isobutyl Benzoate
Isopropyl Acetate
Isopropyl Ether
Linseed Oil
Maleic Anhydride
Mercury Sulphide
Meta Cresol
Monoamyl Naphthalene
Naphthenic Acid
Para Coumarone
Paraformaldehyde
Phenol
Phthalic Anhydride
Pine Tar
Polyvinyl Alcohol
Succinic Anhydride
Sulphur
Sulphuric Acid
Thiourea
Triacetin
Tricresyl Phosphate
Triethanolamine
Triethyl Phosphate
Triethylene Glycol
Triphenyl Phosphate
Tungstic Acid
Ultramarine Blue
Urea
Vanillin
Vinyl Acetate
Zinc Sulphide

XVIII. RUBBER INDUSTRY

Acetanilide
Acetic Acid
Ammonium Benzoate
Aluminium Chloride
Ammonia Aqua
Ammonium Carbonate
Amyl Alcohol
Aniline Oil
Antimony Sulphide Golden
Barium Sulphate
Barium Sulphide
Barytes
Benzol
Benzyl Chloride
Blanc Fixe
Butadiene
Cadmium Sulphide
Calcium Phosphate
Carbolic Acid
Carbon Bisulphide
Carbon Black
Carbon Tetrachloride
Casein
Cellulose Acetate
Chlorine
Chloroform
Chromium Oxide
Cresol
Cyclohexanol
Cyclohexanone
Diamylamine
n-Butylamine
Dichloromethane
Diethylene Triamine

Dimethylaniline
Ethyl Alcohol
Ethylene Dichloride
Fatty Acids
Ferric Hydroxide
Formaldehyde
Fuller's Earth
Fusel Oil
Hexamethylenetetramine
Hydrochloric Acid
Hydrogen Peroxide
Lead Oxide, Red
Litharge
Lithophone
Magnesium Carbonate
Magnesium Oxide
Magnesium Silicate
Mercury Sulphide, Red
Methyl Acetone
Methyl Benzoate
Methyl Cyclohexane
Monoamyl Naphthalene
Naphthalene
Nitric Acid
Orthotoluidine
Oxalic Acid
Paraphenylenediamine
Phenol
Phosphoric Acid
Propylene Dichloride
Soda Ash
Soda Caustic
Sodium Bisulphite
Sodium Sulphite
Sulphur
Sulphur Dichloride
Sulphur Monochloride
Sulphuric Acid
Talc
Thiocarbanilide
Titanium Dioxide
Toluidine
Toluol
Trichlorethylene
Triethanolamine
Triethylene Tetramine
Ultramarine Blue
Vinyl Acetate
Zinc Carbonate
Zinc Chloride
Zinc Chromate
Zinc Oxide
Zinc Palmitate
Zinc Sulphate
Zinc Sulphide

XIX. SOAPS AND DETERGENTS

Ammonia Aqua
Ammonium Carbonate
Ammonium Chloride
Ammonium Sulphate
Amyl Acetate
Barium Carbonate
Bentonite
Benzaldehyde
Benzol
Benzyl Acetate
Bone Black
Borax
Boric Acid
Calcium Carbonate
Calcium Phosphate
Calcium Sulphate
Carbolic Acid
Carbon Black
Carbon Tetrachloride
Casein
Castor Oil
Caustic Potash

Ceresin Wax
Chlorophyll
Cinnamic Acid
Coumarin
Cresol
Cryolite
Cyclohexonol
Cyclohexanone
Dichlorethyl Ether
Ethyl Alcohol
Ethylene Dichloride
Fatty Acids
Formaldehyde
Glauber's Salt
Glycerine
Glyceryl Monoricinoleate
Glyceryl Monostearate
Glyceryl Tristearate
Glycol Oleate
Iodine
Lactose
Lanoline
Lecithin
Linoleic Acid
Linseed Oil
Methyl Benzoate
Methyl Salicylate
Monoethanolamine
Montan Wax
Naphthalene
Naphthenic Acid
Nickel Carbonate
Nitrobenzene
Oleic Acid
Orthodichlorobenzene
Oxalic Acid
Ozokerite Wax
Palmitic Acid
Para Coumarone
Paraffin Wax
Perchloroethylene
Petrolatum
Phenol
Pine Oil
Pine Tar
Potassium Bromide
Potassium Carbonate
Potassium Hydroxide
Potassium Iodide
Potassium Linoleate
Potassium Muriate
Potassium Nitrate
Potassium Persulphate
Potassium Silicate
Propyl Alcohol
Prussian Blue
Ricinoleic Acid
Rosin
Saponin
Soda Ash
Soda Caustic
Soda Aluminate
Sodium Arsenite
Sodium Borate
Sodium Carbonate
Sodium Chloride
Sodium Metasilicate
Sodium Perborate
Sodium Peroxide
Sodium Rincinoleate
Sodium Silicate
Sodium Sulphate
Spermaceti Wax
Starch
Stearic Acid
Sulphur
Sulphuric Acid
Sulphurous Acid
Talc
Tannic Acid
Tetrachloroethylene

Tetrapotassium Pyrophosphate
Trichlorethylene
Turkey Red Oil
Turpentine
Ultramarine Blue
Zinc Oxide

XX. SUGAR INDUSTRY

Alum Potash
Alum Sodium
Barium Carbonate
Barium Chloride
Barium Hydroxide
Blood Dried
Bone Black
Calcium Carbonate
Calcium Hydroxide
Calcium Phosphate
Carbon Activated
Carbon Dioxide
Charcoal
Glycerine
Hydrofluoric Acid
Hydrogen Peroxide
Lead Acetate
Lead Nitrate
Lime
Magnesium Hydroxide
Paraffin Wax
Phosphoric Acid
Phosphorus Pentoxide
Sodium Aluminium Sulphate
Sodium Hydrosulphite
Sodium Phosphate
Strontium Carbonate
Strontium Peroxide
Sulphur
Sulphur Dichloride
Sulphur Dioxide
Sulphur Monochloride
Sulphuric Acid
Talc
Tannic Acid
Tin Tetrachloride
Ultramarine Blue

XXI. TEXTILE INDUSTRY

Acetic Acid
Acetic Anhydride
Agar
Albumen, Blood
Alizarin
Alum Ammonia
Alum Ammonia Chrome
Alum Potash
Alum Potash Chrome
Alum Sodium
Aluminium Acetate
Aluminium Chloride
Aluminium Hydroxide
Aluminium Nitrate
Aluminium Oleate
Aluminium Oxide
Aluminium Stearate
Aluminium Sulphate
Aluminium Sulphocyanide
Ammonia Aqua
Ammonium Acetate
Ammonium Bichormate
Ammonium Borate
Ammonium Carbonate
Ammonium Chloride
Ammonium Chromate
Ammonium Citrate
Ammonium Fluoride
Ammonium Formate
Ammonium Gluconate

Ammonium Phosphate
Ammonium Sulphate
Ammonium Sulphide
Ammonium Thiocyanate
Ammonium Vanadate
Amyl Acetate
Amyl Alcohol
Amyl Chloride
Aniline Oil
Aniline Salt
Aniline Sulphate
Anthracene
Antimony Chloride
Antimony Fluride
Antimony Lactate
Antimony Oxide
Antimony Potassium Tartrate
Arsenic Acid
Barium Acetate
Barium Chloride
Barium Chlorate
Barium Chromate
Barium Peroxide
Barium Sulphate
Barytes
Benzol
Bleaching Powder
Borax
Butyl Stearate
Cadmium Acetate
Cadmium Chloride
Cadmium Sulphide
Calcium Acetate
Calcium Carbonate
Calcium Chloride
Calcium Hypochlorite
Calcium Phosphate
Calcium Resinate
Calcium Stearate
Calcium Sulphate
Carbolic Acid
Carbon Bisulphide
Carbon Dioxide
Carbon Tetrachloride
Casein
Castor Oil
Caustic Potash
Cellulose Acetate
Ceresin Wax
Chlorine
Chloroform
Chromic Acid
Chromium Acetate
Chromium Chloride
Chromium Oxide
Chromium Sulphate
Citric Acid
Copper Acetate
Copper Hydroxide
Copper Nitrate
Copper Sulphate
Cyclo-hexanone
Dichloromethane
Diethyl Phthalate
Diethylene Glycol
Diethylene Triamine
Epsom Salt
Ether
Ethyl Acetate
Ethyl Alcohol
Ethyl Cellulose
Ethylene Glycol
Fatty Acid
Ferric Chloride
Ferric Nitrate
Ferric Sulphate
Ferrous Chloride
Ferrous Sulphate
Formaldehyde
Formic Acid
Fuller's Earth
Fumaric Acid

Furfural
Gallic Acid
Glauber's Salt
Glycerine
Glyceryl Monoricinoleate
Glyceryl Monostearate
Glyceryl Tristearate
Hydrochloric Acid
Hydrogen Peroxide
Iron and Ammonium Sulphate
Iron Oxide
Isinglass
Lactic Acid
Lead Acetate
Lead Nitrate
Lead Oxide, Red
Lead Peroxide
Lead Resinate
Lime
Litharge
Lithophone
Magnesium Chloride
Magnesium Peroxide
Magnesium Sulphate
Maleic Acid
Manganese Acetate
Manganese Chloride
Manganese Dioxide
Manganese Oxide
Manganese Sulphate
Mercury Nitrate
Metanitroaniline
Metatoluenediamine
Methylene Blue
Mineral Spirit
Mineral Turpentine
Monoamylamine
Monoethanolamine
Nickel Salts Single and Double
Nitric Acid
Oleic Acid
Oxalic Acid
Ozokerite Wax
Palladium Chloride
Palmitic Acid
Paranitraniline
Paraphenylenediamine
Phenol
Phosphoric Acid
Picric Acid
Potassium Bichromate
Potassium Bisulphite
Potassium Carbonate
Potassium Chlorate
Potassium Chromate
Potassium Cyanide
Potassium Ferricyanide
Potassium Ferrocyanide
Potassium Metabisulphite
Potassium Permanganate
Potassium Phosphate
Potassium Prussiate, Red
Potassium Prussiate, Yellow
Potassium Silicate
Potassium Stearate
Potassium Sulphocyanide
Potassium Thiocyanate
Potassium Titanium Oxalate
Prussian Blue
Pyridine
Resorcin
Rosin
Soda Ash
Soda Caustic
Sodium Acetate
Sodium Aluminate
Sodium Aluminium Sulphate
Sodium Arsenate
Sodium Arsenite
Sodium Benzoate
Sodium Bichromate
Sodium Bisulphate

Sodium Bisulphite
Sodium Borate
Sodium Carbonate
Sodium Chlorate
Sodium Chloride
Sodium Chromate
Sodium Ferrocyanide
Sodium Formate
Sodium Hydrosulphite
Sodium Hypochlorite
Sodium Hyposulphite
Sodium Lactate
Sodium Metasilicate
Sodium Nitrate
Sodium Nitrite
Sodium Oleate
Sodium Oxalate
Sodium Perborate
Sodium Peroxide
Sodium Phosphate
Sodium Silicate
Sodium Stannate
Sodium Sulphate
Sodium Sulphide
Sodium Sulphite
Sodium Sulphocyanide
Sodium Thiocyanate
Sodium Thiosulphate
Sodium Tungstate
Starch
Stearin
Sulphur
Sulphur Dioxide
Sulphur Monochloride
Sulphuric Acid
Sulphurous Acid
Talc
Tartar Emetic
Tartaric Acid
Tetrapotassium Pyrophosphate
Thallium Sulphate
Thiourea
Tin Chloride
Tin Peroxide
Titanium Dioxide
Toluol
Tungstic Acid
Turkey Red Oil
Turpentine
Ultramarine Blue
Vanadium Pentoxide
Vanadium Sulphate
Vinyl Acetate
Zinc Acetate
Zinc Chloride
Zinc Dust
Zinc Hydrosulphite
Zinc Sulphate

XXII. WATER TREATMENT

Alum Ammonia
Alum Potash
Alum Sodium
Aluminium Chloride
Aluminium Hydroxide
Aluminium Sulphate
Barium Carbonate
Barium Chloride
Barium Hydroxide
Bentonite
Bleaching Powder
Blood Dried
Bone Black
Calcium Chloride
Calcium Hypochlorite
Calcium Sulphate
Carbon Activated
Charcoal
Chlorine
Copper Sulphate

Ferric Chloride
Ferric Hydroxide
Ferric Sulphate
Ferrous Sulphate
Formaldehyde
Hydrogen Peroxide
Lime
Manganese Dioxide
Orthodichlorbenzene
Phenol Sulphonic Acid
Soda Ash
Soda Caustic
Sodium Aluminate
Sodium Aluminium Sulphate
Sodium Bisulphate
Sodium Hypochlorite
Sodium Hyposulphite
Sodium Peroxide
Sodium Phosphate
Sodium Thiosulphate
Sulphur Dioxide
Talc
Zinc Sulphate

APPENDIX "B"

STATISTICS OF IMPORTS, EXPORTS AND PRODUCTIONS

IMPORTS

Figures of Imports during the years 1937-38 to 1948-49 :

TABLE	I	Heavy Chemicals (details of individual chemicals).
TABLE	II	Dyeing and Tanning Substances.
TABLE	III	Manures (excluding Oil Cakes).
TABLE	IV	Drugs and Medicines (excluding Chemicals and Narcotics).
TABLE	V	Paints and Painters' Materials.
TABLE	VI	Explosives (including Dynamite, Gelatine Dynamite, Gun-powders, filled Cartridges and Fireworks, etc., but excluding Military Explosives).
TABLE	VII	Products of interest to the Chemicals and other Industries.
TABLE	VIII	Government Stores of interest to the Chemical Trade.

EXPORTS

Figures of Exports during the years 1937-38 to 1948-49 :

TABLE	IX	Chemicals and Chemical Preparations of Indian Origin.
TABLE	X	Products of interest to the Chemical Industry.

RE-EXPORTS

TABLE	XI	Figures of re-exports of Foreign Chemicals and Chemical Preparations and other products of interest to the Chemical Industry.

PRODUCTIONS

TABLE	XII	Figures of Mineral Productions.
TABLE	XIII	Figures of Agricultural Productions.
TABLE	XIV	Figures of Industrial Productions.

N.B. : 1. **From 1st March, 1948, the figures include the Seaborne Trade of India with Pakistan and excludes the direct Foreign Trade of Pakistan.**

2. **From 1st April, 1948, the distinction between private merchandise and Government Stores has been abolished and combined figures of Trade under both these categories are published.**

TABLE I
Imports of

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Acid Acetic	Cwts.	7,271	5,664	9,772	8,902	9,075
	Rs.	1,73,975	1,41,141	4,65,157	5,37,998	7,27,706
Acid Carbolic	Cwts.	542	884	587	623	1,180
	Rs.	29,917	43,483	28,434	41,899	72,570
Acid Citric	Cwts.	2,583	3,210	3,885	3,181	4,479
	Rs.	1,38,525	1,79,313	2,73,099	2,79,158	4,34,398
Aicd Hydrochloric ...	Cwts.	901	742	577	429	79
	Rs.	14,740	18,617	15,029	17,382	7,383
Acid Nitric	Cwts.	2,407	1,315	1,595	775	15
	Rs.	40,579	27,037	30,210	21,376	1,984
Acid Oxalic	Cwts.	2,489	3,355	3,814	2,079	516
	Rs.	85,129	1,19,103	2,04,153	1,41,425	31,727
Acid Sulphuric	Cwts.	2,645	2,628	5,300	2,235	766
	Rs.	25,178	28,756	47,842	35,426	13,038
Acid Tartaric	Cwts.	1,468	2,257	2,340	849	810
	Rs.	88,524	1,52,836	2,17,063	1,12,334	2,17,087
Acids Other Sorts ...	Cwts.	14,050	13,113	24,642	15,167	21,539
	Rs.	4,42,731	3,95,333	5,85,300	7,93,742	13,64,080
Acids Total	Cwts.	34,356	33,148	52,512	34,240	38,459
	Rs.	10,39,298	11,05,619	18,66,287	19,80,740	28,69,973
Alum	Cwts.	4,183	3,923	10,424	14,647	3,677
	Rs.	30,016	30,196	1,62,773	5,64,459	63,992
Aluminous Sulphate ...	Cwts.	47,759	35,451	45,813	47,679	9,920
	Rs.	1,38,330	1,11,308	1,97,827	3,18,984	50,884
Ammonia Anhydrous ...	Cwts.	2,510	3,045	2,928	2,103	2,722
	Rs.	2,83,013	2,00,575	2,18,160	2,04,787	2,99,181
Ammonia Carbonate (and Bicarbonate)	Cwts.	10,757	11,744	11,891	16,926	11,308
	Rs.	1,71,602	2,02,370	2,69,878	4,313,64	3,06,783
Muriate of Ammonia ...	Cwts.	30,484	25,593	42,204	40,539	39,377
	Rs.	3,96,334	3,51,972	7,07,644	7,53,543	8,21,142
Other Ammonia Salts ...	Cwts.	6,969	6,143	4,300	5,299	2,398
	Rs.	1,45,197	1,49,202	1,13,413	2,00,190	2,17,438
Arsenic and its Oxide ...	Cwts.	5,330	5,623	4,865	5,510	5,976
	Rs.	1,17,238	1,18,159	1,06,664	1,27,998	1,17,225
Bleaching Powder	Cwts.	237,303	213,133	235,755	171,576	100,195
	Rs.	13,12,915	12,49,335	17,81,979	15,29,126	8,92,056
Other Bleaching Materials	Cwts.	1,068	3,326	1,985	1,035	317
	Rs.	14,165	42,005	21,747	12,631	4,256
Calcium Carbide	Cwts.	54,445	57,328	70,707	58,437	65,830
	Rs.	5,94,122	6,36,069	9,95,085	10,10,670	15,98,926
Calcium Chloride	Cwts.	18,206	17,105	20,981	13,282	13,116
	Rs.	72,130	80,088	1,02,946	79,660	85,889
Chlorine Liquid	Lbs.	668,428	682,235	519,871	49,586	..
	Rs.	2,49,220	2,12,752	1,59,203	25,391	..
Copperas (Ferrous Sulphate)	Cwts.	921	3,116	1,184	253	130
	Rs.	7,626	35,566	21,009	4,387	6,954
Copper Sulphate	Cwts.	34,915	28,415	38,121	19,606	23,349
	Rs.	5,53,796	4,25,844	7,37,386	4,51,891	6,33,656
Naphthalene	Cwts.	9,239	10,213	7,835	3,457	7,888
	Rs.	1,59,374	1,50,516	1,21,816	80,005	2,40,730

IMPORTS
Heavy Chemicals

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
12,760	10,128	17,534	6,657	6,973	40,785	8,184
15,06,670	9,44,206	13,37,344	5,49,526	5,91,287	32,32,043	7,68,218
121	1,643	5,818	1,661	267	108	583
10,320	1,43,365	5,54,888	1,65,561	14,375	7,265	42,327
423	2,236	4,163	4,129	3,077	4,887	5,814
73,349	2,80,719	5,70,948	4,82,411	2,85,154	5,69,554	6,74,555
44	11	40	62	24	163	90
2,864	1,184	4,541	5,330	4,184	19,556	14,016
..	5	27	44	47	57	99
131	651	3,416	4,041	3,912	8,460	12,550
98	274	541	2,072	94	534	1,157
12,717	35,024	35,001	1,40,356	8,067	63,575	1,10,026
458	7	38	93	93	81	104
7,745	1,243	13,287	6,585	10,004	13,128	8,868
305	579	1,337	393	3,352	2,258	3,417
1,03,555	1,77,729	3,96,200	1,22,399	8,97,978	4,85,285	4,80,788
17,790	17,925	33,038	8,366	7,652	18,320	22,425
10,56,107	13,33,594	24,21,594	7,46,742	6,95,137	22,00,569	21,23,804
31,999	32,808	62,506	23,477	21,579	67,193	41,873
27,73,458	29,07,715	53,37,219	22,22,951	25,10,098	65,99,435	42,35,147
3,053	7,384	16,582	3,171	1,626	581	125
31,256	95,953	2,01,621	43,423	26,756	19,798	3,658
13,992	44,735	89,980	36,750	11,618	18,408	18,467
1,01,740	3,22,547	6,57,680	3,82,331	1,22,346	2,89,656	1,89,137
1,939	1,011	3,292	3,067	2,589	4,307	2,115
2,23,537	1,45,998	4,67,905	3.93,873	3,25,545	6,03,201	3,45,322
5,020	12,409	26,776	8,309	5,656	9,822	18,633
1,60,758	4,45,145	10,09,773	2,79,132	1,83,684	5,40,025	6,43,035
25,826	20,673	107,470	27,401	41,279	32,612	78,691
6,77,287	5,59,671	24,72,390	8,51,032	10,06,567	7,54,237	21,22,334
3,964	5,289	13,357	17,723	34,156	12,163	51,040
1,70,134	5,12,542	5,73,494	3,55,452	9,65,926	4,50,170	10,25,714
10	39	535	2,034	7,050	16,400	2,339
608	3,713	13,785	52,861	4,41,881	7,94,589	1,42,542
26,233	91,291	81,306	159,699	146,328	167,344	230,410
2,41,640	8,20,348	7,63,763	15,72,160	16,75,066	22,87,454	39,02,790
..	..	185	1	..	..	1
..	..	30,947	349	191	..	38
100,124	63,669	125,911	91,028	65,493	85,686	106,967
17,37,214	11,49,108	22,86,758	16,68,223	12,68,706	18,91,645	26,15,477
7,223	232	281	647	47	1,861	4,571
80,039	16,900	20,248	19,116	5,834	44,461	51,130
1,095	62	..	..	..	..	..
571	31	..	..	..	..	..
153	46	73	196	140	24	641
6,695	3,044	4,869	75,388	8,753	2,642	15,066
44,676	33,174	32,127	12,071	16,038	26,194	25,529
20,01,448	12,45,948	12,07,854	3,97,536	5,33,566	6,29,690	9,57,354
265	626	4,444	4,349	2,103	1,042	1,424
12,950	25,618	2,22,564	2.18,252	1,37,792	78,548	68,214

TABLE I

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Other Disinfectants ...	Cwts.	20,886	16,573	23,951	18,598	21,098
	Rs.	6,62,373	4,25,114	5,18,598	5,90,454	7,44,817
Glycerine	Cwts.	1,628	4,189	880	243	8
	Rs.	1,07,015	1,97,520	42,592	14,956	1,564
Lead Acetate	Cwts.	1,431	1,585	1,257	1,575	3,791
	Rs.	32,590	33,812	37,230	64,555	1,50,818
Litharge	Cwts.	1,228	298	399	227	477
	Rs.	28,970	5,597	8,827	7,483	14,903
Other Lead Compounds ...	Cwts.	854	816	797	437	941
	Rs.	29,149	25,472	21,209	24,999	51,004
Magnesium Chloride ...	Cwts.	11,876	11,671	6,988	4	162
	Rs.	40,017	38,604	22,100	204	4,816
Magnesium Sulphate ...	Cwts.	8,785	7,767	3,702	841	552
	Rs.	52,728	45,966	31,949	24,674	20,744
Other Magnesium Compds.	Cwts.	29,357	16,062	26,535	10,757	23,724
	Rs.	3,60,736	2,23,450	4,08,123	2,02,034	5,03,692
Phosphorus all kinds ...	Cwts.	2,054	2,301	2,374	2,742	2,022
	Rs.	1,10,001	1,22,924	1,64,290	4,44,561	4,51,246
Potassium Bichromate ...	Cwts.	5,509	3,972	6,292	6,983	1,598
	Rs.	1,43,925	1,03,332	4,41,696	4,78,708	64,883
Potassium Chlorate ...	Cwts.	42,207	27,249	38,970	24,991	15,996
	Rs.	7,07,912	5,38,615	11,28,290	22,12,618	17,52,705
Cyanide of Potassium ...	Cwts.	469	483	400	538	305
	Rs.	48,862	46,082	40,954	63,948	44,896
Other Potassium Compds.	Cwts.	8,249	10,656	9,352	13,561	10,925
	Rs.	3,00,081	4,20,516	6,90,359	15,56,907	13,44,905
Sodium Bicarbonate ..	Cwts.	124,161	93,841	126,774	126,241	109,983
	Rs.	5,60,488	4,84,340	7,46,705	8,88,785	8,47,960
Sodium Bichromate ...	Cwts.	20,762	14,391	17,468	66,413	47,381
	Rs.	4,65,925	3,40,692	10,38,892	36,19,817	17,51,418
Borax	Cwts.	32,412	25,906	33,416	24,400	33,026
	Rs.	3,61,853	2,99,822	4,87,424	4,69,270	7,51,236
Sodium Carbonate ...	Cwts.	1,487,632	1,308,526	1,620,984	1,671,444	1,472,098
	Rs.	59,58,039	60,97,763	78,16,453	90,36,425	80,79,921
Sodium Cyanide	Cwts.	5,093	3,464	6,645	2,862	3,891
	Rs.	2,19,327	1,49,537	2,89,395	1,26,760	1,82,484
Caustic Soda	Cwts.	518,485	501,134	713,613	698,818	531,792
	Rs.	42,80,555	45,45,438	72,30,601	75,61,820	67,57,131
Sodium Hydrosulphite ...	Cwts.	48,985	23,461	30,660	38,433	15,514
	Rs.	13,98,378	7,17,034	18,05,542	31,36,230	13,92,643
Sodium Hyposulphite ...	Cwts.	9,115	8,731	11,905	9,064	9,015
	Rs.	80,994	89,673	1,55,224	1,39,592	1,50,902
Sodium Sulphite	Cwts.	33,489	34,492	34,348	12,109	22,409
	Rs.	85,110	94,850	1,26,601	74,169	1,60,253
Sodium Silicate	Cwts.	32,143	18,903	18,415	10,183	15,952
	Rs.	1,82,906	1,14,988	1,33,857	98,347	1,49,365
Sodium Sulphide	Cwts.	62,763	30,373	73,478	50,350	66,148
	Rs.	3,27,566	2,11,186	7,01,429	5,94,611	11,30,973
Other Sodium Compounds	Cwts.	17,793	13,512	20,531	24,098	18,735
	Rs.	3,20,528	2,63,373	3,84,354	6,23,448	7,81,488
Sulphur	Cwts.	588,155	445,683	775,773	777,060	589,189
	Rs.	26,11,876	21,73,816	45,45,014	50,54,419	54,00,666

IMPORTS—*contd.*

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
7,901	8,304	16,519	22,419	31,778	21.153	9,000
3,41,850	4,06,572	8,10,569	11,60,332	30,89,532	11,18,216	8,42,746
..	5	27	28	10	1	3
191	711	3,333	2,063	2,322	861	1,177
1,550	256	2,280	932	49	1,042	265
64.889	10,977	95,771	40,503	4,004	93,262	24,612
311	55	2	..	1	..	15
11.141	2,002	110	47	61	24	1,453
129	236	241	619	198	212	210
8,997	16,000	14,161	29,95 ,	18,973	20,436	31,598
118	2	9	8	4	37	8
4.306	162	556	688	703	3,072	2,094
332	617	884	341	607	1,042	15
14,351	27,470	43,026	17,985	25,975	55,843	1,020
7,814	5,703	10,251	12.157	12,902	6,476	13,360
2.12,954	1,76,413	3,65,152	3,89,656	4,20,566	2,60,817	5,98,190
2,194	1,648	39	689	1,194	2,226	3,681
4,61,405	3.24,111	10,143	1,11,977	1,81,510	3,64,335	5,82,189
100	..	581	1	..	41	11
6,454	15	89,478	110	179	2,551	987
2,947	81	200	3,710	1,333	9,772	21,601
4,42.829	11.748	18,886	3,34,880	68,815	4,99,036	11,47,930
238	432	446	1,418	607	666	362
37,181	49,789	50,507	1,80,410	90,183	1,05,447	53,932
4.816	5,382	7,392	11,251	14,940	21,659	55,880
8,94,581	14.29,195	17,00,560	15,61,851	20,29,865	24,02,882	38,12,665
79,125	68,471	91,195	93,228	148,991	104,679	284,005
7,51,756	7,23,017	10.16.766	10,99.664	16,55,996	14.14.653	46,89,354
26,228	47,843	22,734	..	..	..	400
10,93,310	22,33,940	11,07,191	..	..	54	6,506
39,289	32,164	53,855	28,583	27,948	181,800	28,634
10,13,585	9,91,474	16,13,285	6,70,577	6,72,475	40,54,211	6,40,621
1,331,189	1,015,977	1,577,450	1,566,887	1,157,666	1,358,968	3,251,872
95,15,163	75,84,380	1,22,80,762	1,16,17,961	87,82,425	1,32,74,958	5,31,89,007
4,627	3,755	2,676	3,093	1,335	3,061	2,853
2,20,144	1,86,655	1,36,016	1,63,795	67,302	1,55,884	1,52,890
551.180	707,098	844,611	758,170	597,815	424,621	1,831,796
83,36,955	1,10,91,114	1,30,58,387	1,16,73,714	89,37.653	1,11,83,854	7,65,03,669
7,031	22,903	29,378	23,906	33,679	62,306	35,711
14,53,402	33,03,134	29,10,798	21,33,699	30,78,757	61,45,932	30,69,088
7,178	10,283	9,301	3,175	1,560	131	4,040
1,37,138	2,35,376	2,04,208	70,515	46,185	2,866	3,17,978
9,147	523	2,853	456	1,186	309	2,788
94,595	5,452	32,960	6,724	18,610	9,932	42,049
17,208	7,280	1,034	481	780	166	915
1,34,552	55,363	8,138	6,701	17,307	10,964	29,220
39,685	30,486	39,507	57,169	30,010	20,378	69,132
7,99,686	7,29,323	7,24,247	10,24,396	4,93,628	7,71,024	24,60,144
13,715	61,724	18,730	51,875	68,719	44,622	76.346
6,20,755	13,49,413	11,81,548	10,21,613	12,75,026	13,72,132	22,43,097
294,644	444,040	390,022	199,453	1,047,394	597,022	766,637
28,48,675	30,25,212	35,72,765	16,88,068	1,05,73,843	44.32,783	61,65,922

TABLE I

Product	Unit	1937-38	1938-39	1939-40	1940-41	1941-42
Zinc Chloride	Cwts.	34,732	41,368	31,346	28,326	39,107
	Rs.	3,59,580	5,19,855	5,20,338	5,91,040	8,32,589
Other Zinc Compounds ...	Cwts.	61,839	45,531	12,478	1,352	814
	Rs.	9,82,428	6,35,520	1,76,915	48,084	88,676
Other Sorts of Chemicals ...	Cwts.	—	—	—	—	—
	Rs.	71,77,817	64,72,133	79,20,181	1,00,47,420	1,28,46,630
Total of Chemicals, etc. ...	Cwts.	—	—	—	—	—
	Rs.	3,32,82,055	3,05,28,600	4,51,88,959	5,55,99,178	5,46,64,343

TABLE II

Imports of Dyeing and

Product	Unit	1937-38	1938-39	1939-40	1940-41	1941-42
Barks for Tanning ...	Cwts.	351,990	342,002	698,328	658,591	666,420
	Rs.	21,97,946	23,20,305	44,37,970	44,25,411	46,57,225
Cochineal	Cwts.	612	2,260	1,186	336	385
	Rs.	67,251	1,50,595	2,42,316	65,804	70,103
Cutch and Gambier ...	Cwts.	74,766	90,795	82,162	100,029	82,483
	Rs.	10,62,687	13,43,695	12,82,659	17,41,228	15,25,332
Alizarine	Lbs.	2,259,584	873,867	804,544	1,155,456	140,424
	Rs.	13,78,859	5,68,729	6,02,291	17,55,370	26,95,949
Congo Red	Lbs.	2,106,595	474,384	563,102	1,091,081	798,567
	Rs.	11,37,004	2,53,811	5,50,956	17,04,364	14,84,448
Naphthols	Lbs.	1,358,646	915,739	857,454	663,320	399,360
	Rs.	30,60,510	23,40.138	23,46,252	38,87,031	31,99,392
Rapid Fast Colours (Rapid Salts)	Lbs.	87,758	147,053	126,364	22,889	38,024
	Rs.	5,03,773	8,96,026	7,52,060	2,11,646	4,01,864
Bases (Naphthol Group) ...	Lbs.	777,051	495,366	333,526	452,831	584,225
	Rs.	16,70,460	10,30,854	883,253	27,60,313	43,65,480
Other Salts (Naphthol Group)	Lbs.	1,174,797	1,014,712	855,069	298,213	358,314
	Rs.	18,38,060	17,27,591	15,92,125	11,69,886	19,12,758
Indigo Vats	Lbs.	904,909	676,925	698,359	577,691	544,387
	Rs.	12,67,630	9,74,536	12,27,759	15,24,088	14,86,249
Carbazole Blue Vats ...	Lbs.	145,433	84,615	64,285	92,036	39,965
	Rs.	3,24,163	2,03,708	1,95,543	46,344	2,22,365
Other Sorts Pastes... ...	Lbs.	176,703	156,897	165,713	353,016	464,003
	Rs.	7,65,262	6,91,487	8,02,638	21,16,095	31,60,129
Other Sorts Powders ...	Lbs.	784,929	814,187	631,642	521,417	461,394
	Rs.	1,21,35,205	1,08,11,650	98,07,259	1,31,42,573	1,32,73,734
Sulphur Black	Lbs.	4,759,338	2,638,184	3,798,823	3,865,047	3,061,924
	Rs.	9,81,366	5,75,816	17,82,336	35,35,025	37,18,821
Mentanil Yellow	Lbs.	814,292	202,793	211,613	187,835	132,358
	Rs.	6,68,513	1,94,355	2,73,876	4,00,843	3,41,884
Auramin (Conc.—150% or less)	Lbs.	..	..	78	..	..
	Rs.	..	..	132	..	..

IMPORTS—*contd.*

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
11,170	17,797	13,820	12,703	16,370	10,478	16,642
2,59,611	4,97,515	4,44,330	3,60,329	5,86,755	3,78,886	6,90,704
792	418	488	3,271	815	1,035	1,333
86,232	1,35,046	27,707	1,13,273	57,521	1,80,541	1,29,174
—	—	—	—	—	—	—
86,79,567	68,49,017	1,20,43,451	1,65,44,432	2,31,97,154	2,94,51,351	3,17,40,527
—	—	—	—	—	—	—
4,67,65,540	4,97,04,885	6,88,35,688	6,05,57,987	7,46,06,016	9,25,62,367	20,54,87,520

IMPORTS

Tanning Substances.

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
721,393	632,844	557,907	51,907	561,459	145,981	251,403
52,12,646	50,52,319	47,47,950	48,04,631	60,56,547	20,72,881	40,87,850
1	2	1	8,066	4,883	67	63
877	537	424	82,868	8,49,901	44,024	36,700
6	..	..	145	13,992	16,688	51,367
237	..	..	20,439	14,06,166	14,43,776	29,74,786
662,739	555,047	183,131	247,230	1,387,522	2,504,152	632,448
14,22,521	18,41,806	5,08,768	9,71,125	39,37,104	72,18,337	19,22,090
297,641	471,431	164,547	261,693	522,688	861,289	1,379,778
6,94,886	29,62,515	7,83,542	10,97,522	21,14,950	53,80,850	79,03,958
437,292	625,053	579,142	908,983	904,609	1,434,443	1,231,381
41,89,872	72,22,850	77,58,315	1,06,43,186	94,13,213	1,56,77,574	1,68,08,627
24,899	16,531	58,861	163,999	91,343	87,985	125,826
2,93,184	2,59,347	10,45,379	19,33,939	12,96,733	13,82,542	22,43,096
367,324	373,252	339,566	938,881	1,356,382	1,170,001	510,573
37,21,087	34,00,331	36,92,755	92,86,533	1,31,26,467	1,14,87,012	49,60,761
159,781	198,358	300,911	754,134	810,290	840,327	297,574
7,66,148	12,16,269	20,69,765	39,35,627	40,73,943	40,45,402	16,88,494
297,981	424,670	462,814	933,766	562,434	878,536	932,898
8,92,448	18,89,382	19,83,550	52,02,442	28,31,357	51,65,109	43,00,195
..	..	..	20,018	33,908	51,237	19,110
..	..	..	2,67,207	3,78,745	5,39,954	2,24,550
70,545	52,903	112,292	182,579	378,256	656,489	469,952
9,22,640	4,82,980	8,15,764	15,05,937	39,20,109	1,81,508	57,90,653
259,565	513,335	503,460	755,283	501,755	1,200,828	924,210
1,09,51,256	2,15,31,956	1,95,76,539	2,74,49,652	2,14,55,185	4,59,10,509	3,79,60,138
1,793,425	2,385,347	3,144,911	3,938,453	1,940,548	4,103,069	3,316,179
45,16,906	63,93,901	77,99,379	72,24,261	32,38,246	75,28,107	61,41,029
86,116	157,699	98,596	53,175	119,826	623,027	275,073
3,48,381	9,28,611	4,65,107	2,25,282	5,36,911	25,59,288	12,77,070
..	..	..	..	8,280	13,666	16,413
..	..	..	..	52,964	90,663	1,09,065

TABLE II

Product	Unit	1937-38	1938-39	1939-40	1940-41	1941-42
Rhodamines (Conc.—15% or less)	Lbs.	..	..	..	..	200
	Rs.	..	..	..	..	750
Aniline Salts	Lbs.	373,889	243,743	238,200	210,463	208,783
	Rs.	1,34,507	80,737	1,09,583	2,35,715	2,59,916
Others	Lbs.	5,164,421	3,284,733	3,481,604	3,838,890	3,214,747
	Rs.	84,10,323	56,85,527	77,80,062	1,26,42,975	1,38,84,934
Total of Coal Tar Dyes ...	Lbs.	20,888,345	12,023,198	12,829,926	13,330,184	11,726,675
	Rs.	3,42,75,636	2,60,34,965	2,87,06,125	4,55,49,368	5,04,08,673
Myrobalan Extract ...	Cwts.	7	..	..	1,555	..
	Rs.	67	..	..	10,781	..
Saffron	Lbs.	23,781	10,934	7,189	3,515	854
	Rs.	9,65,471	6,74,657	5,82,529	3,25,596	52,834
Other Sorts Dyes (including Lac)	Cwts.	70,458	39,116	44,243	49,927	74,738
	Rs.	9,86,857	5,95,578	8,26,668	8,97,101	10,50,372
Total of Dyeing and Tanning Substances ...	Lbs.	—	—	—	—	—
	Rs.	3,94,05,915	3,11,19,795	3,60,78,087	5,30,14,289	5,77,64,539

TABLE III

Imports of Manures

Product	Unit	1937-38	1938-39	1939-40	1940-41	1941-42
Nitrate of Soda	Tons	3,208	2,137	6,226	3,151	2,639
	Rs.	3,18,914	2,23,891	8,02,478	4,85,173	7,13,831
Sulphate of Ammonia ...	Tons	53,216	76,748	79,922	32,154	1,627
	Rs.	56,10,337	82,99,126	96,36,445	54,68,702	3,69,032
Other Nitrogenous Manures	Tons	589	891	3,350	900	20
	Rs.	58,948	1,02,974	3,48,375	1,69,043	6,457
Muriate of Potash	Tons	2,928	1,829	2,110	1,585	100
	Rs.	2,85,743	1,82,606	2,69,824	2,02,829	23,656
Other Potassic	Tons	1,604	965	1,045	140	..
	Rs.	1,79,917	1,11,915	1,21,434	23,017	..
Superphosphate	Tons	7,405	6,788	7,758	6,732	2,722
	Rs.	5,67,915	5,65,290	6,27,860	10,49,898	4,59,677
Other Phosphatic	Tons	3,779	3,882	1,839	337	20
	Rs.	4,06,284	4,17,928	2,12,743	42,260	1,104
Ammonium Phosphate ...	Tons	2,167	2,569	973	1,389	250
	Rs.	3,16,744	3,95,116	1,60,204	3,38,209	63,700
Fish Manure	Tons	1,783	2,349	2,498	3,867	2,189
	Rs.	58,239	72,538	98,711	1,23,899	72,294
Other Compounds	Tons	1,746	1,294	1,842	1,015	1,202
	Rs.	1,63,829	1,45,940	2,37,366	64,234	66,316
Total Manures	Tons	78,425	99,452	107,563	51,270	10,769
	Rs.	79,66,870	1,05,17,324	1,25,15,440	79,67,274	17,76,067

—contd.

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
..	..	..	181	8,131	2,932	36,420
..	..	..	3,626	92,324	83,794	12.84,693
55,628	75,939	62,381	642,059	609,286	305,249	197,354
87,346	2,47,546	1,20,688	10,41,014	8,68,948	3,12,355	2,10,884
2,050,938	3,535,085	2,801,902	4,508,122	3,537,222	5,798,085	4.569,053
1.09,74,122	2,23,07,738	1,75,16,542	2,69,74,864	2,06,27,070	3,88,26,055	3,01,63,504
6,563,874	9,384,650	8,812,536	14,308,556	12,872,480	20,531,315	14,934,242
3,97,80,897	7,06,85,241	6,41,36,093	9,77,62,217	8,79,59,269	15,40.89,059	12,29,89,707
20	..	..	..	..	117	..
521	..	..	..	..	879	..
28	..	..	260	10,271	6,148	16,144
2,843	..	..	24,534	11,58,440	6,82,335	17,15,620
104,274	95,991	115,996	58,759	168,744	103,101	60,387
13,91,747	14.80,337	20,19,873	11,02,696	46,76,335	35,72,481	23,18,970
4,63,89,768	7,72,18,434	7,09,04,340	10,37,97,385	10,21,06,667	16,19,05,435	13,41.23,633

IMPORTS

(excluding Oil Cakes)

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
2	..	..	..	1,711	10,361	21,831
336	4	18	..	3,96,311	25,33,812	41,02,634
1,361	2,550	50,841	69,260	126,513	137,456	133,183
3,53,860	3,74,088	1,08,60.884	1,43,74,341	2,82,18,901	3,45,12,408	3,94,26,386
..	..	..	6	1	9,655	4,590
..	..	71	1,376	274	32,53,872	14,74,019
696	1,258	597	1,493	1,288	2,989	1,891
2,91,958	5,21,697	2,04,521	4,18,700	3,94,648	8,60,406	6,06,502
..	..	..	..	..	34	40
..	..	..	..	..	30,552	14,292
..	148	1,572	901	60	380	1,000
..	36,830	3,88,627	1,37,427	16,604	1,46,265	3,66,974
..	..	1,500	..	2,505	16,221	8,127
..	..	1,17,775	..	3,41,244	13,48,858	9,41,223
..	..	54,822	3,853	3,026	7,918	3,984
..	..	27,14,013	9,68,458	7,52,773	27,67,534	14,50,146
1,451	1,558	2,452	9,996	2,964	1,459	1,914
79,162	1,16,319	1,00,489	1,25,395	1,07,342	1,87,712	3,35,385
2	1	..	202	1	3,509	1,804
100	88	..	44,388	344	7,29,303	5,41,200
3,512	5,515	111,784	85,711	138,069	189,982	178,364
7,25,417	10,49,022	1,44,46,398	1,60,70,035	8,02,28,421	4,63,70,722	4,92,58,761

Table IV

Imports of Drugs and Medicines

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Asafoetida	Cwts.	1,973	3,411	3,756	1,861	872
	Rs.	69,050	1,18,551	1,43,902	74,940	43,083
Camphor	Lbs.	1,771,471	1,868,694	1,736,731	1,117,122	687,692
	Rs.	22,33,243	21,88,036	29,21,687	26,73,107	14,64,863
Cocaine	Ozs.	1,041	678	417	582	713
	Rs.	28,833	19,295	11,507	16,821	20,647
Cod Liver Oil	Lbs.	164,924	280,516	219,847	199,668	151,003
	Rs.	92,717	1,33,654	1,65,337	1,84,907	1,75,912
Morphia	Ozs.	709	689	414	441	660
	Rs.	19,490	17,373	13,848	13,249	24,806
Preparation of Opium & (Morphia)...		—	—	—	—	—
	Rs.	73,969	1,93,479	1,27,646	92,648	81,173
Patent Medicines and Proprietary		—	—	—	—	—
	Rs.	73,72,972	60,74,672	88,95,981	65,10,026	49,81,890
Quinine Salts	Lbs.	105,329	98,135	82,783	100,482	174,464
	Rs.	26,28,578	25,37,182	24,87,188	32,27,832	60,15,900
Saccharine	Lbs.	25,721	27,526	38,936	76,892	51,878
	Rs.	86,481	83,210	1,49,254	3,99,488	3,09,787
Other Drugs and Medicines.	Ozs.	—	—	—	—	—
	Rs.	1,08,53,358	1,06,23,298	1,11,38,006	86,32,163	1,46,86,586
Total Drugs and Medicines	Lbs.	—	—	—	—	—
	Rs.	2,36,16,740	2,20,53,280	2,61,21,895	2,18,69,046	2,78,64,370

Table V

Imports of Paints

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Barytes	Cwts.	9,314	9,045	2,149	590	1,020
	Rs.	38,415	35,705	7,426	7,364	12,211
Blue Paint or Paris Blue ...	Cwts.	17,705	15,114	14,113	12,712	12,600
	Rs.	7,15,559	6,38,138	6,22,816	7,79,630	10,75,260
Graphite	Cwts.	11,094	8,383	10,504	7,508	6,846
	Rs.	1,55,722	1,13,902	1,22,641	1,45,630	1,76,664
Red Lead (Genuine Dry) .	Cwts.	7,544	7,016	8,523	3,301	10,943
	Rs.	1,69,980	1,34,688	1,82,007	94,072	77,990
Red Lead (Reduced) ...	Cwts.	2,712	347	58	22	312
	Rs.	46,341	8,101	1,100	611	10,392
White Lead (Genuine Dry).	Cwts.	8,299	7,164	5,509	2,823	5,967
	Rs.	2,03,481	1,58,806	1,44,546	93,004	1,97,870
White Lead (Reduced) ...	Cwts.	9	12	4	104	7
	Rs.	537	310	152	3,889	319
White Lead (Genuine Moist)	Cwts.	1,694	649	2,575	437	460
	Rs.	54,626	19,805	83,712	7,988	20,806
White Lead (Reduced Moist)	Cwts.	1,358	1,248	769	361	190
	Rs.	35,539	31,813	20,871	16,467	9,921

IMPORTS

(excluding Chemicals and Narcotics)

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
571	185	96	232	11,010	14,920	12,632
41,837	13,700	12,852	13,898	1,69,461	3,65,462	14,93,737
46,685	120,085	100,964	442,544	349,705	1,674,904	1,238,613
99,904	210,680	198,454	774,990	1,417,754	4,564,520	2,337,761
293	451	626	1,491	13,097	..	74
8,499	12,817	17,979	35,651	47,519	67	3,166
21,311	590	23,514	387,125	581,860	263,216	384,556
29,569	1,143	35,515	5,10,872	7,79,719	6,00,530	4,81,379
343	613	784	434	3,247	179	34
9,870	27,802	30,578	25,867	1,35,444	6,938	1,173
—	—	—	—	—	—	—
52,377	1,17,652	1,54,420	1,47,761	2,32,204	1,54,985	14,731
—	—	—	—	—	—	—
28,84,391	20,05,442	23,45,351	33,89,637	50,31,464	38,25,408	43,06,346
40,298	2,007	3,301	17,942	61,010	124,117	242,751
15,48,337	80,884	1,66,472	3,57,962	29,32,885	30,45,404	93,32,306
60,703	34,488	37,378	54,159	147,851	315,451	149,407
4,47,325	2,41,897	2,30,488	4,26,366	28,91,048	68,37,583	12,19,514
—	—	—	—	—	—	—
95,45,988	1,81,42,262	2,54,88,319	3,07,07,113	4,37,71,600	7,58,62,612	6,00,89,189
—	—	—	—	—	—	—
1,46,94,769	2,08,66,387	2,87,14,805	3,64,28,848	5,74,08,498	9,52,63,509	7,92,79,302

IMPORTS

and Painters' Materials.

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
362	760	60	382	..	910	224
4,636	9,825	1,357	8,370	..	19,183	1,810
9,418	6,589	13,201	14,058	27,776	30,173	26,919
7,37,949	7,10,443	16,75,076	17,44,818	34,65,572	40,08,457	36,13,881
15,175	2,756	2,158	11,770	11,156	18,464	12,086
4,98,920	1,24,205	94,011	3,17,965	2,76,788	5,60,984	406,497
1,799	169	5,237	65	29	2,195	6
67,351	6,739	1,52,309	2,905	1,376	25,906	674
5	..	..	..	24	41	.. ..
244	..	..	..	1,352	5,934	.. ..
1,235	..	203	10	5	100	.. ..
40,091	..	9,359	434	318	10,222	.. ..
..	..	..	..	..	..	.. ..
..	..	..	..	10	..	.. ..
559	196	2	265	45	200	5
27,098	11,056	123	15,459	2,110	6,916	530
83	200	..	..	..	..	.. ..
1,799	9,813	..	..	..	..	.. ..

Table V

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Lithophone Dry	Cwts.	37,045	31,286	46,248	22,400	36.083
	Rs.	3,45,413	2,87,527	5,30,311	3,76,255	7,80,685
Lithophone White Moist ...	Cwts.	181	390	380	60	..
	Rs.	3,197	6,583	8,065	1,180	..
Zinc White Genuine Dry ...	Cwts.	1,448	10,384	31,901	16,845	830
	Rs.	31,414	1,51,987	5,21,906	3,72,883	29,286
Zinc White Reduced Dry .	Cwts.	1,208	640	631	60	98
	Rs.	13,735	7,761	6,604	1,546	3,088
Zinc White Genuine Moist	Cwts.	16,597	17,889	15,988	4,027	5,773
	Rs.	4,36,025	4,92,726	4,26,183	1,34,417	2,26,490
Zinc White Reduced Moist	Cwts.	587	827	376	212	60
	Rs.	8,721	14,195	7,583	4,387	1,904
Other Sorts White Dry ...	Cwts.	819	528	1,560	1,910	103
	Rs.	27,294	31,330	8,872	9,899	12,062
Other Sorts Coloured Dry...	Cwts.	82,918	74,356	88.122	87,955	67,368
	Rs.	23,67,755	19,63,604	25,77,158	29,53,904	34,85,295
Other Sorts White Moist ...	Cwts.	6,692	5,880	4,829	2,569	3,752
	Rs.	2,05,316	1,87,445	1,69,291	1,41,866	1,74,274
Other Sorts Coloured Moist.	Cwts.	71,295	62,054	59,694	49,548	51,558
	Rs.	26,16,455	23,67,528	26,10,566	27,09,793	28,64,946
Total of Paints and Colours	Cwts.	278,514	253,212	293,933	213,444	20,397
	Rs.	74,75,515	66,51,950	80,51,810	78.54,785	91,59,413
Turpentine (Genuine) ...	Cwts.	5,394	2,508	1,528	1,948	7,758
	Rs.	1,10,869	44,195	34,694	39,644	89,170
Turpentine (Substitute) ...	Cwts.	52,718	36,164	45,201	134,849	66,789
	Rs.	63,220	4,58,160	4,61,448	6,88,935	7,58,249
Enamels	Cwts.	515	501	905	1,098	974
	Rs.	30,147	35,854	75,369	1,05,142	67,802
Lacquers	Cwts.	87	138	197	231	364
	Rs.	9,564	11,645	15,025	29,101	32,994
Other Kind Varnishes ...	Cwts.	22,424	18,651	16.461	12,348	7,681
	Rs.	10,39,538	8,75,613	8,45,668	7,91,252	5,42,710
Painters' Materials (other than paints and colours).	Cwts.	—	—	—	—	—
	Rs.	8,81,139	8,21,436	7,81,065	8,06,643	8,06,822
Total of Painters' Materials other than Paints and Colours	Cwts.	—	—	—	—	—
	Rs.	27,10,477	22,46,903	22,13,269	24,60,717	22,97,752
Total of Paints and Painters' Materials	Cwts.	—	—	—	—	—
	Rs.	1,01,85,992	88,98,853	1,02,65,079	1,03,15,502	1,14,57,165

Table VI

Imports of Explosives (including Dynamite, Gelatine Dynamite,

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Blasting Gelatine	Lbs.	449,650	439,200	207,000	31,900	..
	Rs.	3,79,086	3,46,793	1,73,846	26,611	..

—contd.

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
31,999	29,175	28,995	19,491	18,899	13,112	38,253
7,55,745	7,11,840	6,43,966	4,33,611	3,04,098	5,64,282	16,58,380
..	500	1,060	..	199	20	..
..	10,824	21,185	..	4,058	1,363	..
3,242	..	13	8,170	14,155	11,102	25,570
94,493	8	1,437	2,85,659	5,01,544	5,75,727	13,19,432
..	..	..	..	..	..	183
..	..	..	..	..	..	7,551
302	327	2,824	11,182	5,400	12,284	4,673
11,571	14,128	1,46,171	6,26,838	3,75,933	10,98,335	4,38,197
200	..	..	60	67	35	..
5,855	34	..	3,463	4,452	2,530	..
260	..	231	1,045	1,083	1,112	988
9,814	..	15,772	95,331	41,449	1,03,078	67,935
45,428	32,968	52,669	28,949	46,906	37,542	43,835
25,94,631	22,48,407	26,95,142	30,19,224	47,42,934	51,13,072	45,17,936
1,790	2,257	3,734	3,623	1,988	1,650	255
80,984	90,519	1,89,903	2,53,154	1,50,563	1,75,458	44,166
26,477	10,017	10,794	16,415	21,309	33,131	24,439
14,90,258	6,54,987	8,57,405	13,95,867	19,01,935	24,15,893	27,70,235
138,284	85,914	121,181	115,485	144,041	162,071	177,445
64,21,439	46,02,328	65,03,166	82,03,098	1,17,74,487	1,46,87,340	1,48,47,224
35,127	20,460	677	1,265	28,125	122	45,108
3,43,445	1,95,637	5,848	9,600	1,60,677	6,854	5,61,380
35,244	11,182	700,366	154,924	1,015	38,724	218
3,04,443	1,08,254	5,70,411	9,17,510	9,866	2,09,770	5,897
652	580	310	606	1,017	1,444	1,176
50,893	37,891	35,634	81,279	1,53,274	2,77,300	2,42,128
48	37	167	105	224	218	1,795
3,776	4,591	19,716	29,566	33,862	45,238	2,82,152
4,173	4,529	3,331	4,243	7,432	7,306	1,433
2,88,934	3,83,074	3,29,156	4,35,263	9,34,560	10,74,323	2,22,257
—	—	—	—	—	—	—
5,12,999	4,04,462	8,70,800	6,94,357	14,43,048	21,74,586	63,21,725
—	—	—	—	—	—	—
15,04,490	11,33,909	18,31,565	21,67,575	27,35,287	37,88,071	76,35,539
—	—	—	—	—	—	—
79,25,929	57,36,237	83,34,731	1,03,70,678	1,45,09,774	1,84,75,411	2,24,82,763

IMPORTS

Gunpowders, Filled Cartridge and Fireworks, etc.

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
..	..	..	10,000	96,152	106,250	89,400
..	..	..	11,519	111,962	1,23,257	1,07,810

TABLE VI

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Dynamite	Lbs.	..	..	75	..	..
	Rs.	..	..	57	..	..
Other Nitro Compounds ...	Lbs.	815,596	397,600	409,000	420,550	1,218,950
	Rs.	5,07,289	2,37,215	2,48,864	3,09,561	9,38,576
Gelatine Dynamite (or Gelignite)...	Lbs.	1,218,600	995,500	1,451,350	1,701,500	971,700
	Rs.	8,68,344	7,06,122	10,65,708	13,22,175	7,23,213
Detonators	No.	9,032,800	8,747,500	10,717,650	6,772,500	6,409,500
	Rs.	2,55,118	2,26,498	2,77,600	1,84,373	1,60,065
Other Blasting Explosives..	No.	526,777	777,872	552,949	46,188	190,551
	Rs.	13,36,186	6,22,625	4,79,341	45,293	1,32,674
Total Blasting Explosives...	No.	—	—	—	—	—
	Rs.	38,71,937	25,85,545	26,94,614	31,10,451	30,88,613
Gunpowder Black	Lbs.	38,775	27,525	25,450	20,437	12,770
	Rs.	26,162	23,847	19,848	17,049	14,997
Smokeless Gunpowders ...	Lbs.	16,100	8,945	2,160	4,260	4,110
	Rs.	25,496	10,001	8,706	17,127	21,803
Gunpowder Others... ...	Lbs.	43,525	51,460	63,050	39,485	77,875
	Rs.	21,744	23,197	31,643	25,474	44,421
Cartridges for Shot Guns ...	No.	12,686,687	11,813,804	10,206,027	7,942,323	11,351,256
	Rs.	8,58,752	8,14,185	7,26,886	6,19,514	9,41,239
Cartridges for Rifles ...	No.	3,610,563	3,170,519	2,881,828	1,613,504	547,626
	Rs.	2,23,948	1,71,316	1,42,754	94,602	50,837
Total Cartridges Filled ...	No.	16,297,250	14,984,323	13,087,855	9,555,827	11,898,822
	Rs.	10,82,700	9,85,501	8,69,640	7,14,116	9,92,076
Fireworks	Lbs.	2,061,175	2,926,351	1,609,740	1,000,671	710,597
	Rs.	8,10,526	9,51,720	5,63,201	4,91,502	5,00,551

TABLE VII

Imports of Products of Interest to

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Abestos Raw	Cwts.	52,837	73,163	50,055	150,509	162,994
	Rs.	4,15,076	7,32,524	6,42,931	20,70,917	26,95,118
Asbestos Manufactured ...	Cwts.	—	—	—	—	—
	Rs.	7,74,931	7,94,038	9,14,525	11,74,806	15,63,503
Asbestos Total	Cwts.	—	—	—	—	—
	Rs.	13,40,706	13,56,438	13,92,532	17,57,099	28,94,199
Candles of all kinds ...	Lbs.	3,195,360	2,796,140	2,939,634	2,084,701	3,445,107
	Rs.	9,95,636	8,78,672	8,92,048	7,57,775	13,57,746
Chalk French	Cwts.	932	243	218	109	61
	Rs.	7,833	3,744	3,374	2,353	1,231
China Clay	Cwts.	572,804	597,561	666,481	271,537	123,151
	Rs.	12,83,689	14,78,263	19,26,068	9,20,828	6,02,029
Gelatine	Cwts.	334	686	1,397	1,194	2,199
	Rs.	26,936	51,261	1,18,440	1,43,119	2,24,496
Glue	Cwts.	17,390	19,261	19,418	8,974	9,413
	Rs.	5,95,336	6,06,974	7,24,719	3,62,114	4,44,666

—*contd.*

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
436,000	163,000	253,500	420,000	400,000	499,654	1,017,553
2,24,394	89,998	1,52,069	3,34,667	3,44,119	4,52,352	9,32,678
1,625,250	1,266,020	2,024,320	2,167,500	3,362,183	3,277,950	3,970,739
13,57,090	10,10,500	15,29,789	17,81,059	27,84,454	28,54,867	35,59,375
10,990,435	6,020,000	10,857,500	6,837,500	12,488,000	6,832,113	6,949,830
2,60,681	1,08,746	3,48,143	3,75,401	6,62,007	6,12,721	7,05,270
217,373	596,395	147,410	51,087	374,433	234,035	900,151
1,88,747	4,88,677	1,27,293	95,046	3,70,788	3,11,263	8,82,436
—	—	—	—	—	—	—
30,52,094	30,89,072	26,19,805	33,48,976	58,34,591	61,67,347	70,78,483
2,250	11,150	18,825	18,450	22,550	7,650	16,911
2,294	10,137	21,285	25,844	41,005	14,082	25,248
20	..	3,645	11,300	7,525	4,880	6,995
109	..	9,714	26,109	12,993	14,070	20,501
..	10,190	8,800	24,550	109,100	66,683	61,950
..	25,626	8,692	20,349	97,717	59,977	61,781
1,792,701	1,774,054	3,393,154	10,058,775	14,147,825	17,712,233	4,475,896
1,73,272	1,71,434	3,44,307	10,37,695	15,96,322	25,76,158	7,12,673
43,535	45,565	154,045	591,453	1,930,809	6,969,183	625,273
11,845	7,013	17,253	56,063	2,12,825	4,17,897	1,57,660
1,836,236	1,819,619	3,547,199	10,645,228	16,078,634	24,681,416	5,101,169
1,85,117	1,78,447	3,61,650	10,93,758	18,09,147	29,94,055	8,70,333
1,462	4,752	1,399	1,822	320,947	864,052	399,876
2,493	7,804	2,678	6,005	9,11,549	18,34,343	6,82,879

IMPORTS

the Chemicals and other Industries.

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
226,563	127,892	211,110	97,896	152,232	80,728	108,940
43,24,491	31,20,438	43,66,750	26,75,774	32,56,235	19,90,375	34,85,965
—	—	—	—	—	—	—
10,98,110	6,70,206	13,47,870	15,90,491	25,63,052	33,09,417	46,52,926
—	—	—	—	—	—	—
19,80,629	11,53,173	10,84,086	25,29,031	58,19,287	52,99,792	81,38,891
198,369	104,994	131,400	..	15,738	1,282	701
80,123	38,862	58,476	..	10,703	8,990	3,857
4	2	..	..	..	23	..
105	51	..	12	..	132	53
63,438	5,420	1,877	8,648	6,911	13,711	54,113
3,79,080	44,037	19,375	73,191	64,885	1,16,824	4,36,051
274	318	350	721	1,380	825	1,883
45,338	1,39,059	48,145	1,37,854	3,57,390	1,98,825	4,39,358
3,811	974	1,309	2,931	4,282	3,186	1,376
1,86,509	56,612	1,15,803	2,20,323	3,13,266	3,53,113	1,38,422

TABLE VII

Product	Unit	1937-38	1938-39	1939-40	1940-41	1941-42
GUMS AND RESIN						
Arabic	Cwts.	20,156	28,733	23,953	13,152	37,424
	Rs.	4,45,155	5,43,256	4,45,015	2,46,844	10,21,235
Benjamin	Cwts.	15,447	17,707	20,963	15,620	14,345
	Rs.	5,36,263	6,15,157	6,91,847	5,47,901	5,17,009
Dammer (Resins)	Cwts.	59,694	48,663	51,643	64,764	42,667
	Rs.	4,58,247	3,31,363	4,93,238	7,28,211	6,64,535
Olibanum	Cwts.	23,406	18,493	18,772	19,631	11,904
	Rs.	2,71,052	2,03,598	1,88,869	2,22,569	1,49,044
Rosin	Cwts.	45,726	101,925	22,691	23,662	19,302
	Rs.	4,51,933	6,25,520	2,35,021	2,47,345	1,99,253
Other Sorts	Cwts.	25,269	36,763	30,067	31,665	31,548
	Rs.	5,79,640	6,93,609	6,88,612	6,72,504	6,88,225
Total	Cwts.	189,698	252,284	168,089	168,494	157,190
	Rs.	27,42,290	30,12,503	27,22,602	26,65,374	32,39,301
Raw Films	Ft.	75,327,103	74,215,453	82,953,301	70,028,581	92.510,395
	Rs.	25,44,444	24,90,732	31,02,565	24,45,972	38.82,513
Exposed Films	Ft.	22,278,338	26,034,479	23,811,654	18,367,302	17,122,184
	Rs.	38,14,738	37,69,305	54,18,865	59,43,253	51,88,818
Lac	Cwts.	67,851	101,853	225,242	68,194	77,014
	Rs.	7,35,267	7,76,944	25,54,081	11,01,320	18,74,048
Aluminium	Cwts.	66,832	57,853	31,598	26,668	5,406
	Rs.	52,70,222	46,30,017	25,56,202	37,67,395	9,01,204
Copper	Cwts.	316,063	168,685	243,420	252,568	343,466
	Rs.	1,39,79,489	61,41,088	1,08,65,035	1,25,43,146	1,86,05,514
Lead	Cwts.	156,018	149,465	254,320	291,007	349,157
	Rs.	28,87,032	20,33,555	40,65,174	55,98,776	71,71,751
Quicksilver	Lbs.	225,902	180,927	197,630	20,988	60,921
	Rs.	5,94,366	4,65,750	8,53,118	1,50,337	5,68,295
Tin	Cwts.	60,145	56,046	75,596	63,277	80,267
	Rs.	85,47,596	70,65,658	1,21,30,177	92,10,476	1,51,55,482
Zinc or Spelter	Cwts.	446,857	522,657	450,970	443,665	305,748
	Rs.	76,80,926	56,36,082	58,27,042	95,78,662	99,91,180
Mica	Cwts.	1,207	2,801	3,388	4,319	5,178
	Rs.	90,404	2,19,186	1,26,206	3,98,775	78,091
Paraffin Wax	Tons	1,562	1,074	1,849	4,194	2,798
	Rs.	4,68,913	3,58,595	7,16,102	21,88,486	15,31,128
Salt	Tons	347,305	312,232	314,232	207,159	261,601
	Rs.	55,76,803	37,80,250	61,99,118	47,71,706	98,02,209
Starch Dextrine and Farina	Cwts.	841,762	765,082	768,826	790,203	989,296
	Rs.	59,44,178	48,03,533	70,06,606	83,89,935	1,21,77,856
Tallow	Cwts.	168,202	178,007	193,639	121,243	225,644
	Rs.	31,46,902	26,69,465	29,63,203	21,59,966	47,03,314
Stearin	Cwts.	40,957	45,199	10,897	8,083	6,855
	Rs.	5,54,787	5,03,083	2,04,088	2,46,969	2,39,849

—contd.

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
64,829	26,190	68,077	160,387	89,204	43,389	158,050
21,20,549	9,26,974	35,35,276	69,80,846	36,66,573	16,15,728	61,06,782
128	20	..	788	7,214	3,855	9,160
6,748	3,333	..	1,16,557	9,78,734	4,55,700	9,25,204
3,552	9,273	..	2,030	42,922	23,969	51,516
1,91,621	5,75,223	..	92,729	16,62,048	8,06,164	16,48,203
5,203	50	242	11,276	15,090	3,418	3,505
89,935	1,060	7,083	8,35,662	4,66,267	1,00,345	1,24,360
4	23	1	4,114	13,246	3,053	63,963
2,499	527	175	92,765	8,04,240	1,27,318	20,96,308
7,305	10,471	18,472	12,560	17,857	9,887	22,028
3,18,095	4,72,956	13,49,535	8,27,435	14,18,618	12,64,668	23,43,725
81,024	46,049	86,792	1,91,155	185,533	87,571	309,122
27,29,447	19,80,073	48,92,069	84,45,494	89,96,480	43,69,923	1,32,44,672
86,552,792	78,723,529	87,173,284	80,893,562	128,622,819	174,200,351	156,416,403
31,09,739	29,79,799	29,57,070	29,05,438	54,11,316	79,96,320	76,96,416
6,923.624	11,021,027	11,230,559	16,181,038	15,115,292	15,088,317	12,391,060
18,06,961	28,57,094	33,83,448	45,28,492	24,59,826	19,98,280	31,52,042
502	..	9	331	36,802	212,749	118,355
18,599	50	518	5,182	16,46,719	1,26,44,636	1,04,01,795
413	324	27,215	109,553	234,176	248,920	189,054
52,116	41,400	24,19,196	90,21,651	1,93,34,313	2,86,95,262	2,65,59,138
350,658	319,078	366,364	307,501	711,704	445,276	864,493
1,66,01,076	1,55,74,536	1,83,50,624	1,59,22.824	4,34,15,611	3,79,00,417	7,51,97,001
37,963	9,646	11,217	443,280	132,443	106,892	164,972
16,18.123	4,48,681	2,98,120	99,52,622	43,61,465	68,83,776	1,16,73,522
105,080	54,569	237,213	177,181	506,789	328,203	741,818
10,33,692	5,25,667	21,15,402	11,53.404	18,79,468	10,26,245	19,26,145
245	198	1,297	2,807	20,943	2,589	40,566
95.627	43,867	17,394	5,95,953	52,48,060	9,59,986	1,23,94,634
223,353	33,412	23,873	249,270	1,073,138	553,072	751,832
72,10,876	8,79,527	10,85,594	77,16,568	3,58,35,663	2,38,38,344	4,04,28,006
5,097	2,682	3,355	11,131	115	1,184	3,840
1,53,012	94,862	74,114	72,004	20,617	1,80,898	12,69,798
189	..	653	..	153	13	1,547
1,11,895	73	4,54,121	801	92,482	9,240	12,42,617
133,481	163,625	275,333	216,651	92,583	378,858	300,808
88,72,215	1,54,13,065	2,49,82,101	1,79,59,547	74,22,312	2,87,46,645	2,03,26,650
70,143	6,391	6,888	11,776	521,186	626,110	876,272
14,36,078	1,70,388	1,92,490	2,32,655	1,68,67,698	1,65,71,632	2,61,19,492
93,957	96,521	54,720	64,196	52,883	58,964	59,187
28.68,449	36,48,108	17,14,021	24,00,439	31,38,298	47,70,454	52,93,490
10,504	2,299	2,967	9,154	748	829	1,508
6.10,781	1,52,512	2,39,762	5,11,344	49,764	1,09,038	1,80,649

TABLE VIII

Imports of Government Stores of

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Chemicals	Cwts.	—	—	—	—	—
	Rs.	5,04,635	11,48,585	6,64,012	4,26,562	87,773
Drugs and Medicines ...	Cwts.	—	—	—	—	—
	Rs.	3,47,183	4,21,951	4,50,792	57,21,055	31,12,601
Copper	Cwts.	56,374	53,514	66,976	90,748	6,458
	Rs.	21,16,727	21,59,608	24,56,790	37,79,155	4,53,092
Lead	Cwts.	17,839	9,283	26,722	27,540	800
	Rs.	3,02,423	1,12,747	5,11,194	4,74,449	14,589
Tin	Cwts.	6,361	1,858	9,807	6,684	5,025
	Rs.	10,01,257	2,40,392	8,72,420	11,43,082	9,38,980
Zinc or Spelter	Cwts.	239	180	13,955	9,524	4,773
	Rs.	4,593	3,745	1,54,496	1,28,040	80,741

TABLE IX

Exports of Chemicals and Chemical

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1911-42
Magnesium Chloride ...	Cwts.	12,586	5,137	25,935	16,218	21,500
	Rs.	48,538	26,736	1,49,702	1,10,619	1,58,822
Other Magnesium Compds.	Cwts.	..	472	970	862	915
	Rs.	..	2,447	6,020	5,939	10,936
Saltpetre	Cwts.	158,264	135,008	185,415	196,365	177,169
	Rs.	10,83,785	10,89,214	17,13,047	24,26,569	23,10,951
Other Potassium Compds.	Cwts.	..	4	875	3,067	11,275
	Rs.	..	296	45,893	51,671	1,36,608
Borax	Cwts.	1,024	749	666	574	463
	Rs.	17,805	12,698	12,728	14,902	11,035
Other Soda Compounds ...	Cwts.	854	2,393	6,154	5,962	130,974
	Rs.	6,676	38,600	53,290	51,341	1,10,477
Other Sorts of Chemicals ...	Cwts.	—	—	—	—	—
	Rs.	3,12,354	4,56,238	2,95,418	5,30,132	6,72,324
Total of Chemicals and Chemical preparations ...	Cwts.	—	—	—	—	—
	Rs.	14,69,158	16,21,229	22,76,033	31,91,173	34,11,153

TABLE X

Exports of Products of interest to

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Candles of all kinds ...	Lbs.	6,124	2,239	3,782	14,878	3,302
	Rs.	3,295	1,777	2,272	7,065	1,382
Casein	Cwts.	7,507	5,500	6,845	4,804	4,990
	Rs.	1,79,093	75,154	1,08,265	1,13,046	1,57,621

IMPORTS

interest to the Chemical Trade

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
—	—	—	—	—	—	—
12,64,114	28,93,880	45,55,883	21,40,384	27,62,811	13,63,977	—
—	—	—	—	—	—	—
23,327	3,40,110	14,90,474	13,45,473	4,30,454	7,66,704	—
15,935	7,145	16,162	68,549	12,583	13,984	—
7,67,342	4,10,368	9,21,488	38,49,620	8,11,265	6,56,182	—
5,665	9	7,024	2,398	17,870	8	—
74,966	288	1,55,190	57,863	3,55,816	610	—
701	..	88	12	1,000	18,151	—
1,35,983	..	17,488	7,292	2,51,202	51,41,558	—
16,596	104	35,637	7,350	2,098	5,476	—
2,87,791	4,170	9,27,567	2,03,413	1,11,843	2,75,603	—

EXPORTS

preparations of Indian Origin.

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
14,470	9,683	3,757	11,558	37,091	61,066	65,530
1,13,962	58,635	31,335	87,684	3,27,770	5,75,072	7,41,928
7	127	50	76	1,120,	1,045	312
420	2,717	3,000	8,494	2,40,052	15,815	5,866
84,180	47,129	17,441	4,914	34,101	2.960	792
14,05,698	12,19,253	5,19,681	1,54,264	10,86,633	1,45,935	69,338
4	544	812	361	179	1,558	850
1,314	28,788	56,096	22,124	14,112	2,29,948	1,27,535
..	..	3	..	12	..	..
..	..	165	..	861	..	..
1,344	86	2,706	497	4,190	26,424	30,397
30,905	9,993	81,423	14,152	72,315	18,82,397	13,78,449
—	—	—	—	—	—	—
12,41,511	2,73,696	3,86,419	21,77,893	49,77,133	25,46,128	15,31,690
—	—	—	—	—	—	—
27,93,810	15,93,082	10,78,119	24,64,611	65,02,829	53,95,295	38,54,806

EXPORT

the Chemical Industry.

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
90,267	49,970	..	161	211,648	..	3,592
1,58,626	1,17,593	..	292	3,16,215	..	4,546
679	151	200	..	3,697	..	..
37,614	21,750	19,000	..	2,33,337	..	..

TABLE X

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Cinchona Bark	Lbs.	28,222	32,452	68,824	38,952	21,816
	Rs.	9,820	11,117	23,989	17,114	10,991
Nux Vomica	Cwts.	29,373	26,566	26,280	18,585	48,988
	Rs.	1,42,866	1,06,813	1,05,515	66,756	3,36,972
Senna	Cwts.	63,434	40,395	60,289	48,454	60,965
	Rs.	8,45,412	5,88,728	8,38,820	6,00,907	7,36,475
Other Drugs and Medicines.	Cwts.	—	—	—	—	—
	Rs.	17,20,718	20,41,420	23,14,903	25,80,063	49,28,070
Total Drugs and Medicines.		—	—	—	—	—
	Rs.	27,51,129	27,83,106	33,18,876	33,55,128	61,00,715
Bark for Tanning	Cwts.	3,886	2,248	1,004	106	420
	Rs.	8,085	2,885	1,240	645	3,200
Cutch and Gambier ..	Cwts.	4,339	3,357	3,070	3,348	3,310
	Rs.	59,647	53,629	52,373	60,094	69,684
Indigo	Cwts.	425	341	158	30	25
	Rs.	72,360	41,036	17,473	7,672	4,042
Myrobalans	Cwts.	1,430,280	1,220,832	1,206,902	834,440	641,974
	Rs.	44,34,521	40,01,240	42,48,383	28,41,256	23,30,025
Myrobalans Extract ...	Cwts.	80,069	44,475	82,846	90,909	113,731
	Rs.	7,46,327	4,03,155	7,03,435	9,26,924	10,81,860
Total of Dyeing and Tanning Substances ...	Cwts.	1,625,569	1,376,505	1,429,370	1,049,100	768,417
	Rs.	66,87,016	59,10,611	70,94,150	54,00,116	36,33,384
Gum Arabic	Cwts.	259	65	340	146	1,802
	Rs.	6,750	1,090	5,002	3,347	42,218
Rosin	Cwts.	5,772	4,436	10,860	13,259	59,654
	Rs.	57,601	47,113	1,35,792	2,00,981	7,19,308
Total Gums and Resins ...	Cwts.	84,446	75,475	115,649	97,726	182,064
	Rs.	26,56,582	23,44,707	31,59,596	25,18,990	52,27,259
Lac (Buttons, Seeds, Shell, Sticks and other sorts) ...	Cwts.	664,671	634,848	759.932	594,489	766,393
	Rs.	1,62,18,000	1,26,65,148	1,90,87,270	2,25,42,601	4,91,73,936
Bones for Manurial purposes	Tons	31,910	15,424	5,015	5,565	3,506
	Rs.	31,98,132	11,84,473	3,29,136	3,85,293	2,31,019
Bonemeal	Tons	36.920	25,072	47,013	34,519	26,875
	Rs.	19,98,750	14,85,764	27,35,163	19,66,952	15,87,347
Fish Manures	Tons	6,398	4,710	6.212	6,521	5,814
	Rs.	5,59,178	3,79,374	5,79,726	5,98,686	3,55,301
Guano	Tons	519	178	751	927	153
	Rs.	48,686	19,045	86,924	44,030	6,425
Hornmeal	Tons	2,563	1,007	1,954	1,043	1,943
	Rs.	2.38,692	1,04,883	1,60,766	2,02,824	1,87,899
Sulphate of Ammonia ...	Tons	1,919	1,313	3,633	403	20
	Rs.	1,96,412	1,36,855	3,77,832	73,448	2,103
Other Kinds	Tons	8,467	5,546	6,268	16,230	4,038
	Rs.	6,56.465	4,11,341	5,21,009	12,02,160	4,26,413
Total of Manures ...	Tons	88.696	53,250	70,846	66,108	42,349
	Rs.	68,96,315	37,21,885	47,90,556	45,63,393	27,96,007
Chromite	Tons	41,452	14,696	29,720	35,555	57,198
	Rs.	12,69,078	5,36,863	9,18,742	15,92,195	27,73,734
Manganese Ore	Tons	1,001,096	455,982	718,734	510,174	722,392
	Rs.	21,28,945	1,07,24,787	1,82,74,458	1,47,48,458	2,46,31,983

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1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
..	95	..	..	..	..	..
..	475	..	..	..	..	..
33,303	18,990	25,546	51,331	42,471	30,575	8,989
3,98,962	2,31,626	2,76,633	7,19,772	6,54,595	4,54,114	98,342
47,575	16,460	12,577	25,499	47,962	32,856	24,657
6,76,285	2,78,186	2,26,252	7,29,672	19,78,350	10,12,832	5,87,832
—	—	—	—	—	—	—
19,80,410	16,85,333	21,00,803	39,36,642	67,08,766	50,92,710	74,08,408
—	—	—	—	—	—	—
30,57,747	22,13,191	26,16,659	55,39,024	93,36,711	65,59,656	80,94,582
5,197	1,650	1,062	122	1,210	2	..
35,393	9,576	15,025	1,862	36,040	60	..
4,047	5,185	3,955	6,535	4,931	6,736	8,116
86,411	1,45,394	1,54,844	2,03,510	1,89,928	3,69,023	7,76,208
71	..	6	13	1,004	518	588
30,775	..	6,336	8,736	6,84,123	75,950	59,197
544,798	320,758	507,286	670,393	608,884	638,493	611,940
21,50,363	18,08,748	31,55,892	44,67,998	49,28,115	46,32,201	54,55,027
72,982	61,670	42,532	77,375	55,226	55,950	41,953
6,93,601	6,49,226	5,86,093	11,16,823	8,16,999	11,18,870	10,98,758
636,943	394,357	564,192	758,209	683,919	759,437	699,712
30,58,304	27,16,214	40,07,170	58,87,562	70,89,210	70,29,877	81,15,812
4,442	70	399	881	2,550	131	205
1,25,705	3,164	17,544	96,452	2,42,289	11,021	16,391
13,685	2,188	..	..	793	1,140	3,131
2,37,796	51,965	..	..	27,093	51,840	2,17,936
82,313	84,763	65,143	91,936	108,025	82,853	99,827
34,48,893	45,28,506	42,54,111	62,91,178	85,82,191	72,59,101	78,10,643
321,257	236,029	437,856	434,174	678,540	542,172	490,623
2,89,16,636	2,47,34,167	4,32,16,013	4,33,22,025	11,19,01,625	9,11,36,653	8,67,81,417
7,455	3,176	1,189	5,577	9,675	3,772	1,728
5,06,025	2,51,108	1,65,686	6,34,948	11,57,051	6,81,131	3,81,707
23,894	10,648	10,309	10,491	7,778	7,416	7,018
15,91,763	6,33,653	8,58,820	9,10,924	9,66,863	15,56,458	22,32,821
6,141	3,515	1,078	3,323	2,992	1,615	7
3,83,964	2,60,466	78,418	2,69,192	3,36,414	2,02,884	23,030
..	..	..	..	..	453	..
..	..	..	..	..	1,23,705	..
1,783	185	497	520	3,324	1,404	544
2,13,273	12,119	52,200	1,04,026	8,44,328	3,46,645	1,75,628
..	..	..	..	..	..	..
..	..	..	..	..	..	..
2,219	5,756	1,450	134	26	964	1,934
2,56,287	76,398	2,81,500	27,700	18,044	3,21,501	4,34,480
41,492	23,280	14,523	20,045	23,795	15,624	11,231
29,51,312	12,33,744	14,36,633	19,46,790	33,22,700	32,32,324	32,47,666
41,310	27,060	19,187	14,036	21,901	19,711	2,640
19,89,890	14,13,973	9,86,466	7,76,478	13,17,399	14,04,660	2,34,535
577,389	549,200	156,695	184,681	461,500	520,746	308,895
1,90,62,214	1,84,77,958	53,34,717	65,34,100	1,84,14,344	2,48,64,232	1,81,00,132

TABLE X

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Wolfram Ore	Tons	16	8	8	28	61
	Rs.	58,000	18,000	19,000	66,500	1,39,611
Mica	Cwts.	293,971	161.844	218,926	139,099	241,043
	Rs.	1,48,40,258	1,14,11,540	17,68,385	1,47,37,942	3,05,40,978
Monazite	Tons	..	..	..	100	..
	Rs.	..	..	..	15,000	..
Sandalwood Oil	Gals.	13,259	9,695	11,101	10,083	18,060
	Rs.	13,86,216	9,47,318	10,86,196	8,76,976	13,49,518
Palmrosa Oil	Gals.	10,827	6,642	3,568	3,520	7,421
	Rs.	4,13,413	2,34,305	1,52,252	1,90,710	5,15,800
Lemongrass Oil	Gals.	90,121	97,920	100,135	83,573	122,924
	Rs.	7,22,845	7,13,068	9,79,392	12,14,068	35,80,071
Total Essential Oils ...	Gals.	115,918	118,263	124,380	103,286	152,678
	Rs.	25,61,034	20,12,536	25,18,198	24,56,395	57,50,434
Castor Oil	Gals.	1,583,516	1,103,085	1,253,750	1,205,413	1,077,912
	Rs.	24,65,273	17,08,358	23,66,559	25,67,877	22,19,799
Linseed Oil	Gals.	266,224	264,051	903,298	1,855,001	3,016,441
	Rs.	4,35,998	4,38,743	19,07,981	43,04,569	71,77,820
Cocoanut Oil	Gals.	79,513	72,000	50,557	49,281	71,949
	Rs.	1,31,469	1,13,169	90,260	83,521	1,35,522
Groundnut Oil	Gals.	2,317,102	3,887,675	3,926,685	8,702,674	6,411,538
	Rs.	33,65,608	48,13,754	51,59,304	1,28,58,041	93,34,680
Mustard Oil or Rape Oil ...	Gals.	325,117	406,344	337,798	400,372	305,963
	Rs.	4,83,728	5,70,664	5,04,455	5,65,573	4,66,524
Sesamum (*Til* or *Jinjili*) ...	Gals.	251,827	243,434	239,996	204,037	11,4,584
	Rs.	3,89,295	3,03,599	3,26,967	3,14,750	1,62,812
Total of Vegetable Oil non-essential	Gals	4,951,621	6,157,499	7,221,345	12,864,086	11,524,706
	Rs.	74,73,571	82,17,456	1,11,82,958	2,14,80,512	2,04,97,604
Castor Cake...	Tons	2,527	1,028	941	84	203
	Rs.	1,01,638	42,390	54,740	4,801	7,117
Cotton Cake	Tons	8,166	21,566	6,435	2,966	31
	Rs.	5,33,542	14,92,478	4,36,291	1,21,382	1,348
Goundnut Cake	Tons	251,576	365,147	232,095	138,610	81,861
	Rs.	1,74,86,441	2,40,65,487	1,58,71,270	65,47,003	23,54,461
Linseed Cake	Tons	47,003	31,436	29,555	20,095	5,111
	Rs.	32,41,075	22,17,233	20,82,339	14,36,661	2,21,371
Rape and Sesamum Cake ...	Tons	36,891	15,384	14,213	12,068	11,602
	Rs.	22,11,735	15,14,111	14,98,358	12,52,776	11,59,026
Total of Oil Cakes	Tons	356,953	446,530	288,473	176,889	98,737
	Rs.	2,42,57,726	3,01,19,532	2,02,91,618	84,15,772	37,44,398
Turpentine	Cwts.	7,642	14,313	15,355	13,608	4,665
	Rs.	95,001	2,13,080	2,31,655	3,61,872	1,29,459
Total of Paints	Cwts.	—	—	—	—	—
	Rs.	14,49,410	13,00,704	17,80,556	21,57,864	23,15,601
Paraffin Wax	Tons	11,883	8,547	7,559	7,600	2,731
	Rs.	51,33,705	36,24,864	32,97,874	35,55,634	14,03,799
Salt	Tons	54	7,535	27,499	13,617	13,617
	Rs.	5,005	1,06,074	5,17,313	4,50,424	3,39,318

	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
68	..	..	[illegible]			
1,48,965	..	..	1,82,270	14,480	..	..
190,851	149,650	76,734	125,031	185,278	255,259	339,975
2,71,16,270	2,80,40,323	294,42,811	2,45,38,615	3,00,08,940	5,65,13,742	5,92,38,583
1,465	2,354	295	100	1,950	..	..
1,81,957	3,26,138	42,022	12,870	2,53,510	..	..
7,510	1,698	2,780	6,104	8,577	7,965	3,602
10,91,243	3,00,582	7,57,041	16,52,181	25,13,875	28,03,094	10,97,229
4,345	54,306	121,629	150,790	132,290	84,053	95,824
4,00,177	873,907	32,12,243	70,13,862	1,07,95,131	36,56,595	24,07,677
59,452	360	7,061	9,293	3,802	2,708	7,950
16,86,797	23,875	12,10,883	12,97,433	7,19,438	3,93,385	10,05,473
77,958	65,344	134,412	168,400	151,044	104,880	111,653
32,68,502	21,73,823	53,58,426	1,00,69,568	1,46,32,394	78,56,700	46,91,720
483,693	38,097	70,739	157,259	266,929	5,640,035	3,009,106
15,02,441	1,93,805	4,26.032	8,83,186	16,62,790	3,99,77,538	21,78,079
1,057,035	603,803	701,023	1,062,117	303,292	3,321,768	2,280,593
29,66,998	27,57,038	37,33,798	46,40,970	17,84,409	2.71,07,975	1,47,43,921
24,610	..	4,952	..	110,363	1,340	161,717
53,157	..	25,959	..	5,19,364	6,550	10,90,928
2,006,536	130.471	147,692	126,864	4,314,822	7,252,330	8,900,805
41,79,397	3,62,143	5,61,894	5,38,752	1,84,41.292	4,62,75,918	6,45,56,391
48,797	4,872	9,768	17,772	1,789	26,651	222,479
1,21,392	25,703	57,724	1,01,451	9,877	1,70,080	18,49,107
51,582	41,453	17,456	75,255	51,591	876	3
1,38,105	1,56,659	94,280	5,02,811	3,59,060	6,125	25
4,208,191	1,689,351	1,013,661	1,553,338	5,409,522	16,727,900	15,537,496
1,04,00,955	60,98,366	51,38,780	69,88,321	2,37,27,941	11,49,88,237	10,85,19,815
346	..	..	..	..	..	..
17,954	..	..	..	..	..	..
33	30	..	..	..	..	413
1,514	2,250	..	..	..	..	36,900
54,449	13,890	..	..	..	..	..
34,91,597	11,57,083	..	..	..	..	..
271	80	10	..	..	..	..
22,431	5,833	800	16	..	..	..
17,682	1,609	285	115	47	..	123
26,14,318	3,16,796	39,808	70,517	3,632	..	76,215
72,792	15,659	295	115	47	2,196	4,039
61,49,042	14,92,379	40,608	70,533	3,632	2,58,314	51,911
105	396	670	797	3,172	307	67
4,915	26,514	56,758	16,393	1,75,913	19,733	4,742
—	—	—	—	—	—	—
5,46,359	7,00,668	10,18,372	6,30,142	26,16,004	42,84,543	61,75,207
2,701	16,227	16,466	14,122	19,196	13,146	10,202
21,31,075	1,22,46,662	1,22,89,947	1,06,42,779	1,34,35,050	1,15,21,561	1,13,24,159
246	56	4,530	1,887	5,465	189	8,582
20,727	11,119	2,45,843	62,826	1,61,552	71,294	2,73,759

TABLE X

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Essential Seeds Total ...	Tons	10,347	11,221	7,504	14,050	18,103
	Rs.	25,55,365	22,65,726	2,07,424	38,44,846	54,05,916
Castor Seeds	Tons	42,079	7,621	40,437	66,995	20,044
	Rs.	64,09,037	10,05,622	71,18,149	1,18,73,181	27,08,724
Copra or Coconut Kernel ...	Tons	132	99	106	115	135
	Rs.	44,883	37,936	37,831	37,533	46,475
Cotton Seeds	Tons	5,008	465	1,351	135	264
	Rs.	3,07,238	36,211	3,55,286	14,381	20,492
Groundnuts	Tons	619,370	835,103	548,564	338,527	394,895
	Rs.	8,93,29,631	9,92,72,141	7,19,01,488	4,06,34,551	4,88,43,663
Linseed	Tons	226,533	318,344	219,212	237,790	256,310
	Rs.	3,56,79,985	4,40,45,275	3,17,60,946	3,68,76,068	3,99,98,485
Mowa or Mowra Seeds ...	Tons	22	43	..	..	11
	Rs.	4,493	6,932	20	..	4,238
Mustard Seeds	Tons	2,514	2,513	2,905	4,235	692
	Rs.	4,39,015	4,17,053	6,65,138	9,55,771	1,15,445
Rape Seeds	Tons	31,918	11,734	21,705	34,935	34,405
	Rs.	46,42,744	15,81,936	32,77,344	46,91,543	45,61,781
Sesamum (*Til*) Seeds ...	Tons	10,126	7,650	3,502	3,875	8,630
	Rs.	19,18,280	14,80,551	7,48,739	6,91,079	14,25,769
Tallow and Stearin (including grease and animal fats)	Cwt.	5,291	5,105	4,881	8,315	6,095
	Rs.	1,46,132	1,41,463	1,40,812	2,17,735	1,40,169
Waxes of all kinds (excluding Paraffin and Candles) ...	Cwts.	3,703	5,605	3,106	3,969	5,527
	Rs.	2,15,177	1,85,848	1,80,996	2,73,836	5,76,122

TABLE XI

Figures of Re-Exports of Foreign Chemicals and Chemical pre-

Product	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Chemicals and Chemical Preparations	Cwts.	—	—	—	—	—
	Rs.	2,45,946	1,46,060	2,59,416	5,56,690	9,70,509
Drugs and Medicines ...	Cwts.	—	—	—	—	—
	Rs.	6,65,844	5,76,345	6,36,891	7,96,803	4,90,503
Dyeing and Tanning Substances	Cwts.	—	—	—	—	—
	Rs.	5,36,717	5,84,961	5,54,218	9,28,939	10,75,190
Gums and Resins	Cwts.	21,494	24,504	23,171	18,946	34,698
	Rs.	4,27,062	4,34,532	4,75,560	4,08,415	9,68,978
Copper	Cwts.	2,540	1,998	1,963	738	1,303
	Rs.	1,22,795	88,091	1,05,915	76,461	1,37,129
Lead	Cwts.	446	212	490	647	588
	Rs.	13,211	4,688	17,548	13,628	13,879
Tin	Cwts.	1,026	8,261	370	69	150
	Rs.	52,518	1,41,274	62,208	13,117	32,890

—contd.

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
12,655	5,211	8,556	15,522	10,021	8,773	9,227
41,26,860	25,82,920	44,24,844	1,24,56,968	96,01,822	68,00,192	56,42,967
28,598	14,230	6,364	5,831	5,791	4,951	..
59,62,668	53,12,597	19,91,542	16,67,211	26,43,224	27,72,838	..
201	..	..	..	..	85	101
79,577	7	..	..	..	63,354	96,759
478	1,423	425	321	70	..	1
49,272	3,44,702	77,335	83,168	25,517	..	360
257,923	240,875	214,953	196,690	..	55,363	38,272
5,12,53,299	8,21,80,565	6,30,58,539	6,07,81,553	..	3,73,73,211	3,13,22,049
160,709	36,652	92,333	169,354	52,122	66,861	25,024
3,10,08,292	1,10,06,974	2,73,57,776	5,83,51,308	2,54,56,369	3,80,88,337	1,39,04,275
50	42	..	22	29	516	728
10,683	9,953	..	5,580	27,284	2,69,315	3,68,035
1,375	443	220	433	3	..	137
3,35,041	1,64,813	1,05,696	1,95,400	2,244	250	74,075
35,204	18,347	16,881	21,893	..	..	..
66,27,591	57,14,108	60,39,218	85,80,628	..	..	..
10,229	6,154	1,315	3,045	2,404	886	33
24.67,727	21,25,084	6,83,701	17,58,306	16,98,011	8,71,215	24,749
2,828	2,097	349	234	202	17	88
1,00,383	1,02,219	22,631	14,922	15,389	1,001	8,817
4,587	980	750	1,209	3,142	2,995	2,967
66,107	1,89,903	1,47,340	1,77,409	6,25,403	6,86,080	6,31,281

RE-EXPORTS

parations and other products of interest to the Chemical Industry.

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
—	—	—	—	—	—	—
4,68,290	1,20,417	13,30,895	12,49,803	4,54,952	2,32,323	5,59,199
—	—	—	—	—	—	—
4,95,499	1,85,368	1,60,986	3,64,377	16,25,205	6,00,718	5,71,110
—	—	—	—	—	—	—
1,65,447	1,50,377	4,26,365	83.255	7,27,280	3,57,306	24,49,356
14,388	2,307	3,320	9,910	16,954	5,484	5,010
5,27,311	77,558	2,26,736	10,41,124	12,55,848	3,37,675	3,16,883
129	6	12	..	10,974	334	207
31,363	3,031	8,179	..	1,04,180	66,000	9,800
175	276	1	654	26	..	..
24,503	40,546	267	36,086	1,856	..	..
763	22,897	94,050	11,279	240	7	10
5,02,714	45,51,425	1,83,88,544	23,63,527	70,057	1,900	2,000

TABLE XI

Products	*Unit*	1937-38	1938-39	1939-40	1940-41	1941-42
Zinc	Cwts.	36	235	48	178	60
	Rs.	826	3,836	2,548	11,310	4,651
Paints and Colours ...	Cwts.	2,572	8,457	2,634	5,189	3,752
	Rs.	1,34,659	1,42,041	1,12,753	1,51,297	1,64,339
Salt	Tons	28	987	..	502	1,108
	Rs.	1,743	58,622	..	39,909	59,200
Waxes of all kinds (excluding Candles) ...	Cwts.	137	254	183	66	3,167
	Rs.	6,256	3,502	2,706	2,149	1,00,045

TABLE XII

Products	*Unit*	1938	1939	1940	1941	1942
Copper Ore and *Matter*	... (Tons)	288.127	360,624	401,293	381,449	363,166
Gold	... (Ozs.)	321,138	314,515	289,324	285,930	260,302
Ilmenite	... (Tons)	252,220	237,835	263,152	129,040	49,188
Iron Ore	... (000 Tons)	2,744	3,166	3,104	3,195	32,017
Manganese Ore ...	... (000 Tons)	968	844	869	785	757
Mica	... (Cwts.)	123,169	139,758	150,349	184,534	185,542
Petroleum	... (000 galls.)	87,082	81,459	96,689	101,451	97,736
Salt	... (000 tons)	1,538	1,499	1,646	1,779	1,892

TABLE XIII

Products	*Unit*	1939	1940	1941	1942	1943
Rice	... (000 tons)	23,950	25,715	22,129	25,331	24,876
Wheat	... (000 tons)	9,963	10,767	10,027	10,037	11,032
Other Cereals	... (000 tons)	12,657	13,272	14,628	13,446	15,342
Raw Sugar (*Gur*) ...	... (000 tons)	3,387	4,661	5,794	4.371	5,076
Groundnut	... (000 tons)	3,219	3,165	3,702	2,586	2,858
Cotton	... (000 bales, 400 lbs.)	5,051	4,909	6,080	6,223	4,702
Jute	... (000 bales, 400 lbs.)	9,738	13,172	5,460	9,047	6,990
Other Oil Seeds ...	... (000 tons)	1,872	2,094	2,075	1,955	2,084
Rubber	... (million lbs.)	32	34	34	34	37

—contd.

1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49
78	20	4	..	..	..	..
9,204	5,620	400	..	..	..	..
12,147	546	1,314	1,038	188	380	1,690
4,48,253	1,46,534	1,97,296	1,02,679	47,608	79,832	2,32,096
..	..	..	..	..	..	..
..	18	28	..	..	..	..
310	20	73	124	..	..	106
12,808	700	1,625	19,799	..	..	63,149

MINERAL PRODUCTIONS

1943	1944	1945	1946	1947	1948
359,780	326,017	329,325	352,712	323,035	—
252,228	188,206	168,366	131,775	171,704	—
37,789	100,794	172,086	185,023	253,409	—
2,655	2,364	2,264	2,408	2,415	—
595	371	211	253	448	—
159,581	139,392	128,313	130,363	121,085	—
95,719	97,453	82,695	76,752	65,192	—
1,927	1,865	1,944	2,199	1,535	—

AGRICULTURAL PRODUCTIONS

1944	1945	1946	1947	1948	1949
30,641	28,162	26,672	28,141	19,584	18,863
9,741	10,551	9,038	7,788	5,364	5,711
14,938	15,636	13,566	12,948	12,854	—
5,848	5,481	5,416	5,576	5,803	4,984
3,823	3,856	3,466	3,492	3,411	3,073
5,259	3,580	3,530	3,566	2,116	1,750
6,189	7,791	5,352	1,658	1,982	—
1,889	1,950	1,793	1,816	1,607	—
40	36	35	37	35	—

TABLE XIV

INDUSTRIAL PRODUCTIONS

Industry	Unit	Installed Capacity	Production 1947	1948	1949 (Jan.-Jun.)
Sulphuric Acid	Thous. tons	100	60	80	42
Superphosphates	Thous. tons	75	5	21	18
Caustic Soda	Thous. tons	13.5	3.3	4.4	2.8
Soda Ash	Thous. tons	54	13.6	28.2	11.4
Chlorine Liquid	Thous. tons	2	1.7	1.8	.9
Bleaching Powder	Thous. tons	6	2.5	2.8	1.3
Drugs (Tinctures and Galenicals)	Thous. galls.	750	500	522	188
Metals:					
Aluminium	Tons	5,000	3,215	3,362	1,502
Antimony	Tons	700	235	330	43
Copper	Tons	7,000	5,981	5,843	2,940
Lead	Tons	7,200	230	625	267
Alloys	Tons	30,000	19,658	15,558	19,658
Semi Manufactures	Tons	50,000	22,545	28,165	18,493
Alcohol:					
Industrial	Million galls.	20	4.82	4.9	1.6
Power			2.20	3.54	1.6
Coal	Million tons	30	30	29.7	15.65
Steel	Thous. tons	1,264	893	854	443
Salt	Million mds.	48*	51	64	45
Raw Cotton	Lakh bales	..	28	26	12
Sugar	Thous. tons	1,400	925	1,000	813
Tea	Million lbs.	551	551	541.6	550
Cement	Thous. tons	2,115	1,441	1,516	948
Paper and Paper Board	Thous .tons	110	93	98	52
Cigarettes	Million Nos.	30,000	18,880	21,825	9,886
Matches	Thous. cases	800	620	640	310
Soap	Thous. tons	180	80	190	43
Glass	Thous. tons	150	80	70	34
Ceramics	Thous. tons	30	20	28	13
Refractories	Thous. tons	225	175	189	102
Enamelware	Million pieces	25	8.5	6.7	3.5
Jute	Thous. tons	..	1,052	1,091	522
Abrasives	Thous. reams	121	40.6	46.1	13.5

APPENDIX "C"

ECONOMIC EFFECTS OF PARTITION OF THE COUNTRY

There had been considerable changes in the industrial and economic allocations of the country since the division of subcontinent of India into the Dominions of Indian Union and Pakistan on 15th day of August, 1947. The following figures clearly indicate the same :

	Particulars	*Unit*	*Indian Union*	*Pakistan*	*Year of Data*
1.	TOTAL AREA (1,574) (Kashmir 82)..	Thousand sq. miles	1,127	365	..
2.	FOOD CROPS				
	(a) *Rice*				
	(i) Area under cultivation (80.7)	Thousand sq. miles	58.1	22.6	1945-46
	(ii) Production (26.7) ...	Million tons	18.5	8.2	1945-46
	(b) *Wheat*				
	(i) Area under cultivation (35.0)	Million acres	24.5	10.4	1945-46
	(ii) Production (9.0) ...	Million tons	5.9	3.1	1945-46
	(c) *Other Food Crops*				
	(i) Area under cultivation (103.7)	Million acres	95.8	7.9	1945-46
	(ii) Production (18.5) ...	Million tons	16.6	1.9	1945-46
3.	OTHER CROPS				
	(a) *Cotton*				
	(i) Area under cultivation (14.6)	Million acres	11.3	3.3	1945-46
	(ii) Production (3.5) ...	Mil. bales, 400 lbs. each	2.1	1.4	1945-46
	(b) *Jute*				
	(i) Area under cultivation (2.65)	Million acres	0.65	2.0	1947-48
	(ii) Production (8.5) ...	Mil. bales, 400 lbs. each	1.7	6.8	1947-48
	(c) *Sugar Cane*				
	(i) Area under cultivation (3.8)	Million acres	3.2	0.6	1945-46
	(ii) Production (5.2) ...	Million tons	4.5	0.7	1945-46
	(d) *Tea*				
	(i) Area under cultivation (839)	Thousand acres	730	109	1945-46
	(ii) Production (575) ...	Million lbs.	502	73	1945-46

Particulars	*Unit*	*Indian Union*	*Pakistan*	*Year of Date*
(e) *Coffee*				
(i) Area under cultivation (212)	... Thousand acres	212	*Nil*	1945-46
(ii) Production (56) ...	... Million lbs.	56	*Nil*	1945-46
(f) *Tobacco*				
(i) Area under cultivation (1.2)	... Million acres	1.0	0.2	1945-46
(ii) Production (0.4)	... Million tons	0.3	0.1	1945-46
(g) *Rubber*				
(i) Area under cultivation (158)	... Thousand acres	158	*Nil*	1947
(ii) Production (37) ...	... Million lbs.	37	*Nil*	1947
(h) *Oil Seeds*				
(i) Area under cultivation (24.5)	... Thousand acres	23.0	1.5	1945-46
(ii) Production (5.3)	... Million tons	5.0	0.3	1945-46
4. POWER AND ENERGY				
(a) *Installed Capacity*				
(i) Steam	... Thousand kilowatts	624	59	1944
(ii) Oil	... Thousand kilowatts	91	27	1944
(iii) Hydro	... Thousand kilowatts	469	10	1944
	Total	1,184	96	
(b) *Generated Units*				
(i) Steam	... Million kilowatt hours	1,516	117	1944
(ii) Oil	... Million kilowatt hours	107	48	1944
(iii) Hydro	... Million kilowatt hours	2,038	15	1944
	Total	3,661	180	
5. INDUSTRIAL ALLOCATIONS				
(a) *Mills and Factories*				
Cotton Mills	... Number	405	16	1946-47
Jute Mills	... Number	113	*Nil*	1946-47
Sugar Mills	... Number	135	10	1946-47
Iron and Steel Mills ...	... Number	18	*Nil*	1946-47
Cement Factories ...	... Number	18	5	1946-47
Paper Mills	... Number	16	*Nil*	1946-47
Glass Works	... Number	170	4	1946-47
(b) *Minerals*				
Coal	... Lakh tons	290	2	1947
Petroleum	... Lakh gallons	652	211	1947
Chromite	... Thousand tons	21	22	1946
Copper Ore *Mattee* ...	... Thousand tons	323	*Nil*	1947
Iron Ore	... Thousand tons	2,415	*Nil*	1947
Manganese Ore ...	... Thousand tons	448	*Nil*	1947
Mica	... Tons	6,054	*Nil*	1947

APPENDIX "D"

WHAT MANKIND OWES TO CHEMICALS

A FEW of the industries mentioned below would clarify how the present industrial achievements are dependent on chemicals :

1. *Agriculture :* Plant nutrients and fertilisers ; Manures and composts ; Biochemical and photo-synthetic reactions, etc.

2. *Building Materials, Mortars and Cements :* Bricks and tile-making ; Plasters, limes, distempers, paints and varnishes ; Cements : portland, white and coloured ; Waterproofing cements ; Ferro-concrete, etc.

3. *Ceramics :* Pottery, porcelain, stoneware and crockery ; Glass and glasswares and glass bangles ; Enamels ; Refractories ; Thermocouples, etc.

4. *Coal and Coal Tar Products :* Gaseous fuels, producer gases, gaseous condensation products, ammoniacal liquors and chemical products ; Coal tar distillates ; Coke and coking products ; Coal tar intermediaries ; Coal tar dyes ; Chemical products ; Asphalt, bitumen and pitch, etc.

5. *Commercial Gases :* Carbon dioxide and aerated waters ; Acetylene and welding jobs ; Fixation of nitrogen ; Oxygen ; Anhydrous ammonia ; Sulphur dioxide ; Freon gas ; Liquid air ; Liquid chlorine, etc.

6. *Disinfectants, Antiseptics and Preservatives :* Solid disinfectants ; Naphthalene, DDT. ; Disinfecting fluids ; Insecticides ; Fungicides.

7. *Drugs and Medicines :* Drugs : natural and synthetic ; Patent and proprietary medicines and preparations ; Galenicals ; Pharmaceutical chemical products ; Essential oils ; Vitamins and hormones.

8. *Food and Nutrition Products :* Bread making and bakery ; Flour milling and starch making ; Dairy products ; Sugar ; Confectionery and chocolates ; Canning and fruit preservation ; Syrup and squashes ; Cold storage, refrigeration, ice making, ice cream, ice candy ; Brewing, alcohols, wine, spirits ; Mineral waters ; Salt and table salt ; Edible oils and fats ; Hydrogenated oils and fats.

9. *Electronics and Atomic Energy :* Atomic energy, atom bomb and electronics, X-Rays, cosmicrays, radioactive elements, alpha, beta and gama rays ; Television, photo-electric cells, wireless transmitters and receivers, emission tubes and valves.

10. *Forest Products :* Timber, teak wood, etc. ; Structural wood ; Furniture ; Herbs and plants.

11. *Heavy Chemicals and Technical Products :* Basic chemicals and raw materials ; Mineral acids and allied products ; Alkalis and alkaline salts ; Miscellaneous chemicals ; Fine chemicals and analytical reagents.

12. *Hides and Leather Goods :* Preservation of hide ; Leather tanning ; Leather dyeing ; Finished leather goods.

13. *Match Industry, Pyrotechnic and Explosives :* Matches ; Fireworks ; Explosives (military and industrial).

14. *Minerals and Metals :* Prospecting and mining ; Ore dressing and concentration ; Mineral grinding and pulverising ; Metallurgy : oxidation, reduction and fusion processes ; Extraction and refining ; Metals and alloys ; Electrometallurgy and electroplating.

15. *Perfumery, Cosmetics and Toilet Preparations :* Perfumes and flavours ; Face powders, talcum powders, face creams, hair oils, brilliantine, hair removing preparations; Dental preparations ; Medicinal preparations.

16. *Petroleum Products :* Aviation spirits ; Motor spirits ; Kerosene oil ; Diesel oil ; Furnace and fuel oil ; Lubricants and greases ; Petroleum jelly ; Waxes.

17. *Photography :* Raw film and celluloids ; Photographic chemicals ; Developing and fixing ; Printing and exposures ; Flashlight photography.

18. *Plastics and Synthetic Resin :* Moulding resin ; Plastic products ; Synthetic ivory ; Synthetic resin ; Cellulose plastics ; Lac resins.

19. *Rubber :* Latex rubber products ; Moulded rubber products ; Rubber shoe soles and heels, canvas shoes, gum boots ; Waterproofing materials and rubber sheets ; Rubber tyres, tubes and tonga tyres ; Mill accessories.

20. *Pulp and Paper :* Pulp paper making ; Paper board and straw board ; Newsprint and printing.

21. Soaps and Other Products : Washing soaps ; Toilet soaps ; Shaving soaps ; Medicated soap ; Soft soaps ; Glycerine refining.

22. Transport and Communication : Telephone and telegraph communications and batteries ; Electricity and power plants, thermal stations ; Railways ; Road transport.

23. Textiles : Cotton textiles ; Woollen ; Silk and art silk ; Cellulose derivatives and rayon ; Bleaching, dyeing, printing, finishing processes ; Dyestuffs ; Textile auxiliaries.

24. Water Supplies and Sanitation : Water treatment ; Sewage disposal ; Public health and vaccination centres ; Pests and rat killers.

25. Miscellaneous Works : Ink making, writing inks, fountain pen inks, printing inks ; Lithography and engraving ; Crayon and school chalk ; Painters' materials (water and oil colours) ; Tobacco and cigarette industry ; Waxes and candle making ; Laundry industry, cleaning, washing of fabrics ; Dry cleaning of fabrics, cotton, silk, woollen ; Cleansing powders ; Industrial salt refining; Shoe polishes ; Leather dressings ; Oil cloth and linoleum ; Electrical industry ; Incandescent gas mantles.

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