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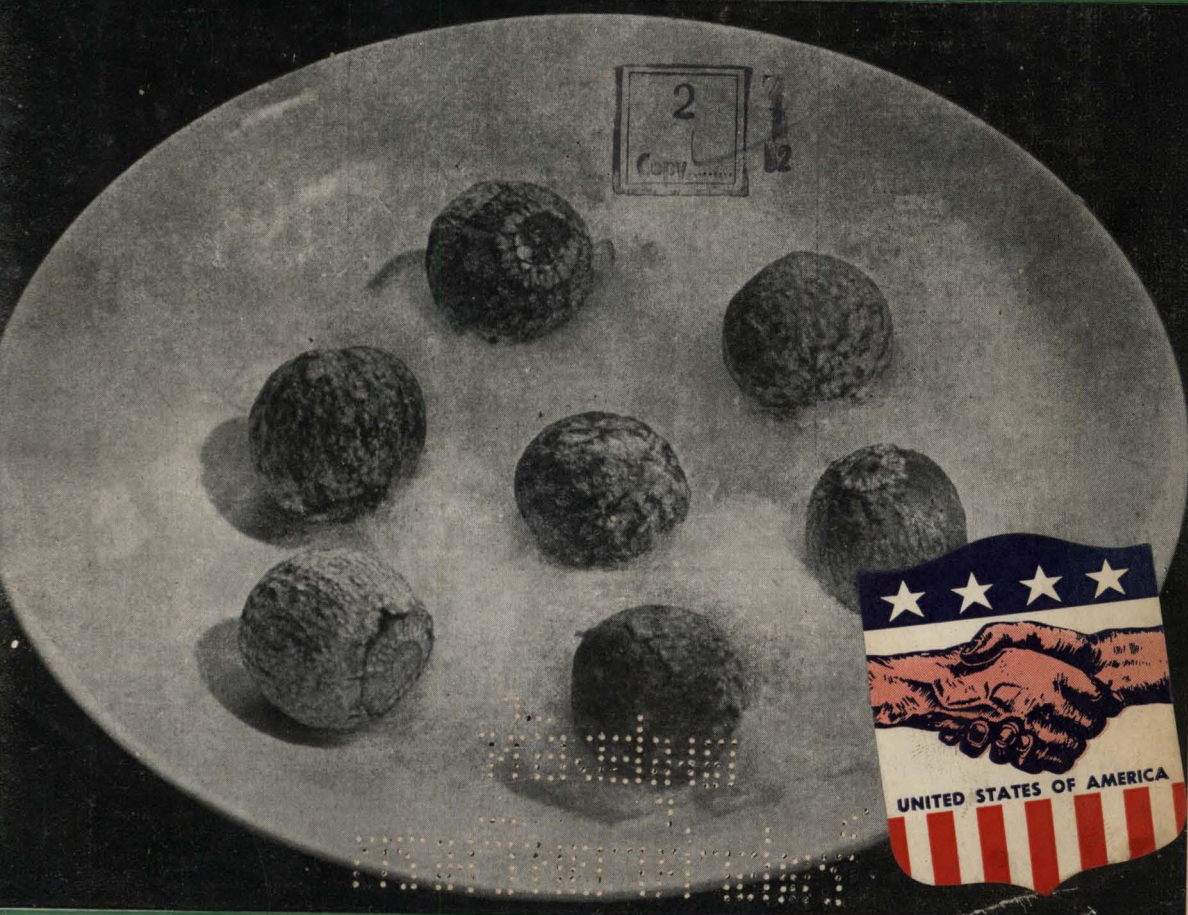


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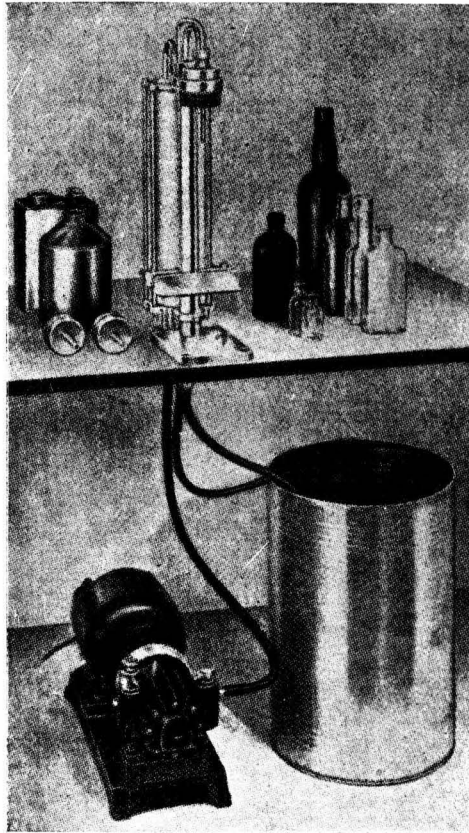
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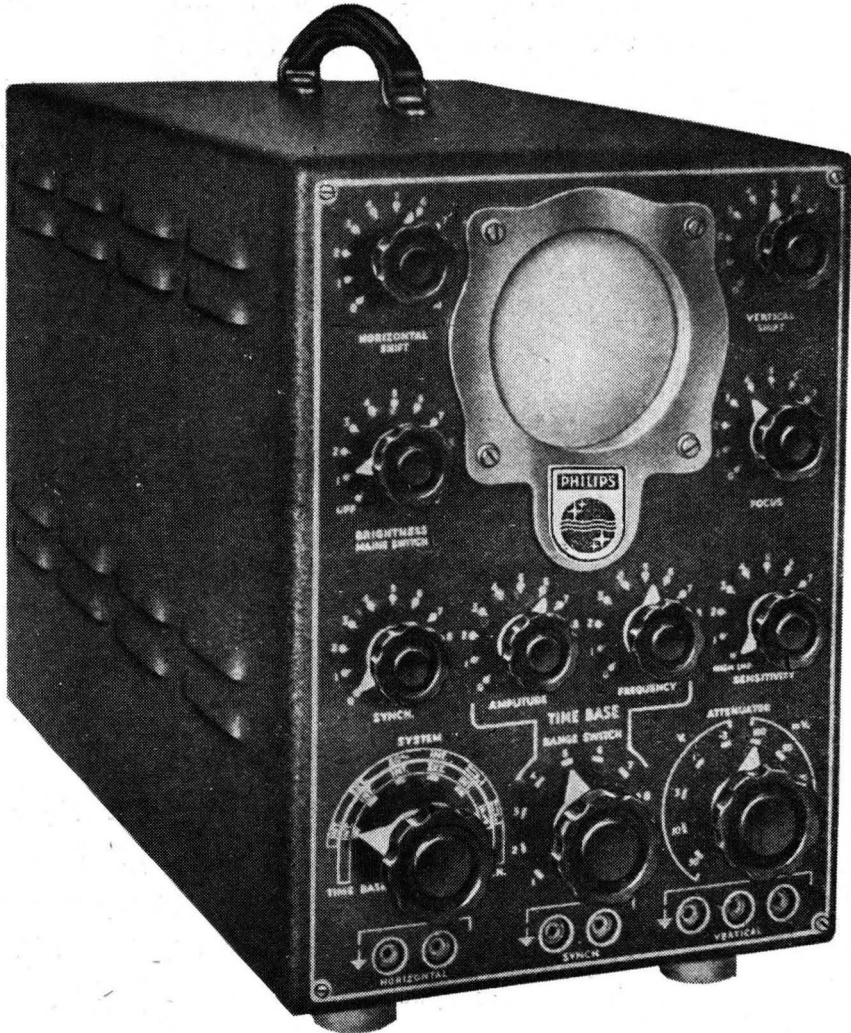
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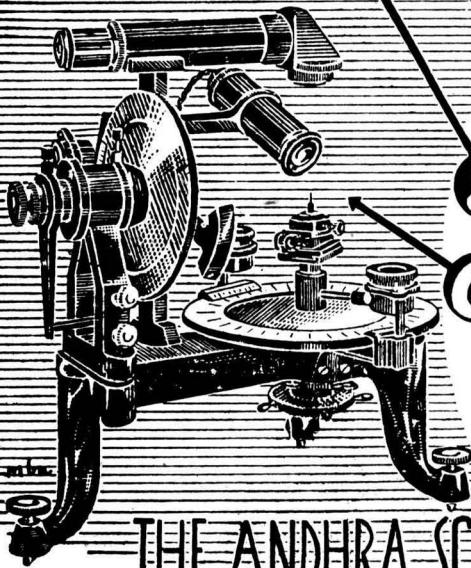


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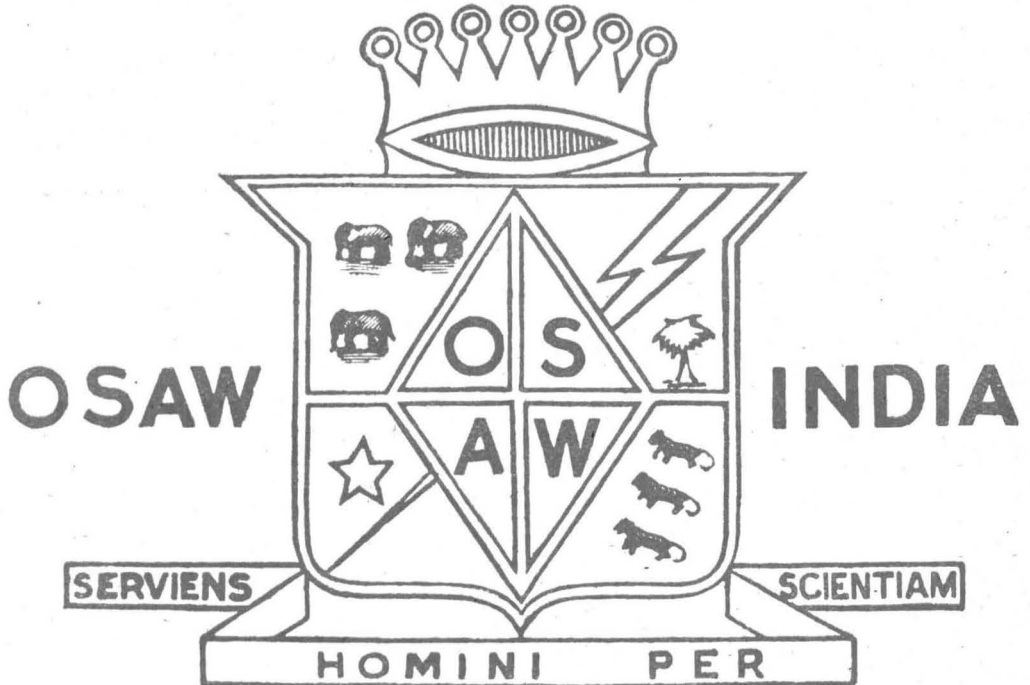
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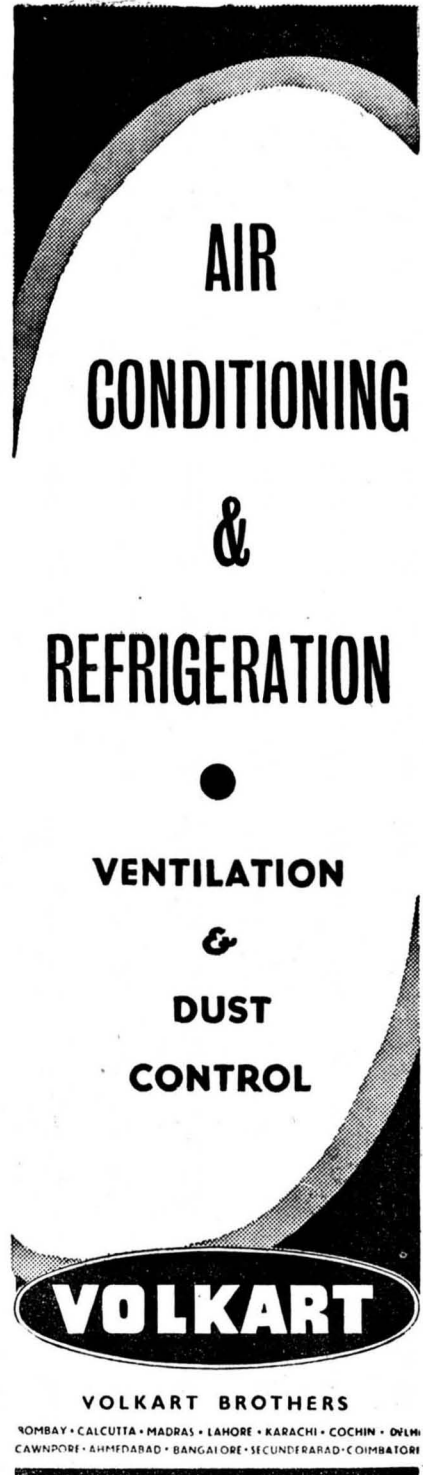
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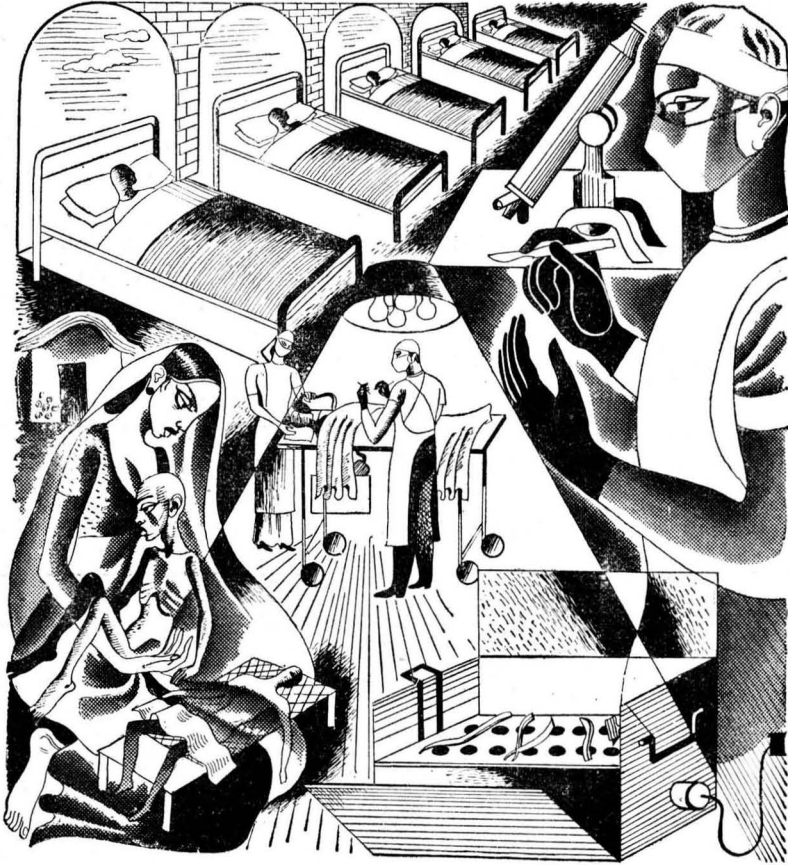
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[No. 10

Chemical Engineering Education in India

A Committee set up by the Central Government to report on Technical Education in India, recently submitted its recommendations. Amongst the engineering courses they recommended was one on Chemical Engineering, thus giving public recognition to the fact that a chemical engineer is an essential element in the industrialisation of India. A question which naturally springs to one's mind is: What must be the curriculum of a Chemical Engineering Course? how does it differ from one on Industrial Chemistry or Chemical Technology? In the October (1946) number of *Science and Culture*, Mr. S. K. Nandi surveyed briefly the scope of Chemical Engineering education in Europe and America; in this article we shall discuss the sort of curriculum needed in India, taking into account the present state of her industries and future developments.

What is a Chemical Engineer?

A Chemical Engineer may be defined, briefly, as a man who can design, erect and run a chemical plant. Erection and running of a plant need not be a specialist chemical engineering job: a structural engineer will erect, and an ordinary chemist run, a plant as well as a chemical engineer. It is in the designing of chemical plant that the chemical engineer becomes the real specialist. This is not to suggest that the only place for the

chemical engineer is the design office of the plant manufacturer, but to point out that the chemical engineer who is running a plant is valuable not because he is running it well, an ordinary chemist would run it as well, but because he has an insight into the design of the plant he is running; any alterations, repairs, renewals the plant may require can be carried out according to the best practice of his profession and so maintain the efficiency of the plant.

It is often thought that a good knowledge of pure chemistry is more important to the Indian chemical engineer as "machinery manufacturing factories are yet to be developed in India". There seems to be some confusion about the term 'machinery': if it is meant to be such items as pumps, motors, roller-crushers, then they never are normally designed by chemical engineers. But if by machinery is meant evaporators, condensers, distillation columns, then they are and must be, designed by chemical engineers. Even if fabricating facilities are not available in India that is no reason why we should not at least design our plants here and get them made elsewhere to our own specification. In any case, chemical plants are made in India; during the war several factories making important chemicals expanded their capacities by getting new plant items made locally. It was actually at this time that the country really suffered for its dearth of

chemical engineers with design experience. The chemical firms could only expand by copying their existing plant, but some of this plant was already thirty years old! The country now finds itself saddled with plant which are 30 years out-of-date and have yet at least another 10 years life in them, and which run with about half the efficiency of a modern plant. At to-day's inflated prices the products from such factories can be sold at a profit,—but at what cost to India's power resources!

We have to look to something beyond the running of India's existing chemical factories. Some of them are quite modern; most are out of date; many should never have been allowed to exist at all,—but they are all running and presumably adequately staffed. But India needs to expand her industries and the country must make sure that the new factories are the most modern in design and layout, making the most efficient use of her man-power and fuel resources.

Reverting to our definition of a chemical engineer, we may say that as far as India is concerned a chemical engineer is a man who can design chemical plant, although his actual professional career may consist in developing chemical processes, or in running chemical plant or doing the dozen other jobs he may find for himself in chemical industry.

The Basis of A Chemical Engineering Course

In reading through all that was said on chemical engineering education and curriculum before about 1938, it is obvious that chemical engineering was being looked upon either as

- (a) a veener of engineering on a background of chemistry, or
- (b) a veener of chemistry on a background of engineering.

But in recent years it has come to be recognised that Chemical Engineering,—the study of Unit Process—, is a branch of engineering in its own right, alongside Civil, Mechanical, Electrical and the rest. This is clearly shown in the suggested syllabus for a degree course put forward by the *Institution of Chemical Engineers* (London); it is also shown by the fact that recently three Chairs in Chemical Engineering were founded at British Universities; and that London and

the M.I.T.,—to mention only two places—, have been giving graduate degrees in chemical engineering for many years.

There is thus no question of including chemical engineering under the faculties of chemistry or engineering; it is a faculty in itself. A study of the syllabus suggested by the *Institution of Chemical Engineers* for the graduate course shows the wide variety of subjects that have to be studied. No doubt some of the pure chemistry subjects can be taught best in the chemistry faculty, some of the engineering subjects taught best in the engineering faculty, but it will need a special chemical engineering department to (a) teach the purely chemical engineering subjects, (b) co-ordinate the chemical and engineering parts of the subject and (c) to plan the chemical and engineering subjects with special reference to their application in chemical engineering.

Mr. Nandi suggests that chemical engineering should be placed under the faculty of chemistry. Such a suggestion ignores what is involved in the teaching of chemical engineering. It confuses chemical technology with chemical engineering and imagines that a course in the latter subject consists in instructions in soap and dye-making; or it imagines that chemical engineering can be taught by giving a course of lectures on the Theory of Distillation, or The Design of Condensers.

A chemical engineer must be a practical person. If he is employed in running a plant, he is concerned with valves that stick and pumps that fail, welds that crack and joints that leak,—and repairs have to be done on the spot and perhaps by himself. If he is designing a plant he must be able to visualise the practical possibilities of his design,—will it work?—or perhaps what is even more important, can the designed plant be fabricated at all? He must have practical, though not expert, knowledge of the various methods of fabrication of the different materials of construction used by him so that he can specify the appropriate method in his design. It is not unknown to find designs where welds have been specified in positions which no welder, not even a contortionist, could reach! A designer must have a feel for his job so that by looking at a drawing he can say at once whether or not a plant will be comfortable to work.

True, most of this practical knowledge can only come by actually working in factories, but the groundwork must be laid in the student's college days. His chemical engineering department must have a black-smith's and copper-smith's shop where he can be taught welding, braising and soldering; a machine shop where he can cut and mill and work a lathe; a laboratory equipped with apparatus to carry out experiments in unit operations,—and these apparatus to be not laboratory models but of a size big enough to approximate to small factory equipment, preferably also instrumented as plant in any modern factory should be. The provision of all these facilities is absolutely essential if the chemical engineering course is to have any value at all. Is a chemical faculty really equipped in training, temperament and outlook to provide this sort of training?

There seems to be some confusion in India between chemical technology and chemical engineering. Chemical technology is knowing the process by which a particular product is made; Chemical Engineering is knowing how the plant works in which the process is carried out. A chemical technologist is necessarily an expert in this particular industry; a chemical engineer knows nothing about any particular industry,—he studies Unit Processes. That is to say, he studies distillation, evaporation, drying, etc. without any reference to the particular industries in which these processes may be used. He is thus a more versatile person; because of his background knowledge of the unit processes he is soon able to learn the particular application of any unit process in any industry he

may choose to enter. The point to be emphasised here, however, is that the chemical engineer is concerned with the behaviour of the plant, and hence his education would be out of place in the hands of a chemist who is primarily concerned with the behaviour of reactions.

An Institute of Chemical Engineering

What sort of a place, then, should our department of chemical engineering be?

It should have a small but well equipped workshop where the student can learn how chemical plant is fabricated.

It should have a large laboratory equipped

with evaporators, dryers, columns, etc. at least of pilot plant size, where he can study unit operations. These items must be properly instrumented with indicating and control instruments. In this laboratory the student will learn to handle his plant, he will learn how instruments work, he will learn to dismantle and re-erect heavy items of equipment,—operations he will need to perform all too often in later life.

The department should also have a well equipped drawing office where the student can be taught the forms of drawing so essential to a chemical engineer; machine-drawing, lay-out drawing, line-and flow-diagrams.

Finally, our department should have an active research programme. Several Indian Universities have departments of chemical engineering; few of them have yet published a single paper on a chemical engineering subject. India will never have a school of chemical engineering worth the name unless she goes in for research work on the subject. Can we imagine the Physics Department of The Indian Institute of Science achieving its present high standard without doing a single piece of original research work? The chemical engineering departments of the American universities and institutes of technology are world famous; pages of journals like *Industrial and Engineering Chemistry* are sufficient commentary.

It was pointed out earlier that during the war the only way India could expand a lot of her chemical plant was by copying old existing plant. That is not good enough. India aims to have her industries free of foreign control. But it is no use having our industries entirely under our financial control if we have to go to foreign countries for drawings and plans. To be truly independent, our industries must also be designed by us,—and our designs must be as good as anywhere else in the world. And we shall never be able to design our own plants until we have our original thinkers and workers in the field backed by research laboratories.

It may be objected that such a department of chemical engineering would be too elaborate for India's needs; that it ignores the present poor condition of Indian industry. Our industry is not so much poor as antiquated. We want men who will enter industry and modernise it; who will design new in-

dustries in the best modern manner. The writer recently visited a factory which had a fairly complicated distillation unit,—and on this unit there was not a single thermometer, pressure gauge, flow-glass or steam-meter! Heaven knows how control is obtained or efficiency maintained! Such plants should not be allowed to exist; certainly no new plant of such a type should be permitted. A student from our suggested school of chemical engineering, if he got in charge of such a plant, would try his best to modernise it; if he had to design a similar plant he would never be guilty of such a horror!

India demands the finest industries; she must also have the best men to run them. It would be a short-sighted policy to send our best men overseas for training and turn out mediocre stuff at home merely because we shirk having the elaborate machinery required to produce experts ourselves.

It may be objected that such a school would be too expensive to start and maintain. This is true. By its very nature chemical engineering equipment is expensive, and so is chemical engineering research. But if the country really needs chemical engineers, then the money must be found from somewhere. A national need must be met by the nation. Perhaps this suggests a solution. The Central Government recently inaugurated schemes for National Laboratories for fuel and metallurgy

and an Institute for medical research and tuition. Can it not start a similar National Institute of Chemical Engineering? Some scientific body of national status should appoint a committee whose duty would be to impress upon the Government the desirability, nay the need, for such an Institute.

A Plea for Action

The matter is very urgent. State and Provincial governments are drawing up ambitious schemes of industrial expansion; industrialists are starting factories all over the country. But none of these schemes will come to much if there are not chemical engineers of the highest training to man these factories. Also, if Indian industry is to be entirely free from foreign control, then Indians must design their own factories and plants. The training of expert chemical engineers is a matter which will take years to accomplish. That is all the more reason why we should begin at once. The industrialization of India is a national problem; the training of men to run these industries should also be made a national concern. Is there any organization which will take it upon itself to draw the Governments attention to the urgency of the matter and point out the country's need for an Institute of Chemical Engineering?

H. E. Eduljee.

Linseed Oil Substitute

THE Liverpool research team headed by Prof. T. P. Hilditch has discovered a satisfactory commercial substitute for linseed oil after four years of research. This discovery, which should be regarded as an important development, relates to the processing of conophor oil obtained from the nuts (*Awusa* nuts) of a small shrublike

vine that grows wild in Nigeria. Extensive trials with the processed (a special heat-treatment) oil have shown that the product can satisfactorily replace linseed oil. The picture on the cover page shows kernels of the *Awusa* nuts, which are of the size of a normal nutmeg, from which conophor oil is extracted.

The Discovery of the Electron

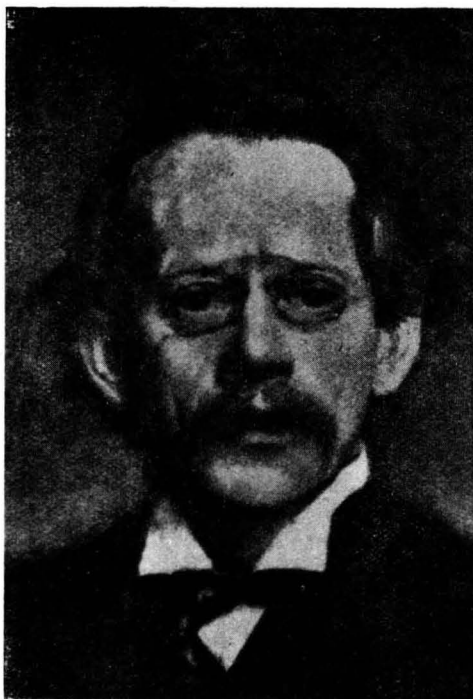
Introduction

THE electron was discovered by J. J. Thomson in 1897. This discovery inaugurated the remarkable scientific development which we call "modern physics".

It would be interesting to consider the state of physical science about 1895. Newton's laws of mechanics and the kinetic theory of matter explained a variety of observed phenomena. The discoveries of Young and Fresnel, Arago and Biot had given an adequate theory of light. The foundations of electricity and magnetism were well and truly laid by the brilliant researches of Oersted and Ampere, Ohm and Faraday. Maxwell's theory of electromagnetism had shown an intimate relation between light and electricity and led the way to the celebrated work of Hertz and Marconi on the production and propagation of electromagnetic waves in space. There was, in general, a feeling of robust optimism in scientific circles that the fundamental laws of the universe had been established beyond doubt.

Major discoveries of 1895-1900.—This contentment was rudely shaken by the great discoveries which followed each other in quick succession during the period 1895-1900. In 1895, Rontgen discovered X-rays. In the succeeding year, Becquerel discovered the phenomenon of radioactivity. And in 1897, J. J. Thomson discovered the electron. These apparently diverse discoveries, made by physicists trained in different schools of thought, were soon blended by master minds like Bohr and Rutherford into a single harmonious picture of the atomic universe.

It was during this period that classical theories were found to be inadequate to account quantitatively for the radiation emitted by a black body. In 1900, Planck proposed the quantum theory, which appeared quite revolutionary at that time. The basic assumption of this theory is that an oscillator emitting a frequency can radiate only in integral multiples of $h\nu$ where h is a universal constant. Planck's theory accounted comple-



J. J. THOMSON

tely for the properties of black body radiation.

Electric discharge in gases.—The facts relating to the patience and persistence with which J. J. Thomson tracked the electron and studied its properties make admirable reading. Today we know that the electron is one of the fundamental particles of matter. There is perhaps no branch of pure or applied physics in which the electron does not find a prominent place.

The study of the electric discharge in gases at low pressures was undertaken initially by Faraday. There was a sudden outburst of activity in this direction during the seventies of the last century. Hittorf, Geissler and Sir William Crookes were pioneers in this field of research.

It is well known that at atmospheric pressure, an electric discharge will not pass from one metal sphere to another about a centimetre apart unless the potential difference between them is raised to a considerable value. In fact a potential difference of about 30,000 volts is necessary for an electric spark to pass across a gap of 1 cm.

If however the pressure between the electrodes is reduced, discharge takes place at much lower potentials. A striking demonstration may be given with a discharge tube shown in Fig. 1. A glass tube about 50 cms. long and 4 cms. diameter has a metal electrode inserted at each end. The two electrodes are connected to a high tension generator giving about 2,000 volts or more. As the pressure inside the tube is progressively reduced discharge commences in the form of a reddish column when the pressure falls to about 1 cm. of mercury. As the pressure is further reduced, the crackling discharge gives place to a silent streamer. A considerable length of the tube near the positive electrode is occupied by a bright column known as the positive column. At lower pressures, this column breaks into striations. The appearance of the tube at this stage is illustrated in Fig. 1. Next to the positive column, there is the Faraday dark space. Between this dark space and the negative electrode are successively the negative glow, Crookes dark space and the cathode glow. At lower pressures, the Crookes dark space gradually expands and

finally occupies the whole space. The current read by the ammeter included in the circuit shows a gradual decrease throughout this process. When the Crookes dark space occupies the whole of the interior, the glass walls of the tube give rise to a bright phosphorescence, the colour of which depends on the nature of the glass. As the pressure is still further diminished, the current decreases continuously and the tube becomes practically nonconducting.

Crookes in England discovered that when the dark space known after him fills the tube, something which he called 'radiant matter' was given off from the cathode of the vacuum tube. Investigations on the properties of this matter were undertaken simultaneously in Germany. The name *kathoden strahlen* (cathode rays) was given to the radiant matter of Crookes.

It was gradually realized that these rays, emanating from the cathode in the discharge tube, have several interesting properties.

Several bodies phosphoresce when placed in the path of the cathode rays, the effect is markedly shown by potassium platino-cyanide. A screen covered with a fine powder of this material is useful in the study of cathode rays. A pencil of these rays when allowed to fall on the screen produces a bright spot of light.

The rays are always emitted normal to the cathode surface. By arranging cathodes with concave surfaces, it is possible to focus the

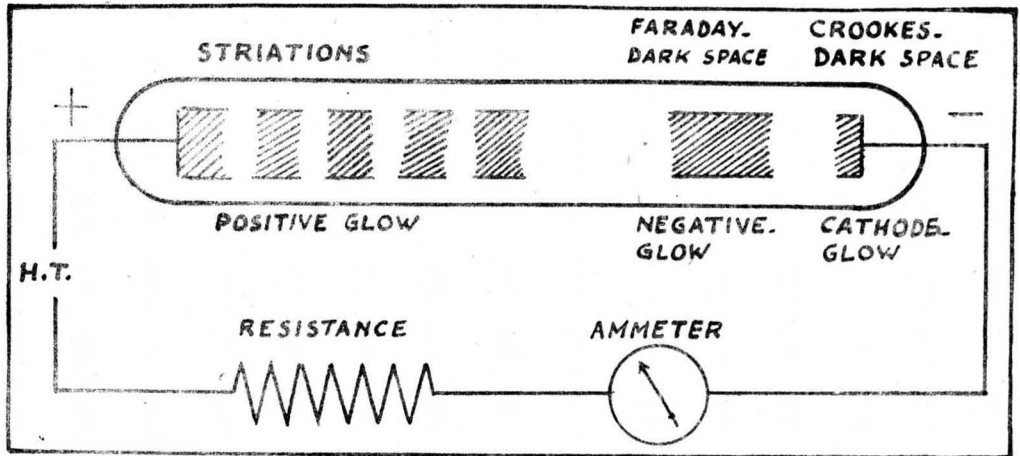


Fig. 1

rays. The rays exert a small mechanical pressure on the bodies on which they fall. There is also a large heating effect. In fact, by focussing a strong beam of cathode rays on platinum, it is possible to melt this metal.

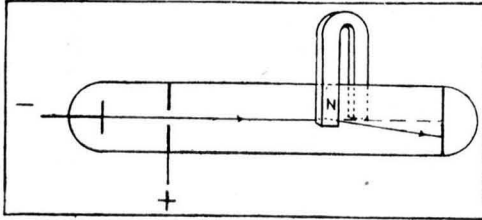


Fig. 2

The rays are easily deflected by electric and magnetic fields. Crookes showed that weak magnetic fields are enough to deflect the beam. This is illustrated in Fig. 2. In 1895 Perrin allowed the rays to fall into a metal cylinder (known as the Faraday cylinder) connected to an electrometer and obtained definite evidence that the rays carry a negative charge.

J. J. Thomson.

It was at this stage that J. J. Thomson became interested in the problem of cathode rays. Born at Cheetham Hill near Manchester on 18th December 1856, he joined Owens College, Manchester, in his 14th year. Here he came under the influence of Balfour Stewart, Professor of Physics. He was also greatly impressed by the lectures of Osborne Reynolds, Professor of Engineering and Barker, Professor of Mathematics. It was in these early days that he came into contact with Schuster and Poynting.

When Thomson was 20 years, he joined Trinity College, Cambridge. In due course, he appeared for the Mathematical Tripos examination and came out Second Wrangler, Larmor being the Senior. This was in 1880. Two years later, he submitted his thesis to Trinity and was admitted a Fellow.

Cavendish Laboratory. In 1884, the Professorship of Cavendish Laboratory fell vacant. This great institution was started in 1870 due to a generous grant from the seventh Duke of Devonshire. The main function of the laboratory was to provide facilities for practical work in physics for the students of Cambridge. The first professor was J. C.

Maxwell. When he died in 1879, the third Lord Rayleigh was appointed to the chair. After holding the post with great distinction, Lord Rayleigh resigned in 1884. The boards of electors unanimously recommended J. J. Thomson. Thus at the early age of 28, he found himself successor to Maxwell and Rayleigh.

The first 10 years of Thomson's professorship was spent mainly in organizing the department and adding greatly to its facilities. It was during this period that he published his book on *Recent researches in Electricity and Magnetism*. His keen interest in the subject of electric discharge in gases is amply illustrated by his elaborate treatment of this subject in his book.

In 1895, the University of Cambridge allowed graduates of other Universities to work for Cambridge degrees by thesis or by examination. Simultaneously, the Commissioners of 1851 Exhibition made it incumbent on the scholarship holders to proceed to institutions other than those which nominated them. These favourable conditions brought several prominent scholars to Cavendish laboratory. The most prominent of these was Rutherford, who arrived at Cambridge in 1896 from New Zealand.

Rontgen's discovery of X-rays in 1895.— Rontgen's discovery of X-rays in 1895 created a great stir in all physical laboratories. At Cambridge, Thomson prepared many X-ray tubes with the help of his assistant Everett. Photographs were taken of broken bones at the request of the surgeons in the local hospitals. Thomson rightly conjectured that the new rays should be electromagnetic waves, having wavelengths in the neighbourhood of molecular dimensions.

One of Thomson's earliest discoveries on the properties of X-rays was that the rays caused

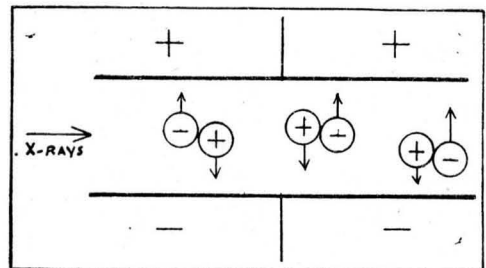


Fig. 3

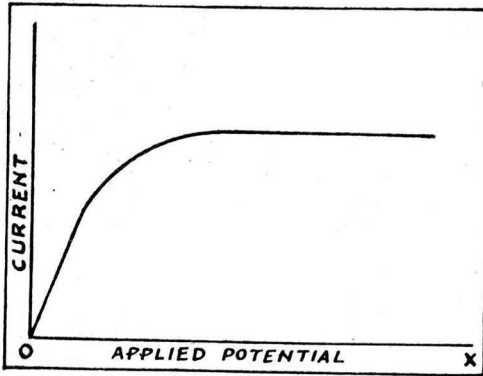


Fig. 4

the discharge of a charged electroscope. Thomson and Rutherford studied the effect of irradiating the space between two condenser plates. The gas atoms are broken into negative and positive ions by the X-rays. When the two parallel plates of the condenser are subjected to a difference of potential, the positive and negative ions drift in opposite directions (Fig. 3) and set up what is known as an ionization current. This current is found to be proportional to the applied potential up to a certain stage (Fig. 4). After a certain difference of potential is reached, the current becomes independent of the potential. A saturation current is thus obtained. This happens when all the positive and negative ions produced every second by the X rays are removed by attraction to the respective plates.

These studies led Thomson naturally to the subject of the nature of the cathode rays. Having already come to the conclusion that these rays were corpuscular and had an electric charge, he directed his attention to the determination of the ratio of the mass m to the charge e of the particles and incidentally of their velocity.

m/e for electrons: Thomson's first method.— It is of interest to consider the first method by which Thomson arrived at an estimate for the value of m/e for the cathode ray particles. He utilized the observation that the cathode rays get deflected in a magnetic field. Consider a particle of charge e and mass m . Let it move along the direction OX (Fig. 5) with a velocity v . If a magnetic field of intensity H is applied in the direction OY (perpendicular to OX), the particle experiences a force in the direction OZ (normal to the other two axes). This force acting on the

particle would deflect it in the direction OZ. The path would become an arc of a circle with a radius r given by $Hev = mv^2/r$. If the particle had a negative charge, the deflection will be in the opposite direction.

In the first part of the experiment, J. J. Thomson subjected a cathode ray beam to a magnetic field of known intensity. By determining the deflection produced, he calculated the radius of path of the deflected beam. Since $Hev = mv^2/r$, we have $mv/e = Hr$.

The cathode ray beam was then directed by a magnetic field into a Faraday chamber connected to a quadrant electrometer. A thermocouple was also fitted to the Faraday cylinder. From the known rise of temperature in a given time and the thermal capacity of the cylinder, the amount of heat developed per second may be calculated. If N particles are collected per second, the heat given is obtained from the expression $\frac{1}{2}Nmv^2 = Jh$ where J is the mechanical equivalent of heat. Also the charge received per second is $Ne = q$. From these two equations, we

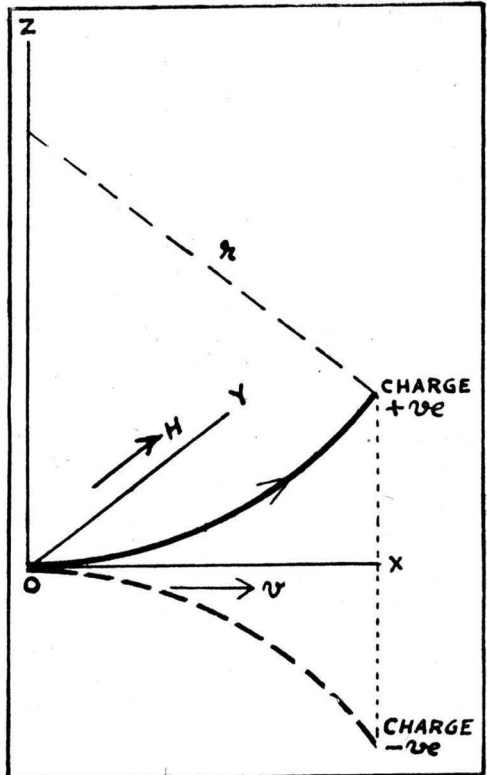


Fig. 5

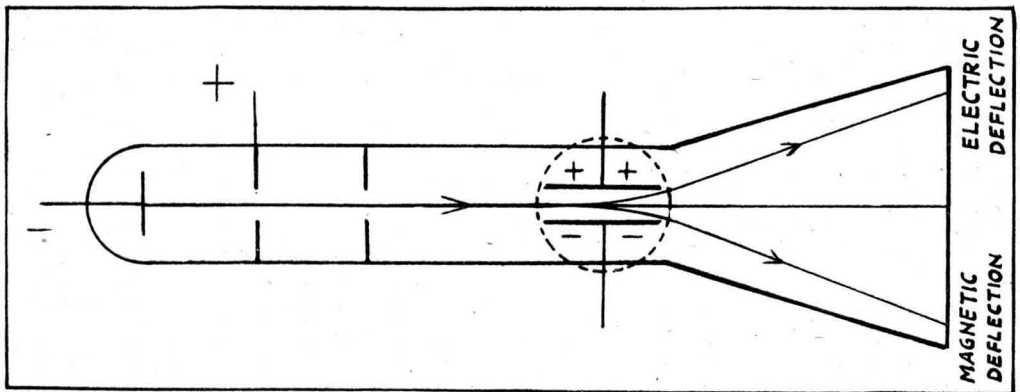


Fig. 6

have $mv^2/e = 2Jh/q$. This relation combined with $mv/e = Hr$ enables one to calculate v and m/e .

Thomson's first experiments on these lines gave him the values $v = 15,000$ kilometres per second and $m/e = 2 \times 10^{-8}$ gram per coulomb. The charge e was found to be definitely negative from the direction of deflection in the magnetic field.

Thomson thus showed that the cathode rays were corpuscular and that the particles were negatively charged. He drew attention to the fact that since for hydrogen ions, the ratio of mass to charge is about 1×10^{-5} gram per coulomb, the cathode ray corpuscles are much smaller than hydrogen ions.

m/e for electrons : Thomson's second method.—In a later series of investigations in 1897, Thomson used the electrostatic deflection of the cathode rays in conjunction with the magnetic deflection. For, if the rays pass through the space between a pair of plane condenser plates (Fig. 6), the radius of path r' is given by $Xe = mv^2/r'$, where X is the electric intensity between the plates. The magnetic deviation gives $Hev = mv^2/r$. If the rays are subjected simultaneously to the electric and magnetic fields and the intensity of the magnetic field is adjusted till the deflections mutually cancel each other, then $r = r'$. Also $X/H = v$. From this relation, the velocity of the corpuscles may be calculated. If further we determine the magnetic deviation, $m/e = rH/v$.

In an important paper published in 1897, Thomson showed that although in the limits

set by the experimental conditions, the velocity varied from about 15,000 to about 36,000 kilometres per second, the value of m/e was nearly 1.3×10^{-8} gram per coulomb. This value shows good agreement with the result of his first investigation.

The cathode ray corpuscles came to be known as electrons. The term electron had been proposed much earlier by Dr. Johnston Stoney for the fundamental unit of electric charge.

m/e for photoelectrons.—In 1888 Hallwachs showed that when ultra-violet light falls on a clean surface of zinc, negative corpuscles are given off. J. J. Thomson determined the value of m/e for these corpuscles by the following method.

Consider a beam of ultraviolet light falling on a clean surface of zinc. The corpuscles liberated from the surface are subjected to an electric field normal to the surface and a magnetic field parallel to the surface. Under these conditions, the electrons would move perpendicular to both these directions. In Fig. 7, the X-axis is taken normal to the surface. The Y-axis is taken parallel to the surface and perpendicular to the magnetic field (taken normal to the plane of the paper). G. is a piece of wire gauze placed parallel to the surface. Ultra-violet light passes through the gauze and falls on the metal surface. The liberated corpuscles are attracted towards the gauze by making the metal negative with respect to it. Due to the magnetic field, however, the path of a corpuscle is bent in the manner shown in the Figure. When the gauze is gradually moved

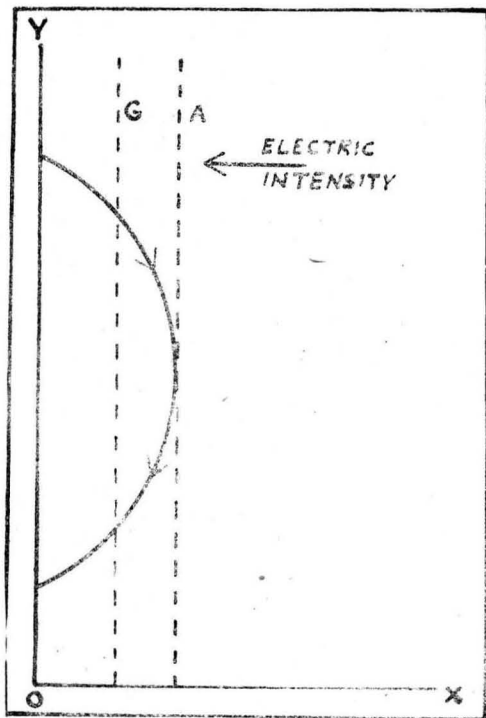


Fig. 7

away from the zinc, at one position (indicated by the broken line A), it would cease to receive any charge. This critical distance may be shown to be $2mX/eH^2$ where the terms have the usual significance. Thomson determined this distance and obtained for m/e the mean value 1.37×10^{-8} gram per coulomb. He thus showed beyond doubt that when a zinc surface is illuminated with ultra-violet light, electrons are liberated.

m/e for thermions.—Thomson next investigated the corpuscles known to be emitted from red hot filament of carbon, an effect which had been studied by Elster and Geitel during the period 1882-1889. Using the same method as the one adopted by him for photo-electrons, he obtained for these corpuscles $m/e = 1.16 \times 10^{-8}$ gram per coulomb. He proved in this manner that the red hot filament of carbon gives out electrons, a result which formed the subject of extended study later by O. W. Richardson in Cavendish laboratory under Thomson's own inspiration.

Determination of e .

Thomson's attention was next directed to the determination of the charge carried by

the corpuscles. His contemporary C. T. R. Wilson had shown that when a space rendered dust free is irradiated with X-rays, the charged particles which are produced serve as nuclei for the condensation of water vapour. To enable such a condensation to take place, the space had to be given a sudden increase in volume. This adiabatic expansion resulted in a general cooling and the superfluous water vapour was condensed on the charged particles. Thomson's method was to determine the number of charges produced by X-rays in the given volume and also the current between two electrodes under a known difference of potential. To determine the number of charges produced, he assumed that water condensed on all the charges when the given volume was suddenly expanded. The heat absorbed during this adiabatic expansion could be calculated and thus the mass of water condensed.

From the rate at which the cloud settled, assuming that the individual droplets settled down in air at constant speed in accordance with Stokes law, Thomson calculated the radius of these droplets. It was thus possible to calculate the number of positive and negative charges produced in the given volume.

He found that the total number of droplets was 40,000 per cubic centimetre. Hence there should have been 20,000 positive ions and an equal number of negative ions. The current carried by the positive charges would be $20,000 e \times 2.4$ where e is the charge and 2.4 is the velocity of the ions in cms. per second under the given conditions, this value being taken from the experiments of Rutherford. If the current carried by the negative charges is also the same, the total current is $2.4 \times 40,000 e$. Thomson found in this experiment that the current was 1.035 ampere per sq.cm. The value of e thus obtained was 2.15×10^{-19} coulomb. It is remarkable that with a variety of assumptions, Thomson's value agrees with the modern accepted value of 1.601×10^{-19} coulomb.

Other determinations. Perhaps the most reliable method of determining the charge on the electron was carried out by Millikan, following an earlier method of H. A. Wilson. Individual droplets of oil having a diameter of about $1/10,000$ of a centimetre were observed in the space between two parallel condenser plates. When the space was irradiated with X-rays, positive and negative

charges were produced. The parallel plates were raised to a difference of potential of about 1,000 volts. Whenever the droplets picked up one or more charges, their velocities showed a sudden change. From the smallest change observed in this velocity, Millikan was able to calculate the unit of charge as 1.601×10^{-10} coulomb.

Taking the best mean value of m/e to be 5.691×10^{-9} gm. per coulomb, we find that the mass of the electron is 9.110×10^{-28} gm. Accurate determination shows that the mass of the hydrogen atom is 1834 times the mass of the electron.

An estimate of the radius of the electron could be made by collision experiments. The results suggest that the radius is nearly 2×10^{-13} cm.

Conclusion

We know today that the electron is a fundamental particle of matter. Electron beams have been used in various investigations. Radio, television and radar techniques are

all based on the electron. Photoelectric cells, cathode ray oscillographs and electron microscope have become powerful tools in different branches of pure and applied science. Production of high energy electrons has made it possible to organize powerful X-ray outfits. The extensive experimental investigations on the atomic nucleus in recent years are largely due to the electron. In the field of theoretical research, the electron has occupied a high place. The wave mechanical considerations of de Broglie have led to some fine piece of work at the hands of Schrodinger, Sommerfeld, Max Born and Brillouin. In astrophysical problems also, the electron has found a high place.

Much no doubt has been done during the last fifty years. However, it is only fitting that today we turn our thoughts reverently back to the old Cavendish laboratory where half century ago J. J. Thomson, working with remarkably simple apparatus, successfully isolated the electron and gave us a complete picture of its properties.

Present Position of Soil Survey in India

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SOIL and forest resources constitute a vital national heritage. In the best interests of the country, they should be utilized in an appropriate manner. This is all the more imperative when a food crisis stares us in the face. India has to confront with a deficit of some 21 million tons of food grains in the next ten years with a population growing at the rate of 5 millions a year. The possibility of bringing more land under cultivation, of increasing the fertility of soil by proper management and the use of manures, fertilizers, better seeds etc., should be looked into with greater care and attention. Apart from the broad aspects of land utilization survey, the soils which are to be allotted for growing agricultural crops require to be surveyed in great detail along lines similar to those followed in the United Kingdom, United

States of America, Australia and Canada. The main objectives will be to recognise the agricultural capabilities and potentialities of each soil type of the country. This will entail long-term investigations on soil-crop relationships. The maximum productive capacity would be a guide to procedures the peasant should adopt to get the optimum production. It would even be possible to work out suitable and definite schedule of manurial and tillage operations and cropping systems for each tract so that detailed instructions may be handed over to the peasants.

The Present Position

A survey of the soils of India along lines envisaged above has not been so far attempted. In fact, a survey of the soils by any method

whatsoever on a uniform basis has not been carried out. A lot of valuable information is, however, available from old records such as those of Land Settlement and Geological Survey. Besides, as a result of the studies carried out by Government Agriculture Departments and by soil workers all over the country, a vast mass of data on the properties of India soils has accumulated.

A comprehensive attempt was made to collect and collate these data under the auspices of all India Soil Survey Scheme financed by the Imperial Council of Agricultural Research.* An attempt has been made in the following pages to give an idea of the lines along which soil survey and soil classification in India have so far proceeded and to indicate the salient facts which have emerged from such studies.

The scattered data which have been collected may be classified into the following groups:-

Land assessment methods: The earliest information about Indian soils is available in the *Land Settlement Records*. In areas of old settlements it has been possible, through experience, to determine the suitability of the land for the production of crops, and a textural classification of the soil has been arrived at by empirical methods. The main factors which governed the system of classification for land assessment purposes are texture, colour, availability of water, level of the land and yield of crops. The information is useful, but is insufficient and lacks a scientific background for efficient utilisation of land and land use planning.

Study of soil from the geological point of view: The study of soils from the geological point of view was made by various workers of the *Geological Survey of India*, and this forms an important contribution to our knowledge of Indian soils. The subject has been summarised by Wadia, Krishnan and Mukherji who have also prepared a soil map of India on the basis of geological formations. The generalisation put forth by workers in the *Geological Survey* are based on the examination of lithographic materials on a very broad scale.

For soil survey, however, a much more detailed examination of the nature of the parent materials, including petrological study of the rock-forming minerals is necessary as also the study of profiles and examination of profile characteristics.

Assessment of Soil Fertility

Classification of soils has been attempted by some workers on the basis of their nitrogen, phosphorous and potassium i.e., the nutrient status, the lime content and the mechanical composition of surface and subsoils. Such classifications have some agronomic value but have many limitations. This method of grouping of soils has been used extensively until recently in most soil survey work in India. In most of these fertility surveys uniform and standard methods of sampling have not been used. Moreover nitrogen, phosphorus and potassium being transient constituents of soils, as their contents depend on many external factors, soil maps prepared on the basis of these figures do not differentiate soil types and are unsuitable for soil classification on a physical basis. The number of samples taken for analysis in these surveys is also in many cases, too small for the area surveyed, as shown in Table I.

Soil Studies on Profile basis

Soil studies on profile basis and the classification of soils based on them are of comparatively recent development in India. Except the one initiated in the Bombay Deccan Canal area, no soil survey carried out so far seemed to have this objective in view. It has been shown in that area that the different soil types produced as a result of difference in topography, grainage and subsoil water table respond differently to manuring and irrigation.

Soil Survey for Irrigation purposes: Soil surveys in connection with irrigation have been carried out on extensive scales in Sind and the Punjab. Usually the surface and subsoil samples are analysed for clay, silt, soluble salts and, less often, for exchangeable bases. The Soil profiles up to 3' or more are generally examined, but morphological characters are not always taken into consideration. The latter are particularly important in view of such factors as rise of water table and salts and waterlogging, which are prevalent in the irrigated tracts.

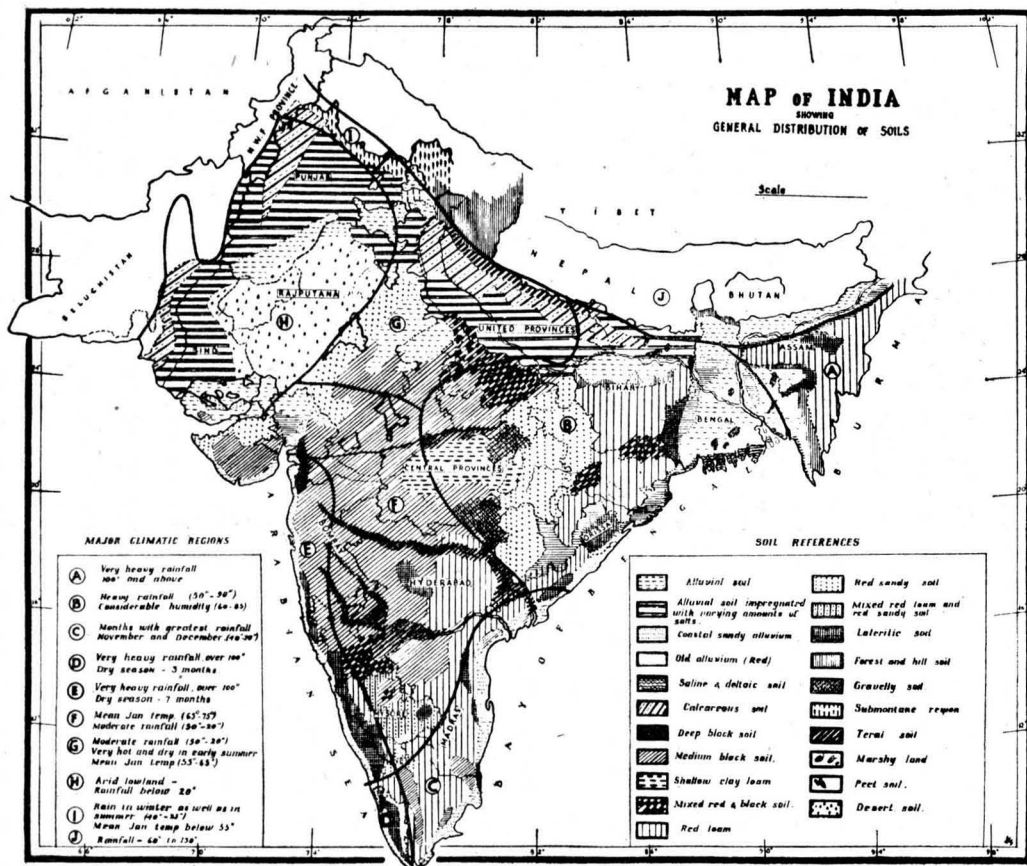
* The final Report of the Scheme was approved by the Soil Science Committee and the Advisory Board of the I. C. A. R. at its meeting in February, 1946. The report has not yet been published.

TABLE I.

	Approximate area surveyed Sq. miles	Average area per sample Sq. miles
Madras, (Guntur, Malabar, Tanjore, & (Kistna & Godavari deltas)	11,000	20
Travancore (Shertallai Taluk)	117	2
Travancore (Shencottah Taluk)	46	0.78 (500 acres.
Tungabhadra project (Madras)	1,600	4
Tungabhadra project (Hyderabad)	2,700	0.0125 (8 acres.
Bihar (Sugar factory areas)	1,600	0.1
Deccan (Canal area)	100	0.0031 (2 acres.

Saline and Alkaline soils and their Reclamation: About 21 lakhs acres of land are affected by *usar* in the United Provinces alone. In Bombay Deccan, out of the total area of 75,000 acres irrigated, one-third is more or less affected by salts. It has been estimated that in the Punjab over 5 lakhs of acres have been abandoned as unfit for

cultivation owing to the accumulation of salt and it is estimated that nearly 25,000 acres are being added to this figure each year. In cases of badly damaged alkali patches, e.g., in Trichinopoly, treatment with sulphur and gypsum accompanied by adequate watering has led to steady improvement of the soil, and successful crops have been raised. In the



Soil map of India.

Punjab and Bombay Presidency also, methods of reclamation of these soils have been suggested which are based on suitable processes of irrigation, application of lime or gypsum where necessary and growth of salt resistant crops like rice, berseem and sugar cane.

Broad Soil Groups in India: It is possible on the basis of the existing data to recognise a number of broad soil groups. e.g. red and lateritic soils, black soils, alluvial forest soils, desert soils and peaty and marshy soils. Of these, the red and the lateritic soils and the black soils have been studied more than the rest. The so-called alluvial soils are an ill-defined group whose actual classification will depend on a much more detailed study; for instance, they may include desert, meadow and forest soils. There is also not much information about the nature of forest and hill soils and it is desirable that more systematic studies on high level and low level forest soils should be undertaken and the characteristics of podsoils and other important soil groups ascertained. Information on desert soils is also meagre. The Thar or the Rajputana desert alone occupies an area of 40,000 sq. miles. These soils consist mostly of sands which have been derived from the old sea-coast. The extent of occurrence and the nature of peaty and marshy soils are not known except in one or two places and a survey for the purposes of reclamation and proper utilization of these soils is necessary.

Soil Maps

Attempts have been made by several investigators to draw soil maps of India, e.g., by Schokalsky by Wadia, Krishnan and Mukherjee of the Geological Survey of India and by Viswanath and Ukil of the Indian

Agricultural Research Institute. These maps are good attempts but they are not based on sufficient data. The available data on Indian soils collected under the All India Soil Survey Scheme have enabled us to prepare fresh soil maps of India and of the Provinces and the States. But even then the maps show only a general distribution of the soils and fall far short of what are needed for any land use plan.

Future Plan of work

It has become apparent from what has been said above that fresh approaches for a soil survey require to be made. In a vast country like ours, a detailed survey will involve much time and evidently money also. Particularly in this case time becomes more precious, and it can be saved if the number of trained workers is increased. To achieve this end it is desirable that a strong nucleus of training is set up in a central institute from where workers trained in the modern methods of soil survey will be sent out to different places all over India, who will work under the Provincial and State Departments of Agriculture. The idea is to initiate uniform methods of investigation; otherwise the soil survey will lose much of its value. It may be mentioned here that such a nucleus section has been already started at the Indian Agricultural Research New Delhi.

Acknowledgment

The authors express their thanks to Dr. J.N. Mukherjee C.B.E., D.Sc., F.N.I., Director, Indian Agricultural Research Institute, for criticisms and suggestions in writing this paper.

Reference

Wadia, Krishnan and Mukherjee.

Some Aspects of the Economics of Sulphuric Acid Manufacture in India

By A. NAGARAJA RAO

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THE selling price of sulphuric acid has always been much higher in India than in the other industrially developed countries, and this has been one of the factors responsible for the non-development of subsidiary industries consuming this acid in their manufacture. While the acid enjoys a kind of natural protection against its large importation into the country, mainly on account of its corrosive nature and the incidental high transport and insurance charges, the products manufactured from it have been extensively imported into India before the war. During the war years, however, want of shipping space and higher demand in the producing countries themselves resulted in the diminution of imports of these products also. Consequently, manufacture of some of them was undertaken in India with improvised equipment, in spite of the higher price of sulphuric acid and the resultant higher prices of these products. With gradual reversion to peacetime conditions, foreign manufacturers are once again attempting to export their products, while the indigenous manufacturers who put up their plants under stress of war conditions are anxious to retain the local market for themselves.

Considering that sulphuric acid is the most important basic chemical required in a large number of industries, either directly or indirectly, there are no two opinions that every effort should be made to lower the selling price of this product to a level at which co-ordinated development of industries depending on it could be achieved. Not only the manufacturers of bichromate and superphosphate, but also the Government and the Tariff Board are anxious to secure this result with minimum delay. But before any satisfactory solution of this problem can be had, it is necessary to examine carefully and remedy the causes leading to its higher cost of production in India. Unless these factors are investigated and a co-ordinated development of the industry planned, there is

very little that can be done to bring down the cost of this acid.

Factors influencing cost of production

As is well known, the cost of production of any manufactured product depends on:

- (a) The type of process, raw material and equipment employed,
- (b) The size, condition and age of the individual plants,
- (c) Other operating costs such as labour, supervision and overheads.

In regard to the influence of each of these factors, India had to depend so far only on imported sulphur, the small deposits at Koh-i-Sultan which were attempted to be used during the war years proving neither satisfactory nor sufficient. The cost of the sulphur delivered at site in India is about double of that at factory site in America. In the United Kingdom, where also sulphur is used as a raw material in a number of plants, it is said that its cost is subsidised by the Government. In Germany, the bulk of production of sulphuric acid is from pyrites occurring within the country or imported from nearby countries at comparatively low prices. There are also instances where large plants have been put up for recovering and converting exit sulphurous gases from plants manufacturing products such as sodium silicate from sodium sulphate. In England, in addition to sulphur, pyrites, gypsum and waste sulphurous gases from metallurgical industries are being used as raw materials. Advantage has also been taken in a number of countries of the gypsum process that was developed in Germany during the first world war for producing sulphuric acid in large plants. It is only in India that we have still been depending entirely on imported sulphur without any rational attempts at using alternative raw materials which are available in the country. As regards pyrites, some deposits are said to occur in the Khympoor Hills in Bihar and near Simla in the Himalayas. There are also

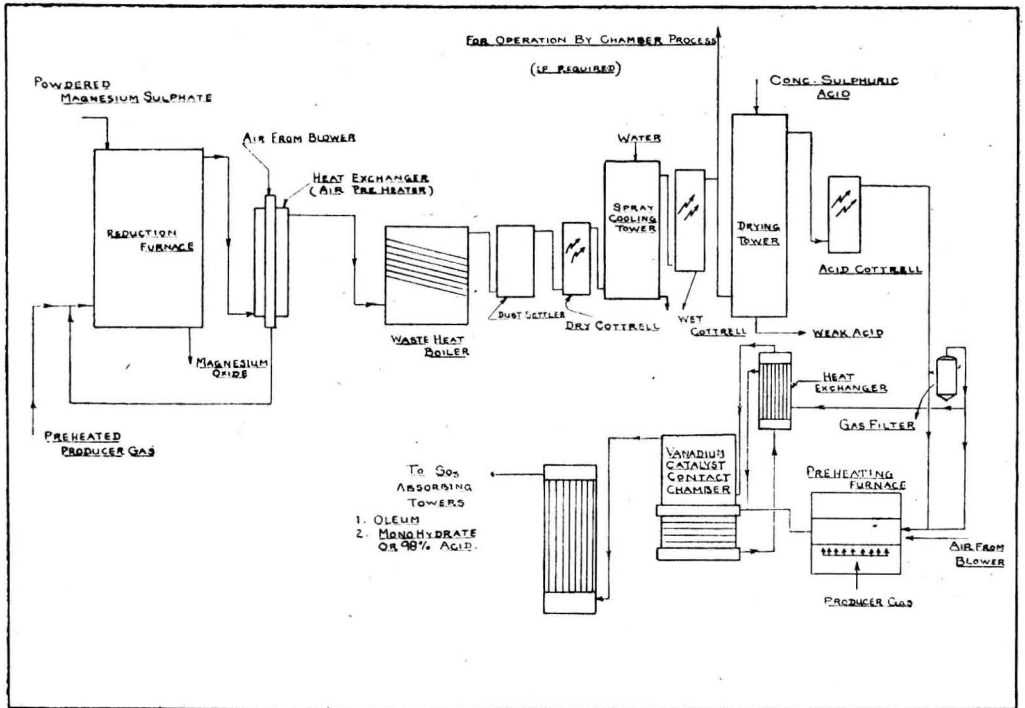
reports of other occurrences here and there, and our resources have not been sufficiently prospected. It is imperative that this is done without further loss of time. This is particularly important, since the deposits so far known are in comparatively inaccessible places, making their transport or that of the acid produced from them expensive. As regards gypsum, India's deposits are mainly in the Punjab, Trichinopoly, Jodhpur and Bikaner with small occurrences in Sind, Jaisalmer, Gharwal and Kashmere. Considering the large quantities of this raw material that are already known to be available, the use of the gypsum process which has been found to be industrially successful not only for manufacturing this acid but also for generating elemental sulphur and liquid sulphur dioxide in Germany, should be a clear pointer to us to solve our raw material problem.

During the recent visit of the author to Germany, he had the opportunity of inspecting a large pilot plant designed and put up for producing 50 tons of sulphuric acid per day from magnesium sulphate by adopting an entirely new and novel process. In spite of the war time difficulties in harnessing the necessary special constructional materials required, the plant was constructed and put into normal operation for securing the stipulated production. Further developments in this direction had been envisaged for adopting the process more widely in the country. Although on first thought, one may wonder how this process could be applicable in India in the absence of natural deposits, on careful consideration one sees immense potentialities of this process; for, in India, even with the present production of about 2.25 million tons of sea salt per year, the potential output of magnesium sulphate ($MgSO_4 \cdot 7H_2O$) from the bitterns could be about 260,000 tons. Even on the basis of only 40 per cent. recovery, the country, should be able to produce more than a lakh of tons of this material by the treatment of bitterns from all the salt works on the coast. By adopting the German process about 17,200 tons of magnesium oxide and 43,200 tons of 98 per cent. sulphuric acid can be manufactured from this quantity of magnesium sulphate. According to the estimates of the Heavy Chemicals Panel of the Government of India, the annual production and consumption of sea salt in India is expected to increase to about 5 million tons, so that on the basis of recovering magnesium sulphate from all the bitterns corresponding to this larger sea salt

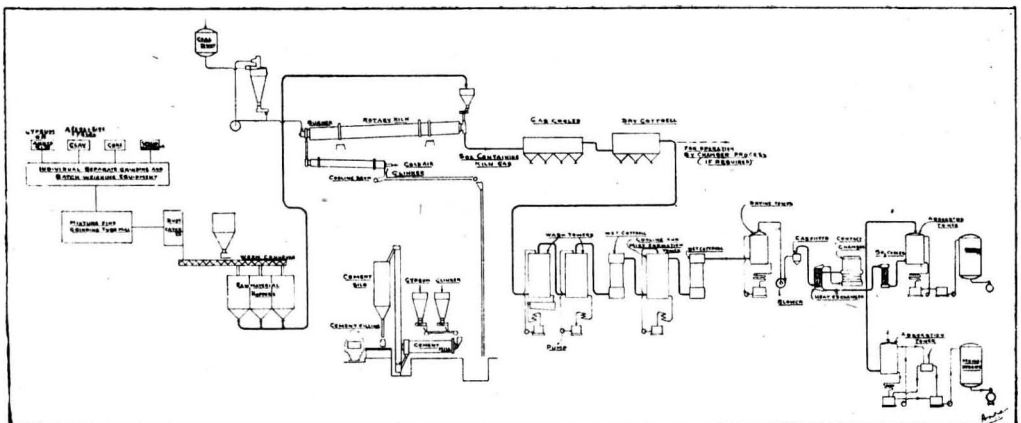
output, anywhere from 90 to 100 thousand tons of 98 per cent. sulphuric acid can be manufactured from this source alone. By improving the recovery efficiency of magnesium sulphate from bitterns, it should be possible to further increase the production of acid from this source. Magnesium oxide obtained as a by product of this process is a valuable material and should find an easy market. In regard to our raw material problem, therefore, there are at present two indigenous raw materials, gypsum and magnesium sulphate on which the future of our entire sulphuric acid industry has to be based, pending the detailed prospecting of our pyrites resources and utilization of the available deposits.

In regard to the question of process and equipment adopted in India, till recently most of the plants were producing the acid by the chamber process and were designed and erected according to the practice prevailing several decades ago. This was probably necessary at that time in view of the small sizes of the plants. It is only during the last decade that contact plants came into operation, and even today only about 25% of the manufacturing units employ the contact process. Excepting two plants, the rest of them are small and the designs do not seem to be quite in line with the latest practice for economical and efficient production. It is, however, expected that one of the bigger units that is now under erection and which happens to be of considerably larger size would be of the of latest type. It is well known that the cost of concentrated acid from a chamber plant is always higher than that from a contact plant and this dependence of the cost of production on the process employed should be remembered.

In addition to the factors mentioned above, the cost of production of acid in a small plant is always much higher than that in a bigger plant. The statement that is made in some books and which has also been mentioned by the Tariff Board (Page 14 of Report on Bichromates Industry) that the cost of production of sulphuric acid is roughly $\frac{1}{3}$ the cost of sulphur per ton plus Rs. 30/- seems to have recently received greater importance in our country than what it deserves. There is no doubt that this method of rough reckoning is useful in determining the approximate cost of production in big plants with capacities of 100 tons and over per day, for, it is based on the experi-



Manufacture of Sulphuric Acid From Magnesium Sulphate



Sulphuric Acid and Cement by Gypsum Process

ence of other industrialised countries in which the average daily capacities of plants in operation are of the order of 250 tons and over; but in the case of small plants such as those generally operating in India, this method of reckoning is likely to lead to very inaccurate inferences. In India, with the exception of 2 or 3 plants which are of 25 tons and over, most of the plants are of approximately 10 tons per day, excluding about 10 to 12 plants which are of the order of 1 to 2 tons per day. While even our biggest plants should be considered uneconomical from the point of view of cost of production of acid in comparison with bigger units in other industrialised countries, the smaller 1 to 2 tons per day plants should be considered as little more than laboratory units in which the cost of production is bound to be extremely high.

It may perhaps be desirable to discuss here in detail the reasons for wide variations in the costs of production in plants depending on their capacity:

(1) *Cost of raw material.*- The cost of raw material per ton of product is almost independent of the capacity of the plant, although in the case of bigger plants it would go down slightly due to higher efficiencies in operation and some saving in handling charges.

(2) *Steam.*- While extraneous steam is required in all smaller plants, in the case of bigger plants steam can be generated within the system and the cost of production is reduced by making due allowance for this steam which is available for other process purposes.

(3) *Power.*- In the case of smaller and medium sized plants, external power is wholly required, while in the bigger plants a part of the power could be generated using the steam produced in the system.

(4) *Labour & Supervision.*- The aggregate cost of labour and supervision irrespective of the size of the plant remains nearly constant, and in any case does not definitely increase rapidly with increasing capacity i. e., these expenses diminish rapidly per ton of the product with increase in the capacity of the plant.

(5) *Maintenance.*- Expenses on this item diminish rapidly per ton with increasing production.

(6) *Investment.*- The investment on plant, erection, buildings and auxiliaries diminishes rapidly per ton with increase in the size

of the plants. According to the most recent quotations, the costs of contact plants of different capacities ready for operation in India are roughly as follows:

Capacity:	Amount.
10 tons per day.	Rs. 4,00,000
20 " " "	" 6,00,000
50 " " "	" 10,00,000
100 " " "	" 15,00,000

These figures are subject to variations depending on the location of the plants. Provision has not been made here for carrying sufficient stocks of sulphur as well as for working expenses. In regard to the former, there is a fundamental difference between conditions in India and those obtaining in America i. e., comparatively heavy investments ranging from about Rs. one lakh to about 10 lakhs, depending on the capacity of the plant, are required towards cost of imported sulphur, ample stocks of which will have to be carried always. The stock of sulphur to be carried being related to plant capacity, the interest on this investment is directly proportional to production; but as regards depreciation on plant and buildings and other overheads reckoned per ton of the product, they diminish rapidly with increase in the size of the plant, becoming, in the case of a 100-ton plant, only about 40 per cent. of that in a 10-ton plant.

The above brief discussion of the factors convincingly shows that the cost of production of sulphuric acid should always be lower in bigger plants and comparatively much higher in the case of smaller plants. Comparison of the costs of production of this commodity in other countries with that in India is, therefore, not valid.

In regard to our operating conditions, there is another important aspect that has to be borne in mind. Most of our plants are old chamber plants in which efficiencies are low and maintenance charges are high, both on account of the ante-dated designs and the age of the plants. It is expected that in the first instance plants of small capacities which are most uneconomical should be scrapped and gradually even the 10-ton units should be given facilities for increasing their capacities to more economical sizes. Unless a rational development is envisaged and the present difficulties contributing to higher prices are eradicated, it may be futile to attempt to bring down the price of sulphuric acid.

It may not be out of place here to mention that as late as in November 1944, at a Meeting of the Sulphuric Acid Control Panel convened by the Government of India, the factors determining the cost of production of sulphuric acid at that time were carefully gone into and the selling price was fixed at Rs. 290/- per ton. To-day, two years after the cessation of hostilities, circumstances have still not changed much for the better except in regard to the price of sulphur which has gone down by about Rs. 40/- to 50/- per ton. On the other hand, the conditions of the plants have become generally worse, partly because of aging and also since plant operations had to be maintained at all costs to help war supplies amidst difficulties in obtaining repair and constructional materials during the war years. These difficulties continue largely even to day. Wages have also been steadily increasing so that there is no factor which can enable the sulphuric acid manufacturers, as things stand at present, to reduce their selling price to any large extent.

Solution to the problem

In the Heavy Chemicals Panel Report recently published by the Government of India, it has been suggested that about fifteen 10-ton plants should be put up in different parts of the country for increasing the future production of sulphuric acid. The author feels that this step would be retrograde since in the light of what has been discussed above, the cost of production in a 10-ton plant can, under no circumstance, be brought to a level with those obtaining in other countries. He is, on the other hand, of the opinion that possibilities should be explored to amalgamate even the existing small plants operating in nearby areas into larger units so as to bring down the cost of production. Facilities should be given to existing manufacturers to increase their plant capacities and to put up bigger economical units, by Government advocating and contributing, wherever advisable, to the development of acid-consuming industries only in areas in proximity to centres of acid production. The Heavy Chemicals Panel has recommended that the Government should put up an experimental gypsum plant with a capacity of 35 tons per day. While no time should be lost in giving effect to this recommendation, the author found from the discussions he had with the German experts that the manufacture of

sulphuric acid and sulphur from gypsum is a standardised process and not so intricate or undeveloped as has been stated in the report. Gypsum plants with daily capacities of 25 to 300 tons of 98 per cent. acid or for recovering 10 to 50 tons of sulphur have already been put up in Germany, Switzerland, Austria and Japan by a well-known designing firm of Engineers. In addition there are other plants in England and France operating by the gypsum process. As a result of discussion with some of the German experts who have a first-hand knowledge of this process in all its ramifications, a considered opinion has been obtained that the minimum size of the gypsum plant should be 100 tons per day and under no circumstance should a plant of less than 50 tons per day be permitted. It is, therefore, suggested that the capacity of the experimental plant to be put up by the Government in the first instance should be at least 50 tons and on the basis of the data and experience gained for ourselves in the design, erection and operation of this plant, other plants of bigger capacities could come into existence in due course.

As is well known, the gypsum process yields cement also as a by-product and a cement plant of less than 100 to 120 tons of cement per day is not an economical unit. From both considerations, therefore, the plant capacity of the gypsum unit should be 100 tons of acid per day. It has been estimated that the total cost of a gypsum process plant for producing 125 tons of cement and 125 tons of 98 per cent. acid per day by the contact process is roughly Rs. 40,00,000/-. If, on the other hand, the sulphurous gases are converted into acid utilising the modern adaptations of the chamber process, the entire cost of the plant would be only a little over Rs. 30,00,000/-. These estimates are on the basis of investments on German plants and reckoning 20 Marks to a pound Sterling. To-day, however, the standard rate of exchange fixed by the Military Government in Germany is 40 Marks to a pound Sterling, so that estimates of these plants in terms of Sterling and further in Rupees would be very much lower. There is, however, one aspect which requires to be mentioned in this connection. Most of the gypsum plants operating in Germany have been using anhydrite. While using gypsum, slight modifications would be required and these have also been worked out in some places in Germany.

As explained before, the prospects of adopting magnesium sulphate process should be explored without further delay and extensive work undertaken both on this problem as well as on the development work required for the gypsum process, in a suitable research organisation in the country provided with facilities for pilot plant work. Collaboration with senior chemical engineers already employed in the industry, who have visited such plants and possess experience of actual factory operations would be desirable in arriving at tangible conclusions and for translating the data collected into practice. Plant and buildings for producing about 20 tons of magnesium oxide and 50 to 55 tons of 98 per cent. acid per day cost approximately R.M. 3,500,000 or about Rs. 25,00,000 even at the old rate of exchange of R.M. 20/- per Pound Sterling. This estimate was based on war conditions and taking the present advantageous exchange rate of R. M. to Sterling, the price could be very much lower. In case this investment is considered too heavy for a pilot plant, a smaller plant of at least 10 to 20 tons acid capacity per day and entirely financed by the Government should be put up so as to collect the necessary data for the development of this process in India.

In connection with the larger sized plants recommended by the author, there might be a controversy in regard to the distribution of acid and difficulties and freight charges involved. Simultaneously with the introduction of Government directives on the sizes and location of the sulphuric acid plants with a view to bring down the cost of production, it is necessary to organise and co-ordinate also the development of other sulphuric acid consuming industries at such centres of acid production, consistent with the availability of raw materials required for such industries. In other cases, where transport is essential, bulk transport in tank wagons should be encouraged by railways providing the necessary tank wagons for carrying goods in bulk over economic freight distances. Special tariff rates may also have to be provided by Government to enable movement of such essential goods.

In regard to the bichromate, phosphoric acid and phosphate industries on account of which the question of supply of cheap sulphuric acid has been specifically raised at the moment, the solution to their troubles cannot be achieved by influencing them to

put up small acid plants to meet their requirements. From what has been stated above, it should be clear that the cost of production in the small plants would not be lower than the cost in the present sulphuric acid manufacturing units. As regards the cost of phosphoric acid, phosphate, superphosphate; etc., a reduction in the prices of these products is possible, and has to be brought about not merely by lowering the price of acid used but also by carefully controlling the price at which the other basic raw materials,—bones or rock-phosphate—, would be available. With the recommencement of export of bones to other countries, the price of bones which had gone down during war years has again shot up making the cost of production of superphosphate high. It must be admitted that if superphosphate has to be widely used by the farmers to step up food-production, it has got to be made much cheaper by providing every possible facility to the manufacturers. There are other factors which influence the cost of production of superphosphate from bones, and these should receive separate consideration. It may perhaps be found possible to eliminate the use of sulphuric acid almost completely by working out conditions under which the T.V.A. process can be adopted for using bone as raw material.

The views put forward above do not diminish the importance of a thorough exploration of the pyrites deposits in India, for, depending on the different types of raw materials available, the prospects of using each of them under different conditions and in different localities have to be ultimately developed. Whatever be the raw material adopted in different places, the plants will have to be of comparatively large capacities and of economical sizes, in addition to the adoption of the more efficient processes for conversion of sulphurous gases to sulphuric acid. It seems that the future processes to be used in India for this stage will have to be restricted to (1) Contact plants of large sizes utilising vanadium contact catalyst in the latest types of 3-stage converters and equipped with waste-heat boilers and power generating equipment wherever deemed advisable, and (2) Intensive reaction process utilising Mills-Packard or Petersen towers so as to secure high efficiencies with minimum chamber space and low operation and maintenance charges.

Petroleum*

By E. S. PINFOLD

(Continued from September issue)

The oil occurs in the upper part of the Barail and in the Surma and Tipam Series. It is thus at a somewhat higher horizon than the oil-source rocks of northwest India. Assam is one of the regions in which coal and oil are found in beds of the same age (Barail), and this association led Pascoe and others to emphasise the close relationship in this and some other areas of the two minerals.

A large number of test wells have been drilled on structurally favourable areas in Upper Assam, Silchar and Sylhet Districts in the Surma Valley, in the Chittagong region and in the Teknaf peninsula. Only two oil-fields have as yet been proved; Digboi in Upper Assam and Badarpur in the Surma Valley west of Silchar.

The Digboi oilfield, from which almost the whole production of Assam has been obtained, lies on a narrow, asymmetric anticline which runs ENE, WSW, across the eastern margin of the Brahmaputra plain near its northwest corner. The structure is steeply folded, and the southern limb is, in places, overturned and thrust faulted. This area was first drilled by the *Assam Railways and Trading Company* in 1888; *The Assam Oil Company* continued development from 1899 to 1922 when the *Burmah Oil Company* acquired a controlling interest. Production in 1892 was 28,000 gallons only, but this rose to 753,049 gallons, in 1900, and to 3,320,680 gallons in 1920. A rapid increase occurred after 1922, and by 1940 the Digboi was producing 65 million gallons per annum.

The Badarpur field was first drilled in 1915, but yielded only a very small production, and was eventually abandoned in 1933. The oil in this field was obtained from an anticline in the Surma Series of Lower Miocene age. A very deep test was drilled on the Masimpur anticline a few miles east of Badarpur without encountering any oil deposits of workable size.

Arakan Coast.- This forms the direct continuation southwards of the Assam region, and geological conditions are closely similar. The geological succession includes a great thickness of Lower Miocene sandstones and shales, mostly unfossiliferous but with occasional marine bands, overlain unconformably by Upper Tertiary rocks which are mostly soft sandstones. The structure is severely compressed and comprise a number of narrow, asymmetric, anticlinal and synclinal folds, the degree of compression increasing eastward into the Arakan Yomah ranges. Oil seepages are not abundant, but small yields of light oil have been obtained for many years past from shallow wells on a sharply folded anticline at the southern end of East Baronga Island, south of Akyab, and from complex structures near Kyaukpyu on Ramri Island. Large natural gas shows on Cheduba Island give rise to mud volcanoes, and outbursts of considerable violence have been reported from time to time. Mud Islands due to the same causes have been formed several miles out to sea off Cheduba and Flat Islands.

Burma - Ball's account of the Burmese oil industry in 1881 and earlier has already been referred to. A detailed description of the geology and production of the Burma fields is contained in E. H. Pascoe's memoir,⁶ with full bibliography to that date. A later description is that by L. Dudley Stamp in H. L. Chhibber's *Mineral Resources of Burma*⁷. A full account of the regional geology is given in a paper by P. Evans,⁸. The natural gas resources of Burma have been described by C. T. Barber⁹.

Burma can be divided into the following structural zones: (i) The Arakan Yoma, a broad mountain belt of complex structure and composed almost entirely of shales and phyllices with subordinate sandstones; these rocks are mostly unfossiliferous but are believed to range from Trias or older to Tertiary; (ii) The Chindwin Irrawaddy syncline, a wide, open-folded basin of mostly

* Contribution to the *Dictionary of Economic Products and Resources of India*. Suggestions are invited by the Chief Editor, 20 Pusa Road, New Delhi.

Upper Tertiary rocks, but interrupted by elongated anticlinal and dome structures exposing lower beds; (iii) The Shwebo Hills and Pugu Yoma, a second belt of hilly country of simple structure in the north but becoming a wide belt of complex folding further south; (iv) The Shan plateau, a region of much older (Palaeozoic) rocks, which has remained stable and comparatively undisturbed during the violent folding movements of late Tertiary times. Oil and gas shows occur in the foothills of the Arakan Yoma, the Chindwin-Irrawaddy basin, and in the Shwebo Hills and Pugu Yoma; no oil or gas shows are known in the Shan States and their structural continuation from Moulmein through Amherst, Tavoy and Mergui. The productive fields are confined to the Chindwin-Irrawaddy basin.

Granite intrusions of considerable size occur along the fault line which form the boundary between the Shan plateau and the Tertiary folds to the west. Recent or sub-recent volcanic activity has resulted in the outpouring of lavas and ashes in several parts of the Chindwin and northern Irrawaddy valleys; Mt Poga, 4,981' above sea level, is an extinct volcano thirty miles east of the Singu oilfield. No relationship between this volcanic activity and the occurrence or absence of oil has been recognised.

The oil occurrences are confined to the Eocene, Oligocene, and Lower Miocene; the Oligocene and Lower Miocene together form the Pegu Series. These rocks are marine, estuarine and freshwater deposits laid down in a gulf which stretched north and south between what are now the Arakan Yoma and the Shan plateau. The gulf became filled up progressively, so that marine conditions persisted later in the south than in the north, and individual members of the succession tend to pass from marine clays through estuarine alternations to fresh-water sandstones when traced from south to north.

The Eocene is most fully developed in the north of Burma where it attains a total thickness of over 30,000', and includes representatives of all the Eocene stages as known in northwest India. The Eocene rocks are thick shales and clays containing limestone bands and coal seams, interbedded with sandstones and conglomerates, some of which have yielded a rich mammalian fauna. Oil seepages are numerous throughout the Eocene, but despite several test wells in the

Upper and Lower Chindwin and Pakokku Districts, no workable oilfield has yet been proved in rocks of this age.

The Peguan deposits are lithologically similar to the Eocene and include clays and shales with thin fossiliferous hard bands and thick sandstones often containing fossil wood. The total thickness of the Peguan is estimated to be about 20,000'. Oil and gas shows are numerous in the oilfields region, and almost the whole of the oil production obtained in Burma has been from rocks of this age. Mud volcanoes (*Bur. Nagabwet*) occur in Eocene and Peguan rocks at many localities from Henzada in the South to the far north of the Chindwin valley; the Burmese attribute these to super-natural agencies.

There is a pronounced unconformity at the base of the succeeding beds corresponding with that at a similar horizon in Assam and northwest India. The whole of the Peguan is absent in some parts of Upper Burma, due to the earth movements and erosion which occurred at this time. The newer rocks, known in Burma as the Irrawaddian, are almost entirely soft, yellow sandstones, highly ferruginous in places, and containing abundant fossil wood and vertebrate remains. Some brown and gray clays and occasional conglomerates occur in the upper part of the series. The total thickness of the Irrawaddian is about 10,000. No oil or gas shows occur in this formation, but the Irrawaddian basal conglomerate, known as the 'Red Bed', outlines the Peguan inliers as a rim rock in all the main oilfields.

All the productive areas occur as anticlinal interruptions in the Irrawaddy-Chindwin basin (*see* Fig. 6); they will be briefly described from the south northwards.

Pyaue:— Natural gas under considerable pressure occurs in a small dome structure about ten miles south of Thayetmyo. The discovery well, drilled by the *Indo-Burma Petroleum Company* with cable tools in 1926, could not be controlled with fittings available and blew wild for some months. The gas from this field has been utilised as fuel in the *Burma Cement Company's* works; about two million cubic feet daily was supplied to the plant under the well-head pressure available at the field. A deep test for oil was drilled recently but no workable oil-sands have yet been proved.

Padaukpin:— This oilfield is on a faulted dome structure in Peguan rocks, seven miles

west of Thayetmyo. The area has been tested from time to time by various companies, but results have been disappointing. This field attained a production of 17,000 barrels per annum in 1926; no production has been recorded in recent years though some drilling is still being done.

Yenanma:— This small field, about forty miles northwest of Thayetmyo, is exceptional in that it lies close to the foothills of the Arakan Yoma and is an easterly dipping monocline without any surface evidence of anticlinal structure; the cause of the oil accumulation has been attributed to overthrusting or to lateral variation in the sandstones and shales. The field was discovered by the *Indo-Burma Oilfields, Ltd.* in 1922. Only a small production was obtained, and the company went into liquidation. A new company, *Yenan Mines, Ltd.*, took over the property from the debenture holders and was working the field at the time of the Japanese occupation. Production under the new management has fluctuated around 200 barrels daily and was reported to be above this figure in 1941-42.

Minbu:— The Minbu anticlinal is a long, compressed, asymmetric fold with pronounced overthrust faulting on its eastern flank; it is much complicated by cross faults and minor structures. The fold axis runs almost due north and south along the western bank of the Irrawaddy River between latitudes 20°0' and 20°10'. Several small oil-pools have been proved and worked by various companies, the most important localities being Yethaya, Palanyon, Block DS and the area north of Minbu town.

Due mainly to the complex geology, results have on the whole been disappointing and have not repaid the considerable sums which have been spent on prospecting and drilling. The earliest recorded production was in 1910 and the output reached a maximum of over six million gallons in 1928. Production for 1937 was 3.75 million gallons only.

Yenangyaung.— The principal oilfields of Burma, Yenangyaung, Pynma, Singu (Chauk), Lanywa and Yenangyat, all lie on a single elongated anticlinal which rises from the Irrawaddy basin twenty miles east of the Minbu structure and runs NNW for over one hundred miles. Pronounced doming occurs on this fold axis at, from south to north, Ondwe, Yenangyaung, Singu and Yenangyat. All these domes have been drilled to consider-

able depths, with remarkably varied results: Ondwe got gas only to a depth of over 6,000'. Yenangyaung has a succession of numerous and rich oil-sands; at Singu there are fewer and more regular oil-sands, some of them with gas-caps; and at Yenangyat the few oil-sands found are poor producers only.

At Yenangyaung the Peguan is oil-bearing from the surface downwards, and the large number of variable oil-sands and exceptionally close competitive drilling, have resulted in a very high production per acre for this field. The structure is more robust than at Ondwe with flank dips of 35° to 50°, the western flank being somewhat steeper than the eastern.

Yenangyaung is known to have been an important oil producer from seepages and from shallow hand-dug wells since very early times. The production of this field since 1889 is illustrated in Fig. 2; almost the entire production from India and Burma was from this field until Singu and Digboi became important contributors from 1910 onwards. The Yenangyaung field reached peak production, 203,638,043 imperial gallons, or approximately 14,000 barrels daily, in 1918. Production had declined to about half this figure in 1942. Total production from this field to date about 6,000 million gallons, a remarkable figure in view of the restricted area, less than 700 acres, from which this production has been obtained. Recent extensions have been proved some distance east and north of the main dome summit.

In two portions of the Yenangyaung field, known as the Twingon and Beme Reserves the oil rights have been reserved to certain Burmese families, in continuation of rights held under the Burmese kings. Well sites at 60' intervals have been demarcated in these areas and distributed from time to time amongst these Burmese families and their descendants, known as 'Twinzayos', and these in turn lease or sell the sites to the operating companies. A large proportion of the production from Yenangyaung has been obtained in the two Reserves.

In 1942 about 3,000 drilled wells were producing. Deep tests have been drilled to over 7,000' but no oil-sands of consequence have occurred below 4,000' on the dome crest; sands far out on the eastern flank have been proved at depths down to over 5,000'. In addition to the machine drilled wells, over

200 hand-dug wells are still producing from sands down to 300'-400'.

Pyinma, Singu and Lanywa Fields.—These fields, two of them of comparatively recent development, occupy part of a single elongated dome, discovered originally by Grimes of the Indian Geological Survey in 1893, and first drilled by the *Burmah Oil Company* in 1902. Production reached 2,300 barrels daily by 1905, and increased to nearly 7,000 barrels by 1919. In 1937, 568 wells on the main Singu field yielded a total output of 119,858, 608 gallons for the year. This field has been treated as a reserve and production has been drawn from it in increasing quantities to offset the decline of the older field.

The Singu fields have been worked under careful technical control, more especially as regards water incursion and gas offtake, and still remain the most important reserves of oil in sight in Burma.

Due to the marked asymmetry, the east flank dips almost vertically, all the production to date has been from the moderately dipping western flank. Large gas-caps occur in several of the sands, and gas off-take has been carefully controlled; several wells with unduly high gas/oil ratios have been plugged.

The crestal area of the Singu structure has been worked entirely by the *Burmah Oil Company*; other companies later obtained some production on outlying blocks. The *British Burmah Petroleum Company* still produces from an area on the south pitch of the fold. At its northern end the Singu field is truncated by the Irrawaddy River, and in 1919 the *Indo-Burma Petroleum Company* found oil on the opposite bank of the river near Lanywa village, thus demonstrating that oil production was probably continuous across almost three miles of the fold beneath the river bed. A retaining wall was built along a semi-permanent sand-bank, and this wall, with later extensions, has now reached over two miles in length; it has been constructed high enough to be clear of the forty feet seasonal rise of the river. The area at the back of the wall has been sand-filled, and over 100 producing wells have been drilled in the reclaimed area. This is known as the Lanywa oilfield. Production was first obtained from the reclaimed area in 1926, and by 1937 production had reached over 12,000 barrels daily. It was later maintained at about this figure with the assistance of several wells drilled at a considerable and

controlled inclination to tap the sands well out-beneath the river bed to the east. A similar retaining wall and sand-fill was later constructed by the *Burmah Oil Company* on the eastern bank of the river.

The Singu field is intersected by several transverse faults which, to some extent, affect the distribution of oil and gas. The most important of these is the Thatagu Fault which crosses the western flank almost at right angles to the crest, three and a half miles south of the dome summit. This fault has a downthrow to the north of 350' and heads northwards at 35° to the vertical. It has held up an important oil-pool to the south, with two large and several smaller oil-sands between 3,500' and 5,000'. This area, now known as the Pyinma oilfield, was first tested by the *Moola Oil Company* in 1936. The adjoining blocks to the west, belonging originally to the *British Burma Petroleum Company* and to the *Indo-Burma Petroleum Company*, have been developed jointly by a subsidiary company formed for this purpose, the *Pyinma Development Syndicate*, and much wasteful competitive drilling so avoided. Production from this field had reached 2,000 barrels daily in 1941.

Yenangyat.—This is the most northern field on the Yenangyaung Singu anticlinal. The structure is similar to that at Singu, but the eastern flank is now overturned, and overthrust, and a considerably greater thickness of Pegu beds is exposed in the crestal area. Production was first obtained in early wells, this field has been a disappointment; peak production was attained in 1903 (22,668,312 gallons, or 1,550 barrels daily) but the field declined rapidly and in recent years has been producing less than 100 barrels daily. Deep tests have also been disappointing.

Indaw.—Although many test wells have been drilled in the region north of the main oilfields, no workable oil has been proved except in the Indaw field, Upper Chindwin District, 180 miles north of Singu. This field occupies the crest of a large dome structure which arises from the centre of the Chindwin basin. Gas shows, mud volcanoes and small oil seepages occur in the crestal area. The fold is asymmetric, the east flank being vertical and compressed; the west flank dips at moderate angles and there is a wide low-dripping crest. As in the main fields, the basal conglomerate of the Irrawaddian (here

probably at a somewhat lower horizon) forms a rim completely round the structure, the beds within the rim being equivalent to the Peguan. This well has supplied gas for fuel until recently. Oil in fair quantity was struck in the second well, and this led to the development of a small shadow oil-pool. The field has produced a total of about forty million gallons to date, and was producing about 75 barrels daily in 1941. Attempts have been made to test to greater depths, but high pressure gas and water sands have hitherto prevented the test wells from being carried to much below 3,000'.

Prospecting in Burma

The major companies have employed large geological staffs, and all the regions in which oil might occur have been examined in considerable detail. This work has recently been supplemented by aerial surveys and geophysical exploration. A vast expenditure has been entailed, but results have been extremely disappointing, for, apart from the discovery of the Indaw field and extensions to Yenangyaung and Singu, no new field of commercial importance has been discovered. Over thirty separate anticlinal structures have been tested by the major companies with only negative results. A list of these is given by E.L.G. Clegg in *The Mineral Deposits of Burma*¹⁰.

All the fields were demolished as far as possible before the Japanese occupation in April 1942. Many of the smaller wells will not be worth re-drilling or repair. It seems probable that the pre-war level of production will never be regained.

Petroleum Rules and Regulations

Over most of India and the whole of Burma, mineral rights are vested in Government; the main exceptions are the Indian states, Bengal and parts of Assam. Prospecting Licenses are granted to reputable applicants of Indian, Burman or British nationality, and to companies in which a majority of the share capital is owned by persons of these nationalities. Licenses are normally issued for two years during which exploratory work must be carried out and test wells drilled; and license can usually be renewed if the work is not completed in the time allowed. The rental for prospecting licenses is normally annas 4 per acre for the first year, increasing by yearly increments to one rupee per acre.

If oil is proved, a Mining Lease may be granted for any part or the whole of an area previously held under prospecting license. A mining lease is usually for thirty years with an option to renew for a similar period. A dead rent is payable unless this is covered by the royalty on the oil won; this is annas eight per barrel, or 5 per cent. *ad velorem*.

All operations must be carried out in an efficient manner to the satisfaction of government officials, in Burma the warden of the oilfields and his adviser, a Resident Geologist seconded from the Geological Survey of India.

Imports and Exports

India's oil production is quite insufficient to meet her own requirements and the only oil product which is exported in any quantity is paraffin wax; in 1940 the value of paraffin wax exported from India was Rs. 32,97,874.

The following were imported into India in 1940:

Kerosene	Rs. 7,51,32,198
Fuel oil	" 2,14,72,602
Lubricating oil (Batching oil)	" 61,19,939
" " (other lubs.)	" 2,04,92,944
Motor Spirit	" 4,35,64,574
Other dangerous petroleum	" 23,72,439
Grease	" 16,41,479
Paraffin wax	" 7,16,012
Candles	" 8,92,043
Asphalt	" 23,21,048
Total:	Rs. 17,47,25,278

The main sources from which these were obtained include: Burma, the Dutch East Indies, Iran, the United States of America and Trinidad.

Table III gives the important duties in force at present.

The Petroleum Industry in India and Burma

Fifteen major companies, and several smaller ones, are engaged in the search for oil and in its production and refining. Over fifty additional companies are active in the importing, distributing and sale of petroleum products. In 1940 almost the whole of the production in India and Burma was being

Table III.

	Standard Rate.	Preferential rates from.	
	%	Brit. Cols.	Burma.
Asphalt	30	18	6
Min. oils not otherwise Specified.	30		12
Kerosene and illuminate	As. 4/6/per gal.		
Motor spirit	As. 15/- " "		
Jute batching oil	Rs 18/12/- per ton.		Free
Flash Pt. at or above 150°F	15		
Lubricating oils.	As. 2/6 per gal,		

Excise duties in force in India in 1944 were:

Kerosene	As. -4/6 per gal.
Motor spirit.	As. -15/- " "

obtained by the *Burmah Oil Co. Ltd.* and its subsidiaries (including the *Assam Oil Co. Ltd.*), *The Indo-Burma Petroleum Co. Ltd.*, *The Attock Oil Co. Ltd.* and the *British Burma Petroleum Co. Ltd.* The issued capital of the sterling producing companies is over 21 million pounds; that of the more important rupee companies over two crores. More than thirty companies formed to prospect for and produce oil in India and Burma have failed or become moribund in the last thirty years.

The number of nationals employed by the producing companies in India and Burma is over 30,000, whilst an additional 9,500 are employed indirectly. The producing companies paid to Government in 1949 over Rupees 45 lakhs in royalty, and excise payments on kerosene and petrol amounted to over 9.5 crores. Other contributions to the revenue of India and Burma, including income tax, amounted to over 1.6 crores. These figures demonstrate that the production of petroleum and the refining and distribution of petroleum products hold a pre-eminent place in Indian industry.

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10. *The Mineral Deposits of Burma*, 1939, Govt. Press, Rangoon.

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on every branch of the subject by experts. The latter contains a particularly valuable chapter on the literature of the subject, including a list of past bibliographies and others which are being produced in periodical form. Reference may also be made to the *Proceedings of the World Petroleum Congress*, London, 1933, and Paris, 1936.

The following Government Departments and learned societies issue periodical and other publications devoted wholly or partly to the subject: *The Geological Survey of India* (papers in the *Records and Memoirs*, quarterly, annual and quinquennial reports on mineral production), *The U.S. Geological Survey and Bureau of Mines*, *The American Petroleum Inst.*, *The American Bureau of Standards*, *The Inst. of Petroleum* (formerly the *Inst. of Petroleum Technologists*), *The American Assoc. of Petroleum Geologists*, *The Am. Inst. of Mining and Metallurgical Engineers*, *British Standard Specifications*, and the *Imperial Institute*.

There are many handbooks describing the American industry, but these tend to become out of date and are apt to be somewhat parochial. Such are:

D.T. Day (Ed. in Chief), *A Handbook of Petroleum*, 1922, John Wiley and Sons, Inc.

E.R. Lilley, *The Oil Industry*. New York, 1925, D. Van Nostrand Co.

The best known European treatises are:

Boverton Redwood, *Petroleum*. 5th Ed. London and Philadelphia, 1926, C. Griffin & Co., Ltd., and J.B. Lippincott Co.

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Max W. Ball, *This Fascinating oil Business*, Indianapolis, 1940, Bobbs Merrill Co.

J. G. Crowther, *About Petroleum*, Oxford Univ. Press, 1938.

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Special publications of the *Am. Ass. Pet. Geologists*, Tulsa: Sidney Powers (Ed.), *Structure of Typical American Oilfields*, 1929; W. E. Wrather and E. H. Lahee, *Problems of Petroleum Geology*, 1934; Henry E. Ley (Ed.), *Geology of Natural Gas*, 1934.

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W. H. Jeffrey, *Deep Well Drilling*, 3rd Ed., Houston, Tex., Gulf Publishing Co.

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J. R. Suman, *Petroleum Production Methods*, Houston, Tex., 1922, Gulf Publishing Co.

L. C. Uren, *Petroleum Production Engineering, Oilfield Exploitation*, 2nd Ed., New York, 1934, McGraw Hill Book Co.

S. C. Herold, *Analytical Principles of the Production of Oil, Gas and water*, Stanford Univ. Press, 1928.

India and Burma: The following are some of the publications which have appeared since Pascoe's memoirs, and additional to those mentioned in the text of this article. The geology of the north-western region is described in:

C. S. Middlemiss, *Possible Occurrence of Petroleum in Jammu Province: Preliminary Note on the Nar Budhan Dome of Kotli Tehsil in the Punch Valley*, *Rec. Geol. Sur. Ind.*, 1919 49, Pt. 4.

E. Parsons, *The Structure and Stratigraphy to the North-West Indian Oil-Belt*, *Jour. Inst. Pet. Tech.*, 1926 12, 439.

D. N. Wadia, *Geology of Poonch State and Adjacent Parts of the Punjab*, *Mem. Geol. Sur. Ind.* 1928, 51, Pt. 2.

R. van Vleck Anderson, *Tertiary Stratigraphy and Orogeny of the Northern Punjab*, *Bull. Geol. Soc. Am.* 1927, 38, 665.

H. M. Lahiri, *Dome near Mari, Attock District*, *Rec. Geol. Sur. Ind.* 1930, 63, Pt. 2.

G. de P. Cotter, *Geology of that Part of the Attock Distt. west of Longitude 72° 45'*, *Mem. Geol. Sur. Ind.* 1933, 55, pt. 2.

Additional publications relating to the geology of oil region in Burma are:

L. Dudley Stamp, *Conditions governing the Occurrence of oil in Burma*, *Jour. Inst. Pet. Tech.* 1927, 13, p. 21. *The Geology of oil-fields of Burma*, *Bull. Amer. Soc. Pet. Geol.* 1927, 11, 557. *The Oilfields of Burma*, *Jour. Inst. Pet. Tech.*, 1929, 15, 300.

G. W. Lepper, *An outline of the Geology of the Oil-bearing Regions of the Chindwin-Irrawaddy Valley of Burma, and of Assam-Arakan*, *Proc. World Pet. Cong. London*, 1933, 1, 15.

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PROF. MAX VON PLANCK

Obituary

Prof. Max von Planck

(April 23, 1858 — October 4, 1947)

WE regret to record the death of Prof. Max Planck at Göttingen on October 4, 1947. Prof. Planck's name is known wherever physics is taught and studied, as the discoverer of the celebrated Quantum Theory or the Doctrine of Elemental Quanta, which necessitated a fundamental revision of the physical concepts. This discovery was announced in a classical communication to the German physical Society on December 14, 1900, under the title "On the Distribution of energy in a Normal Spectrum." Kirchoff had shown that the distribution in wave length of heat radiation produced in an enclosure surrounded by any emitting or absorbing bodies, all at the same temperature, was independent of the nature of such bodies. This showed that the distribution of radiant energy in an enclosure in terms of temperature and wave length could be expressed in terms of a universal function. As a result of several years of work, Planck established the new fundamental and universal constant which not only provided the general formula for the spectral distribution of heat radiation, but also proved to be "of great value to the problem of specific heat of solid bodies, in explaining the effect of light-electricity and in many other phenomena of

electric science. It throws light on the constructive law of the periodical system of elements and lays the foundation for a future astronomy of atoms."

Max Planck was born in Kiel and studied physics and mathematics at Munich and Berlin. He took his doctorate in 1879 in recognition of his dissertation on the Second Law of Thermodynamics, and in the following year became lecturer in physics at the Munich University. Five years later, at the early age of 26, he was appointed extraordinary professor at the University of Kiel and in 1899, succeeded Kirchoff as professor of theoretical physics of the Berlin University. He was appointed permanent secretary of the Prussian Academy of Sciences in 1912, and was awarded the Noble Prize for Physics in 1918 in recognition of the merit he had attained for the development of physical science by his discovery of the elemental quantum." Prof. Planck was elected President of the Berlin Kaiser-Wilhelm-Gesellschaft zur Förderung der Wissenschaften, a post which he filled with conspicuous distinction until 1933. He was elected Foreign Member of the Royal Society in 1926, and awarded the Copely Medal in 1929.

REVIEWS

Theoretical Chemistry By Samuel Glasstone: Third Printing: (1946) D. Van Nostrand Company, Inc. New York: (pp. viii + 515). Price 31/6 net.

This book is intended to be an introduction to the study of Quantum mechanics, Statistical mechanics, Molecular spectra and allied topics from the view point of the chemist. There are nine chapters dealing with such aspects. Elementary principles and the notation of quantum mechanics are explained in the first two chapters. Great clarity of exposition is a feature of these two chapters. The third chapter deals with the subject of valency and is likely to be of particular interest to chemists. It must, however, be mentioned that the treatment here, as in other chapters, is somewhat mathematical in character as it is bound to be in a book of this type. The next three chapters deal with the configurations of diatomic and polyatomic molecules with special reference to their spectroscopic behaviour. Different types of spectra such as rotation spectra, vibration-rotation spectra, electronic spectra and Raman spectra have been dealt with. Symmetry properties and symmetry effects have been given some prominence. Chapters VII, VIII and IX are devoted to statistical problems and topics like classical and quantum statistics, specific heats, thermodynamics, partition functions, compressed gases, critical state, etc. are ably dealt with.

In a few places, the author errs on the side of giving much detail rather than of observing brevity. The differentiation of the power series, substitution of the results and the collection of coefficients given on pages 31 and 32 while dealing with the harmonic oscillator and a similar process on pages 41 and 42 while dealing with the Legendre's equation are illustrations. Such detail is probably helpful to the class of readers he is having in mind. There are other places where the book is definitely difficult mathematics for a general chemist but the specialist who is devoted to the theoretical aspects will find a most valuable account of topics that have a bearing on his subject. On

page 201 is the statement "With hydrogen deuteride, which does not have two identical nuclei, all rotational lines have equal intensities and none are missing". This is incorrect. The description of the method of extreme fields given on page 211 is not clear enough.

These are trivial lapses and are only few and far between. They do not in any way diminish the value of the book as a whole which contains several extremely lucid and logical accounts of difficult topics. Although the author intends the book to be of help to chemists and has achieved his object in so far as a particular category of them is concerned, the book has been so well written and the topics it covers have been dealt with in such a nice manner that it is of even greater value and wider appeal to physicists and physical chemists.

S. Bhagavantam

Cottage and Small-Scale Industries.
By Mukhtar Singh (Katabistan, Allahabad), 1947, pp. 242, Price Rs. 7/8/-.

This book is a fairly comprehensive survey of the present position of cottage and small-scale industries in India. The author has given his impressions and views based on his extensive tours in England, Germany and, in particular, Japan. The place of cottage industries in the economy of the country has been well discussed and their economic potentialities indicated.

The book is divided into three parts; the first consisting of eight chapters deals with the status, organization and other aspects of cottage and small-scale industries. A definition of "Cottage industries and small-scale industry" is attempted after taking into consideration the various definitions that are in vogue. A critical review of the plans for the development of cottage industries is attempted. This part provides useful data on the density of population in various Provinces, the expenditure incurred on industries, approximate number of cottage industry workers engaged in different industries, and a scheme for a State Organization

to develop cottage and small-scale industries in India.

The industries operating in several parts of the country and the possibilities of organizing them into small-scale industries are discussed in part II. The textile industry, including silk and wool, has received special attention. Other industries examined include: leather, metal industries, fibre and straw, tobacco, oil, soap and perfumery, timber and wood, pottery and glass, agricultural, food, chemical and miscellaneous industries.

The third part deals with what the author calls "New Industries" under three heads: mechanical, chemical and agricultural. Many of the industries included in this part are already working in various parts of the country. For instance, the fountain-pen, button and wire-drawing industries exist in several Provinces and States but they stand in need of State aid and encouragement.

The author favours a pattern of organization for cottage and small-scale industries similar to what was operating in pre-war Japan. He observes, emphatically, "We will have to follow the footsteps of Japan in the employment of our people. We will have to earmark big factories only for the production of those things which cannot be manufactured on a small scale and without which we cannot supply the needs of the country. Cottage industries must be the rule and big industries the exception."

There has been a rather conspicuous omission. The part of the Indian States in the progress of cottage industries has not been insignificant. The usefulness of the volume would have been greatly enhanced if it had included a survey of the industries in the Indian States also.

The volume is well got-up and moderately priced.

A. K.

A plea for the Mixed Economy: by M. R. Masani (The National Information & Publications Ltd.) 1947, pp. 37, Price As. 12.

The pamphlet discusses the relative

importance of state enterprise and free enterprise in tackling the problem of India's industrialization. The 'Mixed Economy' to which the author refers relates to an economy which would keep alive and stimulate both these forms of enterprise. According to the author, the mixed economy can be relied upon to take the country more quickly to the goal of a "free and equal society" than total State ownership and management. The bulk of the pamphlet is devoted to an attack on the policy of Nationalised Economy. The author has strong views in the matter and at one place finds,—“the conclusion is irresistible that not only are State ownership and management not the answer to our needs, but that that way lie destitution and dictatorship”. His main theme, however, admits the need for some amount of nationalisation; and it is pointed out that a lot of experimenting will be necessary before the final attitude towards State ownership and management can be determined in the light of the experience gained.

The pamphlet is brief and stimulating and will be read with sustained interest.

R. B. P.

India Archives, a quarterly published by the Imperial Record Department, is the first of its kind in this country. Primarily intended for the technical personnel of the various Record offices in India Indian Archives will serve as a clearing house for scientific knowledge on the methods and techniques of preserving old papers, renovating old manuscripts, safeguarding printed books against the natural forces of decay and such other matters of interest to Indian archivists.

The first issue of this well edited and well got-up Journal carries articles on Survey of India Records, study of palm leaf manuscripts, preservation of rare books and manuscripts in Huntington Library, and others. It has a lengthy "News Notes" Section containing brief notes on record offices in provinces and states.

NON-TECHNICAL NOTES

Manufacture of Phosphorus in India

THE prewar requirements of amorphous red phosphorus in India were of the order of 150 tons per annum. Although a small quantity was used for the manufacture of phosphorocopper used in nonferrous metallurgy, the bulk of the 150 tons was consumed by the match industry. The demand for white phosphorus was practically nil. During the war, however, white phosphorus was in great demand for munitions purposes. It was to meet this shortage that an investigation was undertaken by the Board of Scientific and Industrial Research and this led to its production on a pilot plant scale at the *Indian Institute of Science, Bangalore*. The present day requirements of red phosphorus for the Indian match industry and in nonferrous metallurgy may be 200-250 tons per annum. Taking into consideration the expansion of the match industry, the development of the nonferrous metallurgical industry, and the operational economics it has been considered that a plant producing about 300 tons of red phosphorus per annum would suffice for the needs of the country.

Pilot Plant

The pilot plant consisted of a 20 KVA single phase arc furnace of 3 cu. ft. cubical contents with a rammed graphite lining and sillimanite crown. The hearth served as one electrode while the moving electrode consisted of a block of Acheson graphite attached to a water-cooled copper pipe moving in a specially designed deep stuffing box. The furnace was insulated by magnesia and firebrick and provided with a gas-tight mild steel shell. The charge of rock phosphate (of 55 per cent. calcium phosphate content) mixed with 40 per cent. of its weight of silica in coarse lumps and 20 per cent. of its weight of charcoal substantially free from volatiles was fed into the furnace through a double hopper system and the phosphorus fumes evolved were cooled in a train of surface cooled condensers with a Stroeder type of spray absorber at the end of the train to retain the last traces of fumes. The product was collected under water after melting by means of an electri-

cally heated coil. The product was dark coloured and required elaborate purification with sulphuric acid and dichromate. It would be possible to obtain a colourless product by pre-calcination of the various raw materials to get rid of the carbonaceous materials. The addition of the calcining unit to the plant will minimise the final purification to a very great extent, and for certain purposes no further purification may be necessary.

The operations involved a moderate amount of skilled attendance. There were many risks connected with the poisonous as well as explosive nature of the products issuing from the furnace and danger of uncontrollable fire in the event of the product being accidentally exposed to air.

Abstract of Test Results

Analysis of Rock Phosphate:

Calcium phosphate ...	59.1 %
Calcium Carbonate ...	12.8 %
Gypsum ...	3.2 %
Calcium fluoride ...	5.5 %
Strontium sulphate ...	3.1 %
Oxides, organic, etc. ...	16.3 %

Test run:

Duration ...	96 hrs.
Interruption in feeding ...	10 hrs.
Arc voltage (average), Single phase ...	70 volts
Average amperage ...	250 amps.
Approximate total energy input ...	1,500 KWH
Total weight of mixed charge fed ...	1,800 lb.
Weight of crude phosphorus obtained ...	98 lb.
Estimated phosphorus content of crude product ...	98 %

Calculations:

Weight of mixed charge per lb. of finished phosphorus ...	30 lb.
Energy input per lb. of finished phosphorus ...	25 KWH

After making due allowances for various losses incidental to small scale operation, it has been reckoned that in commercial scale working, it may be possible to produce 1 lb. of white phosphorus with an input of:

Mixed charge	25 lbs.
Total energy	12.5 KWH

The following comparative figures relate to the efficiency of the pilot plant as against the T. V. A. plant in the United States of America.

	Pilot Plant	T. V. A. Plant
P ₂ O ₅ content of rock phosphorus	27%	26-3%
CaO	44%	37-47%
SiO ₂	4%	8-23%
Flourine	3%	2.7-3.5%
CaO: SiO ₂ mol. ratio	1.25	1.2-1.29
Arc Voltage	70	114-121
	(Single phase)	(3 phase)
Energy consumption in KWH per ton of P ₂ O ₅ charged	1100	5320-5660

The size of the pilot plant is the principal factor responsible for high energy requirements in case of pilot plant.

Proposed Plant for 1 Ton Daily Production:

Reckoning on 0.9 power factor and 22 hours operation, the electrical installation would have to be of 1,500 KVA rating. The transformer would be of customary arc furnace type designed for a secondary voltage range of 130-190 with continuous steps of 10 volts. The taps would have to be provided on the primaries and designed for changing on full load. Usual automatic electrode controllers would be provided; and those could be of electric type, although hydraulic controllers appear to be more popular. The electrodes would be about 18" diam. if made of carbon. Graphite electrodes of 10" diam. would serve as well.

The furnace chamber would be 6' in diam. x 6' high with the highest grade graphite lining 2' thick lagged with superduty firebricks 1.5' and insulation bricks 1 ft. The crown would have to be specially designed in sections so as to obviate spalling due to thermal stresses at high operating temperatures. The overall dimensions of the furnace would be of the order of 15' diam x 13' high with slag hole specially designed to prevent chilling of slag. The condensation apparatus would be a comparatively simple matter; and so would be the auxiliary equipment such as crushers and grinders, calcining

units, elevators, charging hoppers, melting devices, purification kettles and final conversion apparatus for production of red phosphorus. All the requisite equipment and materials are readily available in India and it would be only necessary to import the transformer or to have it fabricated by arrangement with Messrs Crompton-Parkinson in their Indian Works. The furnace and the crushing equipment may be fabricated under the Council's guidance.

Estimates

Capital Expenditure:	Rs.
1,500 KVA furnace transformer and switchgear	70,000
Meters and electric control equipment	5,000
Electric wiring and accessories	5,000
Fabrication of furnace and electrode operation gear	30,000
Crushers, grinders, sieving equipment and elevators	15,000
Refractory lining materials	10,000
Steel plates for furnace shell and other structural materials	20,000
Motors, accessories, piping and miscellaneous	10,000
Fabrication and erection charges	10,000
Freight and incidental expenses	5,000
Complete boiler house equipment	15,000
Pre calcinators for the charge and acid resisting equipment for purification of crude phosphorus	30,000
Final phosphorus conversion equipment	10,000
Safety and fire-protection equipment	10,000
Contingencies and unforeseen expenses	25,000
Control laboratory equipment	20,000
Building and stores	1,00,000
General expenses	10,000
Working capital	1,00,000
Total Capital Requirements:	5,00,000

It is estimated that the building required will cover an area of 10,000 sq. ft. The cost of building will depend upon the location of the plant, etc. but it is anticipated that it will cost about 1,00,000 rupees. The total capital investment will therefore be about Rs. 5,00,000, the plant costing Rs. 3 lakhs while the Building and Working Capital will cost Rs. 2 lakhs.

Boron in Medium Carbon Steel

By G. P. CONTRACTOR* and J. S. VATCHAGANDHY†

During the past few years many sweeping claims have been made for the influence of boron in Steels; for example, it has been asserted that as little as 0.003 per cent. of boron has the same effect on steel as 1 per cent. of nickel, 0.3 per cent. of chromium, 0.2 per cent. of manganese, 0.12 per cent. of vanadium, or 0.10 per cent. of molybdenum. Some important aspects of the influence of boron on medium carbon steels were reported by the authors in the recent Spring issue of *Metal Treatment*, from which the following abstract has been taken.

It is only since 1940 that boron has been reported to be a useful and potent alloying material. Some of the recently published results show that the addition of 0.0025 to 0.003 per cent. of boron to steel gives the best results especially in terms of depth hardenability, accompanied by an increase in ultimate strength and elastic limit. Very little advantage is, however, gained by the addition of boron to a steel which by its composition has sufficient hardenability. It is for this reason that steels with a carbon content of 0.20 to 0.60 per cent. are more receptive and responsive to boron treatment.

The use of boron in cast iron precedes its adoption by steel industry. Much of the early work involved its use in such large amounts, as judged by present standards, that there is hardly any scope for comparison. Walter¹ was perhaps the first to suggest that extremely small boron contents were really effective in improving some of the characteristics of steel and that the amounts employed by early workers were far in excess of those required, making the steel brittle and red-short.

Steels Investigated

The steels investigated were of the following compositions: Carbon 0.40—0.50 per cent., manganese 0.70—0.80 per cent., silicon 0.18—0.25 per cent. and phosphorous and sulphur 0.025 per cent. maximum each. Nineteen heats of the above composition with boron varying from 'nil' to 0.098 per cent. were prepared. The steel was made in a 25-lb. high frequency induction furnace, and all heats were deoxidised with 5 gms. of aluminium before the addition of boron alloy. The boron alloy, added just before pouring the ingots, was developed in the pilot plant of the *Tata Iron and Steel Co., Ltd.*, and contained 0.47 per cent. carbon, 6.65 per cent. silicon, 0.23 per cent. aluminium, 4.5 per cent. boron, and 87.9 per cent. of iron. All ingots were provided with hot tops, and the portion containing the pipe was removed during forging. No relation was observed between the extent of piping and the boron content.

The temperature range suitable for forging was found to be between 1050° C. and 1120° C. Ingots containing up to 0.013 per cent. of boron could be forged without difficulty but steels with higher boron content cracked and showed red-shortness. Experience gained during the forging led the authors to infer that under commercial rolling conditions, the upper safe limit of boron content in medium carbon steel may be placed at 0.1 per cent.

Critical Temperatures

Heating and cooling curves were taken with the help of a platinum/platinum-rhodium thermo-couple working in conjunction with a potentiometer. The results indicated that 0.098 per cent. of boron had little effect either on the position of the transformation. Leitz dilatometer curves were recorded with a view to finding the A_3 Point more definitely. The curves shown in Figs. 1 and 2 warrant the assumption that within the range treated, boron lowers the temperature of the AC_3 transformation from 840° C. to 825° C., in steel containing 0.098 per cent. of boron. AC_1 point, however, remained practically unaffected.

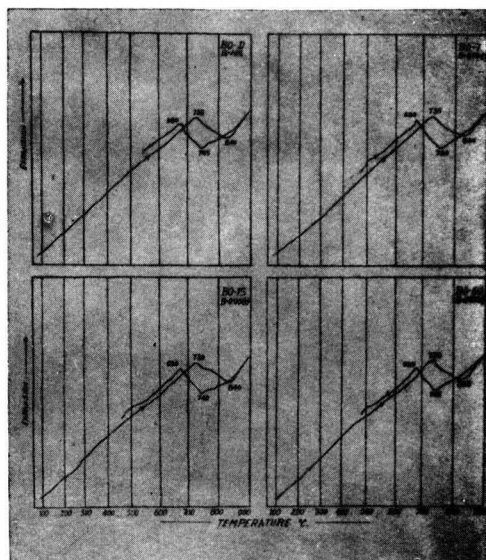


Fig. 1.—Dilatometer curves for steels containing boron varying from 'nil' to 0.028 per cent.

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† Research Laboratories, The Tata Iron & Steel Co., Jamshedpur.

Physical Characteristics

Fig. 3 shows the results of mechanical tests on boron steels. Boron does not appear to have a strengthening effect on the tensile properties of steel, while the ductility in terms of percentage reduction of area decreases. Impact value falls seriously when 0.007 per cent. of boron is exceeded. This sudden fall is attributed by the authors as probably due to the presence of hard particles of boride in the ferrite of the grain boundaries. Figs. 4 and 5 show globules of boride in unetched and etched condition respectively.

Although boron additions up to 0.0065 per cent. have no adverse effect on the fatigue strength of

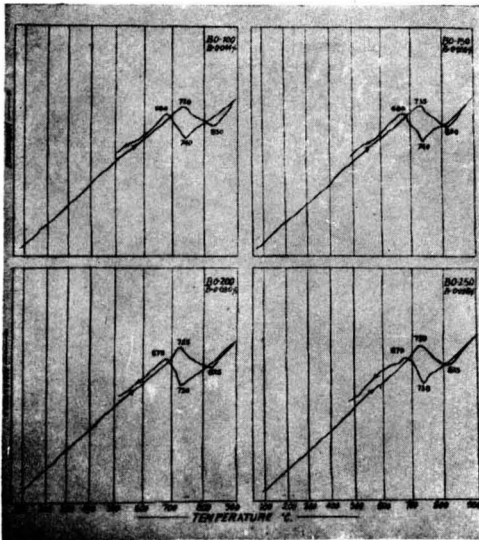


Fig. 2.—Dilatometer curves for steels containing boron varying from 0.044 percent to 0.098 percent.

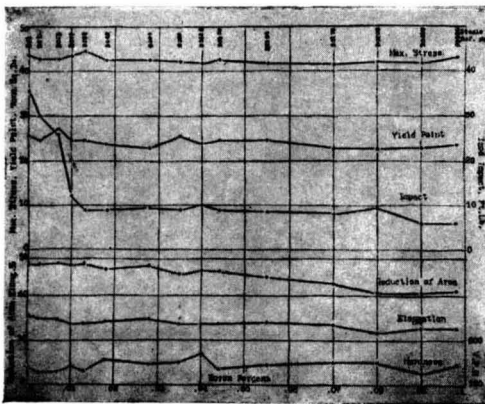


Fig. 3.—Mechanical properties for medium-carbon steels containing up to 0.098 percent boron. Steel normalised twice, first at 900° C. and then at 860° C.

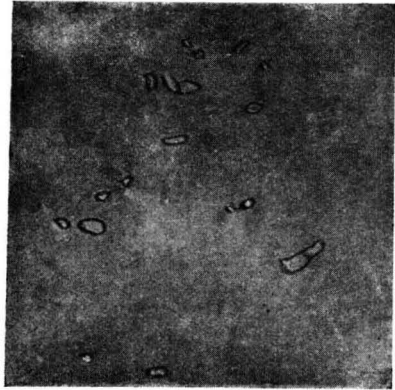


Fig. 4.—Boride particles in steel containing 0.044 per cent. boron (unetched). (X100).

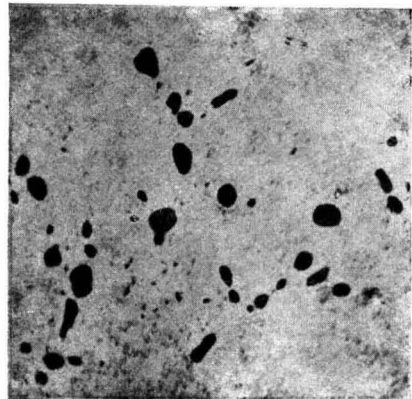


Fig. 5.—Boride particles in steel containing 0.098 per cent. boron (etched in Na picrate). (X500).

steel, amounts higher than this are deleterious as indicated in Fig 6 with 0.038 per cent. of boron the endurance limit is reduced by 22 per cent.

A standard Barr-Bardgett² apparatus was built to determine creep properties of the steels. The tests were made at 500° C., the variation in temperature being of the order of ± 3° C. The results, shown graphically in Fig. 7, indicate that limiting creep stress is progressively lowered with the increase of boron contents. With 0.08 per cent. of boron, the limiting creep stress is reduced from 1.57 tons per sq. in., for steel containing 0.0028 per cent. of boron to 0.16 tons per sq. in.

Case hardening of the steels

Test specimens each measuring 8.80 sq. cm. in total exposed area, were case hardened simultaneously at 920° C. for 6 hrs. The specimens were weighed and measured before and after the test, the increase in weight being taken as the amount of carbon absorbed by each steel. The carburised samples were examined under the microscope and

the surface hardness and depth of penetration determined. The results indicate that although the depth of carbon penetration was practically the same for all steels, the amount of carbon absorbed increased with high boron contents. The authors attribute the increase as probably due to the formation of complex iron-carbon-boron compounds in the steel containing higher percentages of boron.

Up to 0.018 per cent. of boron the hardness of the case is not affected, but above this amount there is a slight drop in hardness. This decrease may be due to the absence of straight iron carbide in the edge with the increase of boron content. With 0.01 per cent. of boron and above, the usual hyper-eutectoid case is changed and is replaced by eutectoid pearlite with globules of boron compound. This is samples containing 0.007 per cent. and 0.055 per cent. of boron. Fig. 8 further indicates that in the shown in photomicrographs (Fig. 8) of carburised high-boron carburised steels there is a distinct tendency for the iron-boron compound or the ternary

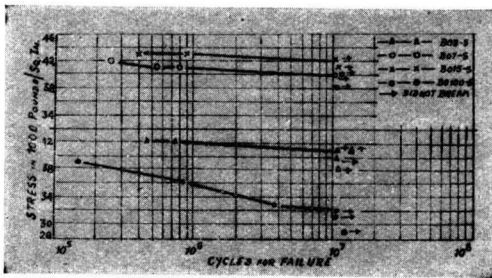


Fig. 6.—Endurance limit (ten million reversals) for steel containing boron up to 0.038 per cent.
Boron contents:— BOD-S=Nil, BO7-S=0.0032%, BO15-S=0.0065% and BO100-S=0.038%.

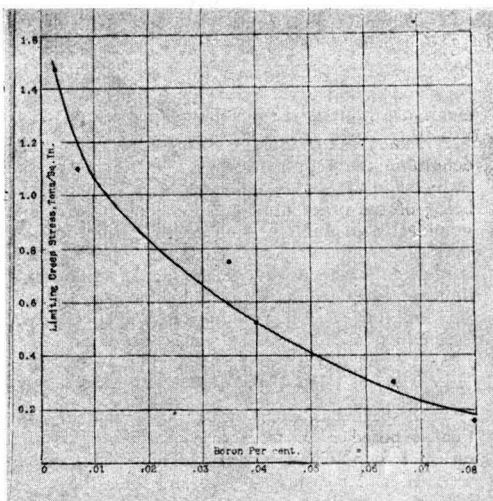


Fig. 7.—Limiting creep stress as a function of boron content up to 0.08 per cent.

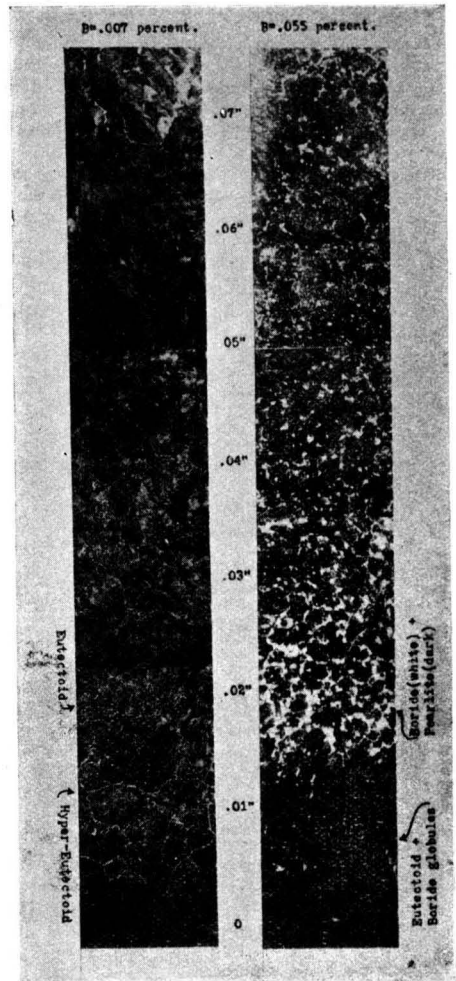


Fig. 8.—Photomicrographs of carburised specimens contain 0.007 and 0.055 per cent. boron. Specimens etched in 2 per cent. nital. (X50).

complex compound to migrate towards the outer layers, but never reaching the edge in large bulk, while retaining the assential eutectoid character.

Hardenability Determinations

Hardenability of the steels was determined by using standard Jominy Technique³. Some of the Jominy curves are reproduced in Fig. 9. Ideal critical diameters (D_1) were determined by the use of curves published by Grossmann⁴ and by Grossmann, Asimow and Urban⁵. In order that the results may be comparable, the ideal critical diameters were corrected to a common grain size and a base composition. Grossmann's factors were used for the corrections. This procedure was adopted to remove the possible effect of slight variations in the compositions of the individual steel.

The corrected diameters were averaged and plotted against the boron content as shown in Fig. 10. The multiplying factor was calculated by dividing the ideal critical diameters by the intercept on the critical diameter axis at zero boron content. Fig 11 shows the effect on hardenability in terms of the multiplying factor. The results (Fig. 10 and 11) indicate that hardenability of steels is increased progressively with boron up to 0.01 per cent, but the increase at the commonly employed levels of 0.003 and 0.007 per cent. is not so great as reported by early workers. Above 0.01 per cent. of boron this element becomes less effective in further increasing the hardenability of steel.

Hardenability was also determined by quenching normalised bars in water and then measuring the hardness from the surface to the core. The results are graphically represented in Fig 12. The rise in hardenability is not significant unless the boron content is 0.0065 per cent. and above. Actually, the results, in terms of ideal critical diameters are even less striking than those obtained by Jominy test. It appears to the authors that the increase in depth hardenability resultant upon boron additions has been over-emphasised in certain quarters.

Corrosion Tests

As a result of corrosion tests it was found that steel with 0.0028 per cent. of boron is more resist-

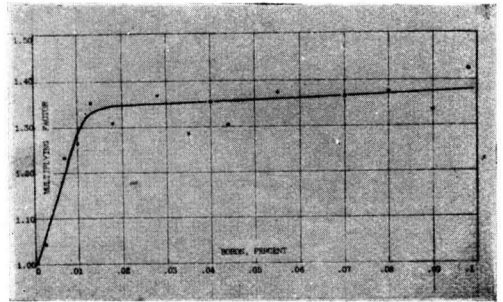


Fig. 11.—Effect of boron on hardenability in terms of multiplying factor.

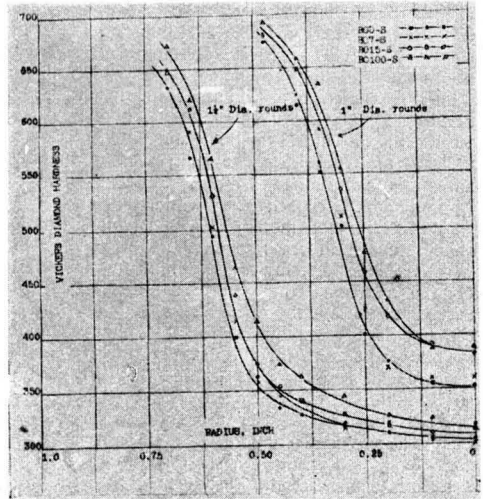


Fig. 12.—Hardness surveys over the cross section of quenched 1'' and 1 1/2'' diameter bars in steels containing up to 0.038 per cent. boron.

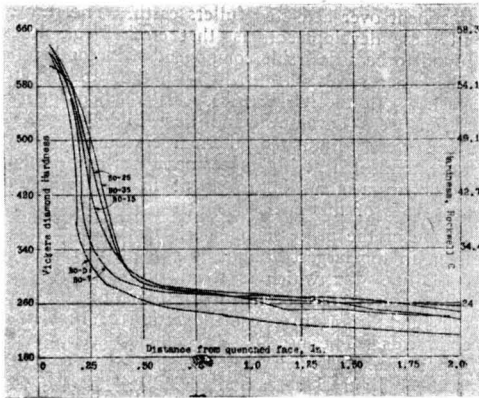


Fig. 9.—Jominy hardenability curves for steels containing up to 0.013 per cent. boron.
 Boron contents:— BO-D=Nil, BO-7=0.0028%
 BO-15=0.007%, BO-25=0.010% and BO-35=0.013%.

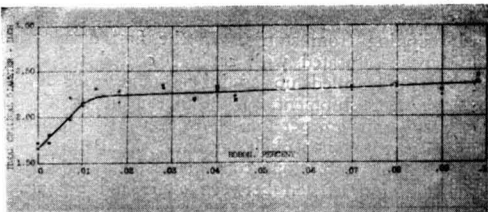


Fig. 10.—Ideal critical diameter as a function of boron content.

ant to attack by 5 per cent. hydrochloric and 5 per cent. sulphuric acids than carbon steel. Similarly, steel containing 0.007 per cent. of boron is more resistant to atmospheric corrosion than boron-free steel. The steels are, however, not increasingly resistant to atmospheric and acid corrosion when boron is present in amounts higher than the above limits. There is little improvement in corrosion resistance when boron steels are subjected to immersion tests using 3 per cent. magnesium chloride solution as the corroding medium.

References.

1. Walter, *U.S.A. Patent No.* 1519388.
2. Barr and Bardgett, *Proc. Inst. Mech. Eng.*, 1932, 122. 285.
3. *S.A.E. Journal*, 1942, 50, 15.
4. Grossmann, *Metal Technology*, June 1942.
5. Grossmann, Asimow, and Urban, *A.S.M. Symposium on hardenability of alloy steels*, 1939, p. 124.

NOTES and NEWS

Synthesis of DDT

A one-step method for the synthesis of DDT from chloral hydrate, chlorobenzene and chlorosulphuric acid has been described (*Ind. Eng. Chem.*, 1947, 39, 868). The method is superior to the original three-step method employing the same reactants in yield of purified product, simplicity of operation, ease of control of experimental conditions and uniform reproducibility of results. The yield of pure DDT by the sulphuric acid-oleum process, in which a large excess of the condensation agent is employed, is claimed to be 70-75 per cent; the yield of pure DDT in the one-step method, in which the reactants are employed in essentially mathematical quantities, is 65-69 per cent.

The apparatus consists of a litre, three neck flask equipped with a mercury seal, motor driven stirrer, thermometer, dropping funnel and gas exit tube, which is vented over a beaker filled with sodium hydroxide solution. A mixture of 165.4 gms. (1 mole) of chloral hydrate and 223.6 cc. (2.2 moles) of chloral-benzene is placed in the flask, which is surrounded by an ice-salt brine bath (4.5 Kgm. capacity). Chlorosulphuric acid (143.4 cc. or 2.2 moles) is added from a dropping funnel at a uniform rate over a period of 2 hrs., with vigorous stirring of the mixture and control of the reaction temperature so that it does not exceed 10° C. The temperature of the flask and contents is allowed to rise to 0° C and maintained at that temperature for 1 hour. During the addition of the acid, and throughout the operating period, a steady stream of hydrogen chloride is evolved. Within 30 minutes after the addition of the acid, the dark brown reaction mixture thickens to a pasty consistency and assumes a lighter colour. The temperature of the reaction product is allowed to rise 10° C. for the fourth hour and finally to 20° C. for the final hour of stirring. After the product has stood at room-temperature for 15-18 hrs., it is transferred to a 2 litre beaker containing approximately 200 gms. of crushed ice, and the mixture is reduced to a colourless, fine grained mass by hand stirring and dilution with 800 cc. of the ice water. After filtration on a Buchner funnel, it is washed with an equal volume of cold water added in 3 or 4 separate portions and allowed to dry under suction for 30-45 minutes. The crude filter cake weighing approximately 340-350 gms. (and containing some moisture together with other contaminants) is transferred to a 800 cc. beaker, covered with 400 cc. of 95 per cent. ethanol, mixed well, chilled in an ice-salt brine bath, filtered on a Buchner funnel and washed with an additional 200 cc. of cold alcohol. The resulting product is treated in a similar manner with petroleum ether (B.P., 30-60° C.). After the ligroin wash the product is dried under suction and weighed. The yield of purified product varies from 236 to 244 gms. or 66 to 68.7 per cent. of theory based on chloral hydrate.

New Products of Petroleum Industry

The wartime developments in petroleum industry in America are described in an article appearing in the *Journal of the Franklin Institute* (1947, 243, 95). The industry had its real growth along with the automotive and aviation industries. The refiner has been mainly seeking ways and means of increasing gasoline production from crude oil fractions. The use of "Cracked gasoline" resulted in poor engine operation and a comparison of notes by the refiner and the automobile designer brought out fundamental information which initiated a series of new developments. It was revealed that the knocking tendency of the higher compression automobile engine could be materially reduced or entirely eliminated by the heretofore disfavoured cracked gasoline in preference to the previously used straight run gasoline. It was found that cracked gasolines contained substantial quantities of olefines and aromatics, whereas crude oil as received by the refiner contains few if any of these types of hydrocarbons.

Two parallel developments were thus started in the refineries as a result of the move by the engine designers to higher compression motors. Processes to remove gummy materials, identified principally as diolefines, from cracked gasoline took the form of treatment with sulphuric acid and vapour phase treatment over activated fullers earth. The result of all these developments is that cracked gasoline is found to be a desirable component of motor gasoline. The other series has to do with the production of cracked gasoline itself. As special methods of fabrication were developed and new high temperature steels were formulated, thermal cracking operations were conducted at higher temperatures and pressures to obtain a great improvement in the anti-knock properties of this fuel.

One of the processing materials made from petroleum in the largest volume is paraffin wax. Micro-crystalline wax which is tough and pliable at low temperatures, has been used as coating for metal cans and drums to resist the action of beer, wines and acids. The use of wax emulsions is gaining importance. They impart a water repellent finish to the individual fibres and the treatment has practically no effect on the appearance and feel of the fabric and because of openings remaining between the fibres, adequate ventilation is assured. A large number of rust preventives containing petroleum as base have been prepared and are in use.

Two new developments in the field of asphalt are prefabricated airport run ways and asphalts resistant to stripping from stones. In the first development burlap is saturated with asphalt, coated with small stones and rolled up as in common asphalt roll roofing for shipment. It is placed in position by employing a 50 per cent. overlap and cementing together with an asphalt cut-back. Asphalts resistant to stripping from stone contains additives to increase the adhesion tension between stone and asphalt.

Other developments in processing materials derived from petroleum include plasticizers and softeners for synthetic rubbers, special oils heavier than water for mosquito control and high refractive index oils for examining quartz crystals cut into oscillators for radar and radio equipment.

Large quantities of butadiene and styrene were needed to make the all-purpose rubber, GR-S. There are several methods of producing butadiene from petroleum, but the best method consists in dehydrogenating certain C₄ hydrocarbons to form butadiene. Government owned plants in America produce as much as 100,000 tons of butadiene per year from petroleum. Styrene, also required for GR-S, is produced by alkylating benzene with ethylene to form ethyl benzene which is converted to styrene by dehydrogenation. Butyl rubber is obtained entirely from petroleum being synthesised from isobutylene, a petroleum hydrocarbon obtained from cracking processes and a diolefin such as isoprene. These two hydrocarbons are converted into butyl rubber at 150° F. by a continuous process.

Among the newer petroleum plastics are polyethylene resins, allyl plastics and polyvinylidene chloride resin. Allyl plastics are based on allyl alcohol derived from propylene. These resins constitute excellent coating materials for metal containers being harder than glass but less brittle. A resin produced from vinylidene chloride differs from vinyl chloride in that 2 chlorine atoms instead of 1 have been substituted for hydrogen atoms in the ethylene molecule. The plastic is tough, resistant to solvents, possesses high tensile strength and can be drawn into strong filaments.

Among the important chemicals derived from petroleum are phthalic anhydride produced by oxidation of orthoxylene.

For many years both oil soluble and water soluble soaps have been produced from petroleum mainly as by-products. Synthetic detergents or wetting agents far superior to either the by-product soaps or vegetable oil soaps have been developed from petroleum hydrocarbons. The petroleum refining industry in America is either in active production or contemplating production of materials used in alcohols and antifreezes; lacquers, paints, varnishes and solvents for rayons and plastics; dyestuffs, textile oils, leather oils, synthetic rubbers, paper, toilet goods, detergents, emulsifiers and wetting agents.

New Diamond Die Drilling Method

A new electrical method for drilling small dies used in drawing and shaping extremely hard and fine wires has been developed at the National Bureau of Standards (*J. Franklin Inst.*, 1947, 243, 424). This method has completely revolutionized the fine-wire diamond die industry.

Although dies of tungsten, molybdenum or boron carbide have in recent years competed with diamond dies, diamond is still the only tool used in shaping harder materials, such as chrome-nickel, phosphor-bronze and high-carbon steel wires. Moreover, wires finer than 15 thousandth of an inch can be drawn to any size and of perfect roundness. Important uses for diamond drawn wire are in radar and radio equipment, in high frequency coil windings, as filaments for tungsten lamps and in delicate and precise electrical instruments. The new process

replaces the older mechanical die cutting with high voltage drilling followed by electrolytic drilling. The electrical methods are adopted for dies used in drawing wires of 0.0015" in diameter or smaller.

A diamond die consists of 5 surface areas: the primary cone, the secondary cone, the reduction cone, the bearing and the exit cone. The appearance of the die is similar to a wine glass. The primary cone is drilled by means of high-voltage sparks formed at the point of a needle electrode in contact with the face of the diamond. These sparks release the energy stored in a condenser charged to a high voltage through a "quenched gap" consisting of a number of very small gaps in series, by a transformer.

When a rising voltage is applied to the circuit, sparking first occurs at the quenched gap. This is followed, as the voltage is increased, by a discharge across the face of the diamond between the needle electrode and the brass block on which the diamond is mounted. Without the quenched gaps in the circuit, overheating of the diamond would result. The rate of drilling increases with power input in the circuit until a limit is reached where the temperature of the diamond is so high that its surface takes on a frosty appearance. The drilling needle, which is 0.02" in diameter, becomes red hot at its tips before the "roasting" point is reached and the reddening point of the electrode is used as a criterion in adjusting power input to circuit.

The secondary cone is formed by the action of a low-voltage spark in an electrolytic solution. The diamond is mounted on an insulating post in a shallow glass dish and enough of the electrolyte is used to fill the dish and just cover the diamond. The "drilling" electrode is a platinum-iridium needle that is lowered into contact with the bottom of the primary cone and rests with very light pressure (around one fifth of a gm.) on the diamond. A second electrode dips into the solution at some distance from the diamond.

When a low voltage (around 90 volts) is applied, sparking occurs at the tip of the drilling needle and a smooth walled conical hole is formed in the diamond. The shape of the hole and the angle of its walls are controlled by the type of electrolyte used, while the hole size is controlled by the pressure of the needle. The power input into the solution is controlled by the depth of the solution covering the diamond and by the voltage applied.

The National Bureau of Standards method involves 10 steps which combine electrical with mechanical drilling. The first 6 stages employ high voltage sparks for drilling, followed by 3 electrolytic drillings, the final step being finishing and polishing. The first electrolytic drilling of the secondary cone utilizes a 5 per cent. aqueous solution of sodium chloride followed by potassium nitrate. Drilling the main body of the secondary cone with potassium nitrate solution is similar to the previous operation, except that the electrolyte is stronger and the tip diameter of the drilling electrode is smaller ranging from 0.0010" to 0.0015". After 40 to 45 minutes drilling, the drill will have pierced the back face of the die giving a smooth-bore with a length of about 0.006" and a diameter at the bottom of 0.0005".

Electric drilling, producing superior dies, takes 7-15 hours depending on the type of the die, with

10 hours as an average. There is a saving of 2 man-hours per die. The method requires no special skill or long training on the part of operators. Equipment is inexpensive and the drilling technique is simple.

Titanous Sulphate

A method for the production of titanous sulphate by the reduction of titanium dioxide (in the form of rutile, etc.), by means of sodium hydride is described (*Chimie et Industrie*, June, 1947). The fusion mixture used is that due to Bardwell (*J. Amer. Chem. Soc.*, 1922, 44, 2499). With this mixture, the rapidity of hydrogen evolution is readily regulated by controlling the temperature and it is possible to make use of the reducing effect of the whole hydrogen in a short time, the molten mass assuming a deep blue colour. The process can be carried out in a rotary cylindrical furnace and continuous operation is possible. After cooling the reaction mass, the Bardwell salt mixture is leached out without water and the residue is Ti_2O_3 contaminated by a very small proportion of TiO . The oxide mixture is readily soluble in medium strength sulphuric acid giving a solution from which crystalline titanous sulphate can be obtained by partial evaporation.

Quaternary Ammonium Compounds as Fungicides

Quaternary ammonium compounds have found practical application in the baking industry (*Biol. Abs.*, 1947, 21, 1452). As they possess high antibacterial potency, they have proved useful in controlling rope and mould infections in the bakery. They can be applied conveniently as sprays. The solutions are odourless and tasteless, and if carefully employed, will not inhibit yeast activity.

Flouring-Hydrogen Flame for Cutting and Welding

A new method for cutting and welding metals using a flourine-hydrogen flame has been patented (*U.S. Patent*, 2,421,649). The cutting and welding of copper has presented peculiar difficulties, partly because copper readily forms oxides as soon as it melts and even more because of its high thermal conductivity. The oxygenless flame obtained by the new combination attains a high temperature,—about $4,000^\circ C.$, which is sufficient to cut copper. It is also good for welding because of the formation of copper flouride, which serves as a flux protecting the metal at once against oxidation and the corrosive effects of the flourine gas itself (*Science News Letter*, June 14, 1947).

Utilization of waste Iron Salt Liquors

The possibility of utilizing the large amounts of waste iron salts from steel mills and titanium oxide plants has been discussed in *Chemical Age*, (1947, 57, 10).

A small steel mill in U.S.A. normally disposes of an iron oxide equivalent of over 125 tons per day in the form of ferrous sulphate dissolved in acidulated water. The proper neutralization of such waste acid ferrous solutions involves much time, labour and money. A certain amount of the iron salt solution is converted to copperas and ferrous sulphate by evaporation and crystallization. From these purified solutions iron oxide pigments can be

made. Another use for the iron oxides resulting from pickle liquor, is the preparation of metallic iron powder, from which many useful objects can be made by applying the technique of powder metallurgy. Larger quantities of pickle liquor can be economically utilized in synthetic iron oxide pigment industry by employing continuous operation methods instead of batchwise operation. Finely divided iron oxide finds application as drilling mud in petroleum industry. The property of hydration and adhesion to rock structures of iron oxide is made use of in colouring cement blocks to red, brown, yellow or blue tints by appropriately prepared iron oxide. A mixture of such material not only gives desirable colours but also improves waterproofing qualities of the blocks.

Uses for Wood Pulp By-products

An up-to-date review of the large and increasing range of industrial uses now being found for the waste liquor resulting from the chemical production of wood pulp in Canada has been recently published. (*Chem. Age*, 1947, 57, 11).

The liquor contains per litre, about 62 gms. lignin, 17.5 gms. hexoses, 1 gm. methanol, 4.5 gm. acetic acid and 1 gm. formic acid, besides furfural, pentoses, etc.

One of the earliest uses for the sulphite liquor was as a soil stabilizer in which it was comparable to calcium chloride, and was employed in making air craft runways, which remained firm even after heavy rains. The liquor is concentrated to 50 per cent. solids and sold for road surfacing, as a binder for sand moulds, linoleum and fuel briquettes.

The war has stimulated the use of the liquor as a source of alcohol. The Canadian paper and pulp industry has a potential capacity of 30 million gallons of industrial alcohol a year. Two plants are producing yeast from sulphite liquor, but the potential capacity for producing yeast is so great that one fair sized mill could supply the whole Dominion.

Wartime research by the *Howard Smith Paper Mills*, at the request of the Canadian Government, has led to the development of a method for isolating lignin in a relatively pure form from waste liquors. The lignin is produced as a fine, brown powder. This is mixed with kraft pulp of other pulp making fibres in a papermakers' beater, and then run over conventional papermaking machine. The retention of the lignin is 40 to 45 per cent. The lignin enriched paper is then made up into piles, placed between polished steel plates and inserted in a hydraulic press where it is subjected to a pressure of 800 lb. per sq. in., and heated to about $160^\circ C.$ On cooling the individual sheets are found to be fused into a single homogeneous sheet material having great impact strength and impervious to mild alkalis, acids, alcohols and ordinary solvents and having high dielectric properties.

A war-time development in England was the use of sulphite liquor as a source of glycerine. By using the proper strain of yeast, yields up to 35 per cent. on the weight of sugar have been obtained. Toluene was produced in Germany by the hydrogenation of sulphite liquor.

A substance with properties similar to rubber has been produced by treating sulphite liquor with hydrogen peroxide and recovering the precipitate which is then hydrolysed and polymerised. Con-

centrated liquor, the organic materials of which have a fuel value of 8,500 B.Th.U. can be used as fuel. One mill in the United States and another in Canada propose to burn concentrated sulphite liquor in their furnaces in order to reduce coal consumption and to recover the chemicals.

A New Method for determining Moisture Contents

A new technique for the determination of moisture in grain, wood, textiles, butter and a wide range of materials, has been recently described (*Philips Tech. Review*, 1947, 9, 13). The method is reasonably quick and offers the advantages of simple operation and inexpensive apparatus.

Water is extracted from the substance to be tested by acetone in which oxalic acid is dissolved. As oxalic acid is only slightly dissociated in acetone, the solution possesses a low conductivity. The absorption of water by acetone increases its power to dissociate oxalic acid and the result is a considerable increase in the conductivity of the liquid, which can be measured by simple means. When a solution of 10 per cent. oxalic acid in acetone is used, the conductivity of the solution as a function of the water content increases very rapidly. Variations in the content of oxalic acid makes relatively little difference and the effect of changes in temperature is also slight.

The presence of other electrolytes, such as common salt, might introduce errors ordinarily. In this method the extremely slow dissolution of common salt in acetone containing little water (< 5 per cent.) is taken advantage of and little difficulty is experienced from the salt content of the substance to be examined. The extraction should be completed within 2 hours and the final acetone-oxalic acid-water mixture should not contain more than a few per cent. of water. Provided these conditions are fulfilled, large deviations from the calibration curve are only observed in cases of substances with an extremely high moisture content such as salted fish. The accuracy of the method is limited by the fact that the test object stubbornly retains the last traces of water and the state of equilibrium, where only a minute quantity of water remains definitively in the substance, is very slowly attained. The extraction with acetone has the advantage that the equilibrium is established much more quickly than when drying in air or in vacuum.

In the practical application of this method care must be taken to see, that during extraction and subsequent measurement of the conductivity, no acetone evaporates. It is desirable to carry out the measurement in a completely closed vessel.

Molybdenum and Soil Fertility

The importance of molybdenum to soil fertility has been discussed in a *Bulletin* recently issued by the Australian Council for Scientific and Industrial Research. Subterranean clover and other legumes have been particularly responsive to small amounts molybdenum. It has been shown that this element is essential for nitrogen fixation by symbiotic bacteria. On soils deficient in molybdenum, lime stimulates nitrogen fixation by increasing the availability of molybdenum present in the soil, but when, molybdenum is supplied, lime is not required for the normal growth of clover. The provision of adequate

phosphate ensures a maximum response from molybdenum.

Protection of Books in Tropical Climates

The Division of Economic Entomology, Council for Scientific and Industrial Research, Australia, has developed new methods of utilizing boric acid for preservation of books. A solution of boric acid, 1 lb. in 1 gallon of commercial methylated spirit, is used for the purpose. The solution is applied to the covers and binding of books by spraying. The treatment does not affect the colour of the covers and even when applied liberally, it does not cause any sticking. The light white coating is finally dusted off, but much of the boric acid is actually deposited in the paper and covers.

Treatment with boric acid is probably insufficient against attacks by *cryptotermes*, which forms colonies in shelves and other wooden fittings of homes. These colonies may be destroyed by soaking infested wood or by injecting into the galleries a 5 per cent. solution of *p*-dichlorobenzene in kerosene. Steel shelving eliminates this trouble.

Where damage is caused by cockroaches a dust consisting of boric acid or sodium fluoride should be scattered liberally wherever cockroaches are known to be present. Persistence in applying the poison dust over a long period is often necessary.

Atomic Research in Australia

A Van De Graaf machine for researches on atom smashing has been recently completed at the Nuclear Physics Laboratory of the University of Melbourne. The unit, made wholly in Melbourne from Australian materials, is the first of its kind in Australia and generates 1,000,000 volts. The design was taken from a German blue-print, which was altered slightly to suit Australian materials and equipment. A pit 9' deep houses the machine and special precautions have been taken to provide safety conditions for research workers, when it is in operation.

Biological control of St. John's Wort

A successful method for the biological control of the weed known as St. John's wort has been worked out by the Australian Council for Scientific and Industrial Research. The weed destroys crops and is poisonous to livestock. The only remedy, until recently, was to scatter salt over the weed. This cost about £ A 25 an acre, involved much labour and was no guarantee against reinfestation of the land after the effects of the salt had worn off.

A species of British beetle *Chrysolina hyperici* and two others *C. Gemellata* and *Agilus hyperici* from France, have now been introduced into Australia for the eradication of the weed. There is no longer any doubt as to their effectiveness. The release of these beetles is being undertaken on a rapidly increasing scale.

Cultivation of Oil Seed Crops in Australia

Australian interests are seeking Government approval for planting 180,000 to 200,000 acres of the Barkly table lands or elsewhere in the Northern Territory with sunflowers. The sunflower seed oilcake constitutes a valuable feed for stock and poultry. The cultivation of castor plant will be undertaken in New South Wales. These schemes will be investigated by the Council for Scientific and Industrial Research, with a view to the economic

development of large tracts of Central Australia.

Jute Growing in the Missipi Delta

The rich Mississippi delta soils in U.S.A. have been found to be suitable for the cultivation of jute. The substitute fibres, *Kenaf* and *Urena lobata* can be grown in the vicinity of Atmore Ala, where the environmental and soil conditions are favourable for their cultivation.

Fibres from Feathers

A new synthetic fibre from feathers, having a structure similar to that of natural protein fibres, e.g. silk and wool, is reported to have been produced in the Western Regional Laboratories, Albany, California. This finding was recently reported to the *American Chemical Society* by Mr. Harold P. Landgreen.

New Cattle Feed

Jamun (*Eugenia jambulana*) seed, rich in protein and calcium, is useful as feed for livestock. Farm animals fed on wheat straw and a concentrate of rape cake mixed with *jamuna* seed in equal proportions, gained on an average 32 lbs. in weight during a period of 30 weeks. It can be satisfactorily used to replace oilcakes to the extent of about 75 per cent.

Fulmer Research Institute

The Fulmer Research Institute founded at Stoke Poges, Bucks, provides facilities both in equipment and personnel to industrial firms for carrying out researches, the results of which remain the sole property of the firms (*C.T.J.*, 1947, 121, 53).

The idea of a common user research institute is somewhat novel in Great Britain. Similar in principle, if not yet on a comparable scale, to the Batelle and Mellon Institutes in the U.S.A., it is claimed to be the only important research organisation in England where independently sponsored work can be carried out confidentially according to an agreed programme. At the moment the activities of the Institute are restricted to the metallurgical field for which it is very well staffed and equipped, but further expansion is by no means ruled out. The Institute is so organised that the staff works as a team, there being no division into water-tight compartments. Research on the same or closely similar projects will not be carried out for more than one sponsor simultaneously unless the sponsors agree to share in the work. Decisions on publication lie with the sponsor and not with the Institute and the Institute will advise publication where practicable, and particularly where the results of the work can be covered by patents which are the property of the sponsors.

Work already in progress includes, among many other subjects, the catalytic distillation of aluminium alloys and other materials, the development of alloys for service at high temperatures, the action of fluxes used in melting aluminium alloys and a preliminary investigation of the effect of different surface finishes on the adhesion of electro-deposits applied to aluminium alloys.

Metal Distillation.—One of the research projects undertaken by the Institute deals with metal distillation sponsored by *International Alloys, Ltd.*, (*C.T.J.*, 1947, 121, 42).

The existence of monohalides of aluminium has been deduced from spectroscopic data and calculations suggested that such monohalides would be

stable at low pressures and high temperatures. That these deductions were correct was proved by showing that aluminium can be distilled catalytically at temperatures in the region of 900°—1000° C. despite the fact that the vapour pressure of aluminium at 1,000° C. is of the order of only 0.0002 mm. and at 1,550° C. of the order of 1 mm. only.

The Catalytic method of distillation involves leading the vapour of normal trivalent halide over aluminium or aluminium alloys at temperatures of about 900° C. at about 1 mm. pressure, when the monohalide is formed. The reversible reaction $2Al + 2AlCl_3 = 3AlCl$ moves to the right at high temperatures and low pressures, and on cooling the reaction proceeds to the left.

The aluminium so produced has been shown to be of high purity, and the findings indicate the basis of a process for purifying aluminium from comparatively dilute aluminium alloys which may be produced by electrothermal reduction.

Expansion of the British Scientific

Instruments Industry

Six new laboratories of the B.S.I.R.A. have been recently inaugurated at Chislehurst Kent. The new building offers greatly extended facilities in the departments of optics, chemistry and physics and adds three new fields of research,—electrical instruments, electronics and mechanics (*Chem. Age*, 1947, 57, 86).

Newsprint Manufacture in India

With a view to manufacture high grade and cheap newsprint, a new company, *The National Newsprint and Paper Mills Ltd.*, (Capital, Rs. 5 crores) has been established. The factory will be situated at Chandni on the Burhanpur—Khandwa section of the G.I.P. Railway in the heart of a 375,000 acre forest tract, of which an area of 100 sq. miles has been leased to the company by the Central Provinces Government. The factory which will produce 100 tons of newsprint per day, will be equipped with Canadian and American plant and machinery.

The new industry will utilise the hitherto unexploited Indian "Broad-leaf" tree. The cost of newsprint produced in the factory will be approximately 60 per cent of the landed cost of the Canadian product.

Indian Medicinal Plants

A scheme of research on Indian medicinal plants and food poisons sanctioned by the *Indian Council of Agricultural Research*, was initiated in April 1945, and terminated last March. The objects of the scheme which has cost the Council about Rs. 96,700 were: (i) to encourage and give expert advice to Provincial and State Governments, public bodies and private individuals in the cultivation and commercial exploitation of medicinal plants in India; (ii) to study active principles and actions of all important plants used in indigenous medicine; (iii) to collect specimens of all medicinal and poisonous plants found in India; (iv) to carry out a systematic investigation of different food and forage poisons; and (v) to prepare and publish a monograph on "Poisonous Plants of India." (*Capital*, 1947, Sept. 18).

Lt. Col. Sir R. N. Chopra, who has been in charge of the scheme, has grouped Indian medicinal plants into 4 categories (a) Medicinal plants used in

Western medicine and their substitutes growing in India, (b) plants used in Western medicine and recognised in the extra pharmacopoeias, (c) important plants used in indigenous medicine, and (d) plants with alleged medicinal properties.

This work will be of special value in selecting areas for growing important medicinal plants on a commercial scale.

Radio-isotopes for Research

President Truman in a message to Dr. E. V. Cowdry, President of the fourth International Cancer Research Congress, announced that the United States will make radio-isotopes for medical and biological research available to users in other nations. According to the U.S. Atomic Energy Commission (AEC) which is to direct the distribution, they are in a position to produce radio-isotopes in sufficient quantity to permit the 20 most important isotopes for medical and biological research to be made available in limited amounts and at reasonable cost.

Conditions of Supply: Governments whose research workers request radio-isotopes from the United States must agree:

(1) To make progress reports to the AEC every 6 months on the results of the work with isotopes and to permit publication of the reports; (2) To insure that the radio-isotopes are used for the purpose stated in the requests, which must be approved by the commission prior to shipment; and (3) To permit qualified scientists irrespective of nationality to visit the institutions where the materials will be used and to obtain information freely with respect to the purposes, methods and results of such use.

U.S. laboratories and research groups have indicated their desire to have foreign scientists visit American institutions where medical and biological research with radio-isotopes is under way. The U.S. State Department has reviewed and approved the proposed distribution programme for the radio-isotopes.

Each foreign government requesting radio-isotopes from the U.S. will be required to designate a representative in the United States to file requests and receive shipments, make payment within the United States, and, upon receipt of shipments, assume responsibility for safe handling in transit of the radioactive materials. Delivery will be made only in the United States.

Designated representatives, after registration with the State Department, will forward their requests to the Isotopes Branch, U.S. Atomic Energy Commission, Oak Ridge, Tennessee. The AEC will publish a catalogue for foreign purchasers which will include detailed instructions for ordering isotopes, price lists and precautions to insure safe handling.

Isotopes available for foreign distribution do not include any radioactive material applicable to the development of atomic energy for military or industrial purposes. No naturally radioactive materials or isotopes of any element of higher atomic number than element 83 (bismuth) are included.

Following are the radio-isotopes available for foreign distribution and the principal fields of their use:

Antimony 122, 124, 125,—Venereal and general parasitological diseases;

Argon 37,—Respiratory functions;

Arsenic 76, 77,—Action of insecticides, arsenic drugs and fumes;

Bromine 82,—Action of bromine drugs (including sedatives);

Calcium 45,—Bone and teeth formation, rickets and bone diseases;

Carbon 14,—Cancer, photosynthesis, biological processes; body;

Chlorine 36,—Chlorine utilization by human
Cobalt 60,—Cobalt utilization by animals, therapy requiring γ -radiation;

Copper 64,—Botanical studies;

Gold 198, 199,—Blood diseases, especially leukemia;

Iodine 131,—Therapy in thyroid disorders, including types of thyroid cancer;

Iron 55, 59,—Blood studies;

Mercury 197, 203, 205,—Action of mercuric drugs;
Phosphorus 32,—Polycythemia vera, chronic leukemia, bone and teeth formation, fat and protein metabolism;

Potassium 42,—Disease of the nervous system;
Silver 108, 110, 111,—Drugs containing silver, radio therapy;

Strontium 89,—Bone metabolism;

Sulphur 35,—Amino acids and proteins, action of penicillin and sulphur-containing drugs;

Sodium 24,—Exchange of body fluids and blood flow, principally in connection with heart malfunctions; and

Zinc 65, 69,—Studies of action of insulin.

International Commission on Large Dams

The next plenary session of the International Commission on Large Dams will be held in June or July 1948 at Stockholm. The following questions will be discussed among others:

(1) Critical exposition of the measurement of uplift pressures and stresses arising therefrom; (2) Research methods and instruments for the measurement of stresses and deformation in earth and concrete dams; (3) The most recent precautions to avoid the formation of pipings; and (4) Experiences arising from the testing and actual use of special cements for large dams.

The Central Board of Irrigation is the National Committee for India for the International Commission on Large Dams.

Fisheries Development

The Central Inland and Estuarine Fisheries Station, Calcutta, has commenced work under the direction of Dr. T. J. Job. The main station is located at Pulta.

Indian Ceramic Society

The President of the Society, Seth P. B. Ganpule, has issued an appeal for donations for the construction of a suitable building at the Benares Hindu University, the Society's headquarters, for housing a library and museum. The President has donated a sum of Rs. 10,000 for the purchase of books and journals. An equal sum has been donated by the Benares Hindu University towards building construction. Contributions may be sent to H. N. Roy, Hon. Secretary, Ceramics Department, Benares Hindu University.

REPORTS FROM STATES & PROVINCES

Fine Chemicals, Drugs and Pharmaceuticals Industry

The panel for fine chemicals, drugs and pharmaceuticals industry appointed by the Government of India, has since issued a report. The industry is still in its infancy in the country. The panel considers that it should be possible to produce sufficient quantities of the chemicals and drugs in the country provided (i) the heavy chemical industry is expanded, (ii) the manufacture of intermediates from distillation products of coal tar is taken on hand, and (iii) manufacture of adequate quantities of solvents and crude vegetable drugs of proper quality is well organised.

enterprise, (ii) protection should be given to the industry (iii) research on fundamental problems connected with the industry should be liberally subsidized, (iv) scientists and technicians should be trained abroad for developing the industry, and (v) a technical planning commission should be set up to evolve an integrated plan on the basis of reports of different industrial panels constituted by the Government of India. The panel recommends that the shark liver oil industry should be placed on a firm basis and a Central Board representing the relevant Departments of the Government of India and the Departments of Fisheries of the maritime provinces should be set up to examine the problems connected with the industry.

Name	Present production	Target in 10 years.
<i>Vegetable drugs:</i>	Lbs./annum	Lbs./annum
Quinine	100,000	2,000,000 (within 15 years)
Pyrethrum	Mainly imported	50,000 lbs. of dried pyrethrum flowers
Emetin	Imported	2,000
Strychnine	15,000	16,000
Santonin	2,000 to 3,000	3,000
Ephedrine	3,000	5,000
Caffeine	20,000	30,000
Morphine	Nearly 2,000	3,000
<i>Synthetic drugs:</i>		
Sulpha drugs	Not known	500,000
Mapacrine	"	160,000
Paludrine	Target not fixed
D.D.T.	Very little	30,000 tons
P-carbaminophenyl-arsonic acid (carbarsonc) ...	2,000	50,000
Sulpharsphenamine and Nearsphenamine	Not known	50,000
<i>Vitamins:</i>		
Vitamin A	35,000 gal.	1,000,000 gal. of Shark liver oil of potency 6,000 units per gm.

The panel has fixed targets of production to be achieved within the next ten years for about 100 different kinds of drugs, vitamins, hormones, liver extracts, insecticides, refrigerants, photographic chemicals, fine chemicals, solvents, etc. Among them are some essential items for which the need is urgent and upon the production of which effort should be concentrated during the next 5 years. The present production of these essential items and the targets to be achieved in ten years are indicated in the above table.

The industry will require considerable assistance from Government. It is recommended that (i) the State should initiate production of coal tar intermediates either by themselves or through private

MADRAS

Research in fruit technology

The Government of Madras have under consideration a proposal from the Agricultural Department for starting a Fruit Technology Research Institute in Madras. The Institute will undertake researches on the preservation and utilization of fruits.

The scheme, it is stated, will involve an expenditure of Rs. 1½ lakhs. Madras has been selected as the venue of the Institute in view of the library and other technical facilities available in the city.

New Minerals discovered

According to the Minister for Industries in Madras, the following minerals have been recently

discovered in the places mentioned against each: **Lignite** in South Arcot; **Chromite** in **Namakkal Taluk** (Salem); **Columbite—Tantalite** in **Trichengode** and **Bavani taluks** of **Salem** and **Coimbatore** respectively; high-grade limestone in parts of **Salem** and **Tinnevely** and **Madura** districts; **magnesite** in **Namakkal taluk**, **Salem**, and **Kyanite** in **Chundi Zamindari**, **Nellore**. Lignite which would be used in the place of coal in some processes had been found in **Coimbatore**.

An area of about 23 square miles had been proved to be lignite-bearing and to contain a seam of an average thickness of 24.7'. The gross reserves of the mineral were estimated at 498 million tons approximately. Lignite could be utilised for steam raising and for generating electricity. It could be used as fuel for industries and locomotive boilers after being briquetted as was being done by the Italian Railways. It was also known to be used for the manufacture of synthetic petroleum by hydrogenation in Germany. Its value as fuel for domestic and technical use was well established in other countries. If it proved possible to convert the lignite into hard coke, it would be suitable also for the metallurgical industries.

BOMBAY

All-India Manufacturers' organization

In his Address at the third quarterly meeting of the Central Committee of the Organization, Sir M. Visvesvaraya stressed the need for stepping up industrial production. He referred to the work of the A.-I. M.O. Delegation which toured the industrially advanced countries of the West, both in Europe and America, to study the latest developments in the production and processes of manufacturing industries. The report of the Delegation, which is now in the press, will become available to the public shortly. The principal lesson which the Delegation has brought back is that "the individual citizen should depend upon his own efforts, his own initiative, self-help and team spirit, to improve his income or earning power. Every individual citizen is expected to contribute his best to the working

power or economic strength of his country at the same time." Another lesson is that "every individual should work on some plan or system in co-operation with other people so as to obtain the best results for himself and the greatest benefit to the group."

Sir M. Visvesvaraya pointed out that one of the powerful impediments to industries is the lack of proper statistics. He said: "The public are awaiting with anxiety the collection and issue of essential statistics to help in expanding the industrial life in each Province. This should be done for various special reasons. One is it will help to secure a substantial increase in revenue to Government; another is the saving of money which is going out of the country to purchase foreign products; a third reason is the increase of employment which it will secure for our labour population. Generally all these will help to raise the average standard of living in this country."

"An industrialization scheme can be evolved in a rough way at first from the material available in the country. And with proper organization and staff a complete industrialization scheme which would be of great benefit to the population can be prepared in the course of a year or two. It may consist of three parts: (1) A Five-Year Plan and associated proposals together with a first year plan based upon it, (2) Development of heavy or large-scale industries by Provinces; and (3) Development of self-help and co-operative spirit in villages by increasing their income from small-scale village industries.

"There will be a large number of medium-scale industries which come somewhere between classes (2) and (3) above. Such industries are generally imitations of existing ones either large or small. The size of the industry will depend generally on the capital available for investment.

"Correct up-to-date or latest statistics are needed to prepare a final five-year plan for industries.

"A five-year plan will be of the nature of a target for any region for which it may be prepared or for the country as a whole."

INDIAN PATENTS

[The following is a List of Patent Applications notified as accepted in the Gazette of India, Part II, section I, for May-June 1947.]

33631. STABILISING OF FOAM: *Contains amino acid metal complex, formed by reacting protein hydrolysate with a polyvalent metal.*—Wormald Brothers Pty. Ltd.
33878. MICROPHONES: *Nickel used as base material for electrodes.*—Standard Telephones and Cables Ltd.
33921. AUTOMATIC TELEPHONE SYSTEMS: *Impulses are registered on a marking device situated early in the train of switches or associated with a selecting switch.*—Siemens Brothers & Co. Ltd.
33991. TUBULAR CONTAINERS FOR SECTIONAL CURING BAGS AND METHOD OF MAKING SAME: *Longitudinal strain members attached to a ring at least at one end of the container.*—The Firestone Tyre & Rubber Co.
34112. PUNCHING MACHINES: *Gear wheel driving crank shaft having a clutch plate with recesses adapted to be engaged by a pin of an engagement block on the shaft; pin kept disengaged by catch against force of a spring; when released pin engages one of the recesses and gear wheel drives the shaft.*—Ahmed.
34164. ROTARY INTERNAL COMBUSTION ENGINE: *Otto two-stroke cycle rotary internal combustion engine.*—Amin.
34317. ELECTRIC PULSE-WIDTH MODULATING SYSTEMS: *Comprising tuned circuit shock-excited by pulses, resonant frequency of the circuit varying with modulating voltage.*—Standard Telephones and Cables Ltd.
34324. PLATES FOR USE IN THE MANUFACTURE OF TILES OR THE CONSTRUCTION OF FLOORS: *Lips projecting from flanges at the edges are arranged in pairs with the free ends of the lips of each pair directed towards one another.*—Constructors Ltd. and Finer.
34335. EDDY CURRENT CLUTCH APPARATUS: *Flux from field coil inter links flux concentrating poles and non-magnetic eddy current element and magnetic means.*—Heenan and Froude Ltd.
34402. A MACHINE FOR SHARPENING TEETH OF A SAW: *Rotatable grinding stone driving shaft, and camshaft with two cams.*—M. S. Industries & Saw Mills Ltd.
34449. PULSE TIME MODULATING ARRANGEMENTS FOR MULTICHANNEL ELECTRIC PULSE COMMUNICATION SYSTEMS: *Comprises means to produce electron beams of a sweep movement which deflection is controlled according to increments of input signals.*—Standard Telephones and Cables Ltd.
84480. EDDY CURRENT APPARATUS: *Adjacent belts poles are staggered; poles in the form of elongated teeth with adjacent ends overlapping and parallel to axis of rotation.*—Heenan and Froude Ltd.
34520. GENERATION OF ELECTRIC PULSES: *Having means of generating the pulses by altering between two conditions of stability.*—Standard Telephones and Cables Ltd.
34648. HYDROGEN PEROXIDE OF HIGH CONCENTRATION: *Aqueous hydrogen peroxide is distilled and fractionated under reduced pressure.*—B. Laporte Ltd. and Whittaker.
34682. APPARATUS OPERABLE DURING THE STARTING AND STOPPING OPERATIONS OF LOOMS: *Interposing a clutch between the picking mechanism and main drive, the clutch opening automatically to render the picking mechanism inoperative during starting and stopping the loom.*—Nicoll.
34684. GLASS BEADS: *Blowing by a glass tube of the same colour as the molten glass to be blown*—Dhar.
34790. ACETIC ANHYDRIDE: *Acetic anhydride is recovered from a mixture containing acetic anhydride and acetic acid by fractional distillation at pressure between 80 mm. and 200 mm. Hg.*—The Distillers Co. Ltd.
34794. GRINDING MILLS: *Beater rotates in a screen comprising a flat circular portion between and a cylindrical portion disposed around its periphery.*—Lipton.
34803. ELECTRIC PULSE SIGNALING SYSTEMS: *A periodic wave time modulating train of pulses, means being provided for phasing periodic wave with respect to pulse train.*—Standard Telephones and Cables Ltd.
35196. REINFORCING AND/OR SHUTTERING MATERIAL FOR USE IN BUILDING CONSTRUCTION: *Sheet metal laths, with longitudinal edges curved or bent providing recesses with re-entrant angles, secured together at intervals by wire strands.*—Johnston.
35198. COMBING MACHINES FOR COMBING TEXTILE FIBRES: *Providing a graduated setting arm located at approximately mid position in the length of the combing machine and in operative connection with the nipper shaft.*—Platt Bros. and Co. Ltd.
35200. ELECTRICAL COMMUNICATION AND SIGNALING SYSTEMS: *Adapted to operate with modulated impulses systems.*—Standard Telephones and Cables Ltd.
30548. COPPER MERCAPTIDES: *Mercaptans derived from monocyclic or bicyclic terpens are interacted with copper or a copper salt.*—Du Pont de Nemours and Co.
31291. PLASTIC DETONATING EXPLOSIVE COMPOSITIONS: *Comprising one liquid explosive nitric ester and a mixture of nitro-cellulose of which the greater portion is guncotton and the smaller portion is industrial nitrocellulose of high nitrogen content.*—I.C.I. Ltd.

31884. ACRYLIC ACID AND ESTERS THEREOF: *Reacting vinylidene chloride with formaldehyde or a polymer thereof in the presence aqueous sulphuric acid.*—I.C.I. Ltd.
33138. SOCKETS FOR ELECTRIC PLUG AND SOCKET CONNECTIONS: *The socket constitutes a skirt with thinned part near edge for admitting conductors.*—Dorman and Smith Ltd. and Lund.
33282. ANTISEPTIC PREPARATIONS: *Mixture of two or more antibacterial substances emulsion and the like of a fatty substance in aqueous solution of an iodonium salt.*—Parisepsin Ltd.
33403. VASOCONSTRICTIVE, ALDEHYDE DERIVATIVES OF AMINOALKANES, AND THE PRODUCT RESULTING THEREFROM: *Vasoconstrictive, aldehyde derivatives of aminoalkanes.*—Eli Lilly and Co.
33446. SEPARATING OILS HAVING DIFFERENT VISCOSITY INDICES FROM A LIQUID HYDROCARBON MIXTURE: *Treating the liquid hydrocarbon mixture with at least an equal volume of a polar solvent having a preferential solubility for aromatic hydrocarbons.*—Shell Development Co.
33459. PHOTOGRAPHIC ROLL FILM SPOOLS: *Having a core, a flange at either end of the core and dished inner surfaces for the flanges to contact the material wound thereon.*—General Aniline and Film Corp.
33463. SOLUBLE SULFANILAMIDE DERIVATIVES AND PROCESS OF PREPARING SAME: *Reacting sulfanilamide substituted in the p-nitrogen atom by an aliphatic-halogens acyl radical, with a tertiary amine.*—Hoffmann-La Roche Inc.
33464. HIGH MELTING OR LABILE ISOMERS OF DIACETONALKAMINE: *Producing unsymmetrical cyclic acetonealkamine by subjecting the corresponding acetoneamine to hydrogenation in presence of nickel catalyst.*—William R. Warner & Co., Inc.
33467. SUBSTITUTED 1,3, 5-TRIAZINYL-(6)- AMINOPHENYL. ARSENIC COMPOUNDS: *Reacting an 1,3,5-triazine derivative containing a halogen atom or an-N H₂ group radial with a substituted phenyl compound containing trivalent arsenic radical.*—Friedheim.
33477. CONDENSER TUBES, CONDENSER FERRULES AND THE LIKE: *Manufacture of condenser tubes etc. from aluminium brasses of compositions 5.1 to 6.25 per cent. aluminium; 12.1 per cent to 17 per cent zinc and remaining copper by effecting the hot working and annealing treatment at 500° C to 650° C.*—I.C.I. Ltd.
33524. CINEMATOGRAPHIC FILM AND METHOD OF MAKING THE SAME: *A ribbon film provided with register teeth in its margin to fit with a film having sprocket holes in printing operation.*—Technicolor Motion Picture Corp.
33526. METAL WORKING AND LIKE PRESSES: *Rotary cams actuating reciprocating tool carriers.*—T. A. Stevens.
33536. POWER STEER FOR SELF-PROPELLED VEHICLES: *A tabular being pin, connected to the tractor in laterally tiltable but steerable relation to the tractor, is mounted in a housing connected to the trailer, for relative rotation about an upstanding axis.*—R. G. Letourneau, Inc.
33539. BLENDING BITUMINOUS COMPOSITIONS, BITUMINOUS PRODUCTS AND SURFACE ACTIVE AGENTS USED ON BITUMINOUS MATERIALS, AGGREGATES AND THE LIKE: *Including in a bituminous material and/or coating an aggregate with a surface active agent.*—Nostrip. Inc.
33544. KETO-SULFONES: *Reacting a benzene sulfonic acid with an unsaturated ketone containing at least one double bond in L-position to the keto group.*—Hoffmann-La Roche Inc.
33547. POWER STEERING DEVICES FOR TRACTOR AND TRAILER COMBINATIONS: *King pin mounted over tractor in laterally tiltable but steerable relation adapted to be rotated by a reversible electric motor, trailer coupled to motor by a gooseneck secured to motor housing.*—R. G. Letourneau, Inc.
33550. CONTROL APPARATUS FOR PLACING A USEFUL LOAD MOVED BY AN ELECTRIC MOTOR IN A PREDETERMINED POSITION: *Comprising a pair of electrically conducting elements electrically separated by a neutral gap and a contractor engaging the conducting elements.*—Yardeny.
33551. GLYCOSIDES: *Reacting an acylbalo-h-aldose with a — (hydroxycyclopentanopolyhydrophenanthrene) — butyrolactone.*—Eli Lilly and Co.
33557. STEAMING TEXTILES: *Comprises means for forming a series of accordion folds for steam treatment.*—The Mathieson Alkali Works.
33558. ENGINES: *In a multirow radial engine adjacent rows of cylinder are circumferentially offset so that adjacent rocker boxes of said rows longitudinally overlap.*—United Aircraft Corp.
33568. CIGARETTE-HOLDERS, AND CIGAR-HOLDERS: *Air inlet is provided in the smoke duct leading from the tobacco holding part to the mouth piece end.*—Sweet.
33582. LAMINATED ARTICLES AND THE ARTICLES SO PRODUCED: *Adhesively binding sheets with resin formed by reaction between an L-substituted ethylene compound and a glycol polyester.*—Bakelite Corp.
33613. ADHESIVE BONDING OF SURFACES AND ADHESIVE COMPOSITIONS: *Applying coating of uncured or partially cured polymerised chloroprene, and a cement of polymerised chloroprene and organic solvents.*—B. B. Chemical Co. Ltd.
33652. HEAT-HARDENABLE RESIN: *Estrifying a mixture of an aliphatic- α -beta-dicarboxylic anhydride and a diolefin-maleic anhydride adduct with a glycol and copolymerising with an ethylene compound.*—Bakelite Corp.
33713. MASHED POTATO POWDER: *Cooked and mashed potato caused to thaw, treated to reduce moisture and subsequently heat dried.*—Chivers and Sons Ltd.
33752. SEATS AND CHAIRS: *A thigh, back or head rest pivotally and detachably mounted on a transverse rod of the seat is positioned angularly by the pressure upon it.*—Chapman.
33753. ADJUSTABLE SEATS AND SEAT BACKS, PARTICULAR SEATS AND SEAT BACKS FOR VEHICLES: *Front part and rear part of the seat hingeably connected to a support and seat back respectively, upward and downward movement of seat back alters angle of tilt of seat.*—Chapman.

33813. TELEVISION SYSTEM: *Producing lines of picture signals with intervals, modulating pulses according to instantaneous values of sound signals and interleaving time modulated pulses between lines.*—Standard Telephones and Cables Ltd.
34682. APPARATUS OPERABLE DURING THE STARTING AND STOPPING OPERATIONS OF LOOMS: *Interposing a clutch between the picking mechanism and main drive, the clutch opening automatically to render the picking mechanism inoperative during starting and stopping the loom.*—Nicoll.
35060. DYNAMOELECTRIC MACHINES: *Toric field linking inductor and field member produced by oppositely directed alternating polar with which are shaped to produce reversing fields with one or other polarity predominating on opposite sides of medial plane.*—Heenan and Froude Ltd.
35207. SIGNAL TRANSMISSION SYSTEMS EMPLOYING PHASE OR FREQUENCY MODULATION: *Arrangements for deriving frequency or phase modulated sinusoidal or carrier wave from a time duration modulated train of pulses.*—Standard Telephones and Cables Ltd.
35259. PRINTING FIBROUS SHEET MATERIALS: *Printing with an emulsion which contains as an aqueous phase a solution of alkali caseinate containing formaldehyde and as an oily phase a liquid of medium boiling point.*—Ciba Ltd.
35306. INSECTICIDE COATED OR IMPREGNATED FIBROUS MATERIAL AND A PROCESS FOR COVERING THE SAME (DIVIDED OUT OF NO. 35639): *Covering the fibrous material impregnated with naphthalene paradichlorobenzene and paraffin with cellulose acetate a plastic sheetings.*—Chakravorti.
35377. BOATS: *Construction with tongued and grooved planking, the planking bent and twisted to suit conditions.*—Buss.
35554. ELECTROLYTE LEVEL INDICATORS AND ANTI-SPLASH DEVICES FOR ELECTRIC ACCUMULATORS: *Provides a baffle-cup open at top and closes the lower parts of the slots, a restricted opening and a level indicator.*—The Chloride Electrical Storage Co. Ltd.
35581. NON-SPILL ARRANGEMENTS FOR ELECTRIC ACCUMULATORS: *A filling hole located in a threaded wall in the side wall of the cell, a threaded plug for screwing into the wall.*—The Chloride Electrical Storage Co. Ltd.
35583. ELECTROMAGNETIC TELEPHONE SYSTEMS: *Armature lies in gaps between the pole-pieces of each of two pairs of pole-pieces whose distance is determined by spacers.*—Siemens Brothers & Co. Ltd.
35586. ETCHING OF ALUMINIUM SURFACES: *Etching solution consisting of barium of stornium hydroxide.*—Aluminium Co. of America.
34342. CONSTRUCTIONAL TOYS: *Comprises as essential elements rods provided with threaded opening at one or both ends and transverse threaded opening intermediate their ends.*—George Reed and Sons Ltd.
34450. HIGH FREQUENCY BALANCE-TO-UNBALANCE TRANSFORMER: *Comprises a first and a second conductive loops on output lead connected to second loop and a pair of shields.*—Standard Telephones and Cables Ltd.
34540. WATER TAP: *Casing having a conical bore has a delivery hole on its circumference and at right angle to the conical bore, a bearing with which a conical plug carrying a handle and having a L shaped hole is screwed on the casing.*—Unadray.
34621. BURNER FOR STOVES: *Prepared from plain metal by casting.*—Lidrovan and Ramzanali.
34640. SULPHUR TRIOXIDE COMPOSITIONS: *Adding thionyl chloride to sulphur trioxide.*—Du Pont de Nemours and Co.
34657. PROCESS FOR INCREASING THE STRENGTH OF PAPER: *Paper impregnated with a polymeric carboxylic acid or water soluble derivative.*—I.C.I. Ltd.
34894. COLLOIDAL SULPHUR: *Decomposing ammonium polysulphide with an aldehyde in presence of a protective colloid.*—Schwartz.
34897. SLAY MOTIONS FOR LOOMS FOR WEAVING: *Effecting beating-up by slay through connecting rods constructed in the form of toggle arms.*—Marsden.
34931. RADIO POSITION INDICATING SYSTEM: *An indicator, a first means responsive to travel time of energy a second means responsive to energy reradiated from objects.*—Standards Telephones and Cables Ltd.
34949. TIFFIN CARRIERS OR THE LIKE: *Each container is swingably attached to a vertical member of the frame or stand of the tiffin carrier.*—Bhappu.
34951. PARACHUTE HARNESS: *Adjusting means allow shortening of straps and prevents lengthening of it when in tension.*—Pioneer Parachute Co. Incorp.
34955. GELATINE BLASTING EXPLOSIVES: *Gelatine blasting explosive having included therein a nitrocellulose cross-linking agent.*—I.C.I. Ltd.
35024. TIFFIN CARRIERS (ADDITION TO NO. 34948): *To a stationary vertical engagement bar is secured a bracket having a hole which is engaged by a pin secured to a plate and another engagement opening is formed in the plate, the opening being engaged by the top ends of the vertical bars.*—Bhappu.
35025. STANDS FOR SWEETS, CAKES, FRUITS AND OTHER GENERAL PURPOSES: *A set of vertical bars is secured to a base each bar having rests for tiers, and each tier has a pin which is detachably held between one of the vertical bars and another co-operating pivoted movable bar and then the ends of the two bars are clamped to each other.*—Bhappu.
36327. TIN OPENERS: *Comprising a shank, a cutting blade and a spring actuated fulcrum piece on the shank and guide place to bear against the outer side of the tin.*—Jorgensen.
36492. MACHINES FOR THE GRINDING OR CRANK-SHAFTS, CAMS, ECCENTRICS OR THE LIKE: *Comprises of a driving wheel having a resilient tyre, a grinding wheel friction contact with the driving wheel and support for the driving wheel and grinding wheel, a member to engage the crank pin with the grinding wheel.*—Beech.
36533. FOOD CHOPPERS OR MINCING MACHINES AND IN LIKE MACHINES: *Comprises vacuum cup or disc and sets in annular a hollow in their under side of a wide lense.*—John Harper & Co. Ltd. and Kermeth.

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Molasses as a Medium for Gluconic Acid Fermentation

By S. K. BOSE

(University College of Science and Technology, Department
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THE disposal of molasses, a problem to the sugar manufacturers, has long attracted the attention of industrial chemists. The direct conversion of uncrystallizable sugar of molasses, which averages up to 50 per cent., into valuable fermentation products is one of the best methods suggested for the purpose. The possibility of direct oxidation of glucose present in molasses to gluconic acid should be considered in this respect, since the calcium salt of the latter has an important place in the pharmaceutical industry. The microbial oxidation of pure glucose to gluconic acid is not a new idea¹ and its production on a technical scale has been exhaustively studied², but few investigators have explored the possibility of utilising molasses as the starting material.

The present work relates to the utilization of molasses as the fermenting medium. It may be noted in this connection that inhibition of fermentative reaction has been reported, when glucose, other than pure glucose, e.g. liquid glucose or 'technical' glucose is employed³. Inhibition also occurs in the case of molasses; the study of inhibitors present in different varieties of molasses and their removal by clarifying methods, forms a necessary part of this study.

Experimental

Preparation of the medium:- The medium employed was made up as follows :

	Gms.
Ammonium phosphate, dibasic,	0.70
Magnesium sulphate,	0.25
Acid potassium phosphate,	0.30
Chalk,	3.00
Cane sugar and molasses,	100-300
Water to make up	1,000 cc.

The medium after sterilization, was inoculated with *Arp. niger* and, incubated for 10 days at 32° C. The fermented liquor was sterilised, boiled with excess of chalk and filtered hot. The filtrate was concentrated under low pressure to a syrup and 92 per cent. alcohol (2 vols.) added to precipitate calcium gluconate. The precipitate was washed with 5 per cent. alcohol (3 times), dissolved in water, shaken up with decolourising charcoal (5 gm. per 100 cc.), and the salt crystallised out from the clear solution. With clarified molasses (sulphuric acid treatment), precipitation by alcohol was not found necessary. Calcium gluconate separated out from the syrup within 24 hours after seeding.

Estimation:- Gluconic acid was estimated as the soluble calcium salt *via* the calcium

TABLE I. Effect of medium on fermenting and spore forming ability of the organism.

Medium	Fermenting ability			Spore forming ability		
	Original	5th sub-culture	10th sub-culture	Original	5th sub-culture	10th sub-culture
Malt	31.40	28.30	20.50	Black	Decrease noticeable	Marked decrease
Yeast	31.50	24.90	19.50	Black	Marked decrease	Marked decrease
Barley	41.50	27.60	24.20	Black	Decrease noticeable	Marked decrease
Potato	31.50	39.60	42.00	Black	Black	Black.

TABLE II.

Concentration of molasses %	Yield of gluconic acid% on basis of total sugar.					
	A	B	C	D	E	F
10	30.30	34.20	28.30	25.90	35.20	33.40
15	27.80	30.30	27.20	24.30	32.90	31.60
20	10.20	24.60	9.80	6.90	24.70	12.40
25	8.50	20.20	7.20	5.20	20.60	12.00
30	7.00	19.20	6.80	5.30	18.50	10.30

oxalate⁴. The results of the volumetric method were confirmed by weighing the calcium gluconate obtained from each batch of fermentation.

Fermenting organism:— 41 strains of *Aspergillus niger* were examined in cane sugar media to determine their physiological characteristics. It was observed that while the production of oxalic and citric acids is quite common, a few can produce gluconic acid, in 87 and 95 per cent. yields on the basis of available glucose and fermented glucose respectively.

The selected strain was inoculated into the following media.

(1) *Malt extract medium*: 0.5 gm. of Kepler's malt per 100 cc. of agar medium, (2) *Yeast extract medium*: 0.5 gm. of extract per 100 cc. of agar medium (3) *Germinated barley extract medium*: 10 cc. of the extract (100 gms. of malted barley extracted with 100 cc. of water) per 100 cc. of agar medium, and (4) *Potato extract medium*: 50 gms. of potato cooked in water, peeled, made into a paste with 100 cc. of water and strained through fine cloth; chalk (0.2 per cent.) and cane sugar (5 per cent.) were added to the strained liquor. Table I gives the results obtained with different media. It will be seen that the potato extract medium not only enhances the fermenting ability but maintains also the spore forming capacity.

Effect of concentration on fermentation:— Molasses obtained from 6 different factories

were examined. Media containing the Molasses (marked A, B, C, D, E, F, & G. in Table II) in which the concentration of molasses was varied from 10 to 30 per cent. were prepared and inoculated with a culture of the selected organism. The concentration of sugar in each case was made up to 15 per cent. by the addition of cane sugar. The results obtained are given in Table II. It will be seen that the yield of gluconic acid falls with the rise in the concentration of molasses, indicating the presence of inhibitors. The drop in yields is highest in A and F, and least in B. It was noted also that in concentrated solutions the mycelia were white and thick and were submerged, while in dilute solutions they were black, and remained floating as a superficial layer.

Composition of molasses:— With a view to ascertaining the nature of the inhibiting substances, the 6 samples of molasses were analysed. The results are given in Table III. On comparison of the analytical data with the results given in Table II, it will be seen that the inhibition is related to the ash constituents and sulphites (absorbed SO₂ and sulphite). This has been confirmed by fermenting cane sugar solutions to which phosphates, nitrates, sulphites and the ash from molasses were added. The results are given in Tables IV and V.

The presence of sulphur in the form of SO₃²⁻ markedly inhibits gluconic acid production.

Clarification of molasses.— The inhibitors present in the molasses can be eliminated to a marked extent by clarification. In the next series of experiments, the effect of clarification by the sulphuric acid method was studied. The procedure was as follows. Dilute sulphuric acid was added to a solution of molasses to bring the acidity to pH.3. The solution was steamed and filtered. The results obtained with the clarified solution are given in table VI.

TABLE III.

Constituents	% present in					
	A	B	C	D	E	F
Cane sugar	30.20	30.60	30.40	31.10	29.20	29.60
Glucose	11.10	8.90	7.60	8.70	7.90	10.40
Laevulose	13.20	9.50	10.00	9.40	9.20	11.00
Total sugar	54.50	49.20	48.00	50.20	46.50	51.30
CaO	1.65	0.45	2.00	1.89	0.38	0.64
Fe ₂ O ₃	0.23	0.20	0.20	0.22	0.19	0.22
SO ₃	1.31	0.82	2.17	1.42	0.84	1.45
P ₂ O ₅	1.99	0.42	1.50	2.01	0.49	2.05
MgO	0.55	0.53	1.50	0.62	0.45	1.32
K ₂ O	4.86	2.82	5.02	5.96	2.03	5.01
Total ash	13.00	7.00	13.30	14.20	6.50	13.50
Amonia	0.018	0.018	0.02	0.02	0.019	0.017
Protein	0.55	0.59	0.67	0.67	0.61	0.50
Nitrate	0.12	0.14	0.14	0.13	0.15	0.17
Total nitrogen	0.46	0.45	0.48	0.50	0.45	0.52
Sulphite and absorbed SO ₂	0.16	0.10	0.17	0.17	0.11	0.16

TABLE IV.

Substance added	Quantity in gms. litre of solution.	% yield on total sugar
Pot. Dihydrogen Phosphate	1.00	41.5
	1.50	41.3
	2.00	30.6
	2.50	25.9
Am. nitrate	0.20	30.6
	0.40	14.4
	0.60	12.2
	0.80	8.7
Na ₂ SO ₃	0.10	39.6
	0.15	30.9
	0.20	21.3
	0.25	11.6

TABLE V.—Effect of ash* from molasses.

Molasses equivalent of ash.	% yield on total sugar.		
	A	B	C
10	29.8	35.9	34.5
15	24.8	29.7	32.7
20	19.6	26.2	24.6
25	16.8	23.7	20.1
30	15.2	20.8	15.9

*The ash was extracted by dil. sulphuric acid, neutralised and added to the medium.

TABLE VI.

Concentration of molasses %	Yield % on total sugar.					
	A	B	C	D	E	F
10	30.9	36.2	27.8	30.2	36.2	29.6
15	28.5	35.7	26.3	29.4	35.6	28.4
20	24.3	35.6	24.4	28.6	34.6	26.2
25	22.1	34.9	18.2	16.5	34.9	18.7
30	20.6	35.2	19.2	15.4	33.8	17.8

A marked improvement in the yield of gluconic acid is secured through clarification. Inhibition is still noticeable at higher concentrations. Other methods of clarification, viz. the superphosphate and calcined bauxite methods, were not beneficial.

The results of the above trials were helpful in fixing the optimum conditions for the production of gluconic acid from molasses.

The procedure finally adopted was as follows :

A 50 per cent. solution of molasses was autoclaved under 15 lbs. pressure for 15 minutes and allowed to settle overnight. The supernatant liquid was acidified to pH. 3.0 with dilute sulphuric acid, heated by steaming for one hour, cooled and neutralized with chalk. To the clear liquid, nutrient salts and chalk were added in the required concentration and the medium diluted so that the concentration of molasses in the final solution was 30 per cent. 100 cc. of the medium were measured out into Roux bottles, sterilized, inoculated and incubated (32°C.) for 10 days. The fermented liquid was worked up for the recovery of calcium gluconate. The yields obtained from different molasses are given in Table VII.

It has been found that some 4 to 5 per cent. of gluconate is lost during the processing. There is a loss of about 1 per cent. sugar during clarification and about 3 per cent. of calcium gluconate remains in the mother liquor after separating out the gluconate crystals which cannot be recovered.

TABLE VII.

Molasses	Fermented molasses gms.	Glucanate obtained gms.	% yield on molasses.
A	3960	396	10.0
B	2280	412	18.0
C	5560	506	8.2
D	2594	506	19.5

The losses which occur during the purification of the salt can be recovered. The total process losses do not exceed 3 to 4 per cent, under efficient control.

These results are helpful in fixing up specifications for molasses which can be employed for the production of gluconic acid by the fermentation process. The specifications are :

	%
Ash	< 7
Protien & Ammonia	< 0.5
Sulphite at absorbed SO ₂	< 0.1
Phosphate	< 0.5

Summary

1. All molasses can be fermented to gluconic acid in sufficient dilution.

2. Commercial molasses contain inhibiting substances which can be reduced by acid clarification.

3. An yield of 80 to 84 per cent. on the basis of available glucose in the medium can be ensured by the fermentation process.

Acknowledgment.

My grateful thanks are due to Prof. B.C. Guha and to Dr. B. N. Ghosh for their kind and valuable suggestions in the course of this investigation.

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Soap Gels in non-Aqueous Media Part II.—Effect of Ageing

By G. S. HATTIANGDI

(Chemical Laboratories, Royal Institute of Science, Bombay).

AGEING signifies the changes in the properties which a system undergoes on standing. Several workers have studied the manner in which the physical properties of colloidal solutions are modified on ageing. Investigations on the effect of ageing on gels have been conducted, however, mostly in the case of the gels of hydrous oxides. It is found in general that newly formed gels are highly hydrated and give a diffused X-ray diffraction pattern; on ageing, they become less hydrous, and bands or lines appear in the diffraction patterns. Earlier workers attributed these changes to the transformation of the disperse phase in the gel from one allotropic modification to another. However, it is now fairly well

established that the phenomenon of ageing is due to the growth or agglomeration of the minute colloidal gel particles into larger granules or aggregates^{1,2}. The ageing of gels is manifested usually by (i) the contraction of the system which is evidenced by a gradual development of opacity, and (ii) the consequent exudation of the dispersion medium which is known as "syneresis".

McBain and McClatchie³ and Hattiangdi⁴ have examined the behaviour of a number of soaps towards several non-ionizing organic solvents before, during and immediately after the process of sol-gel transformation, and remark that structural changes continue to take place in these gel systems even after the setting point has been reached. This is

manifested by the development of opacity, the modification of mechanical properties and, in some systems, by syneresis when the gels are allowed to stand for some time. The present investigation was undertaken to study systematically the effect of ageing on soap gels in organic solvents, mainly with a view to obtaining definite information on this subject which is lacking at present and which may be of some significance.

Materials Used

The sodium stearate employed was a pure product of *Messrs. E. Merck & Co.* Pinene and nujol were products of *Messrs. E. Kodak & Co.* and *Stanco Inc.*, respectively; the other solvents employed were pure products of either *E. Merck, Kahlbaum-Scherring, Riedel-Haen* or the *B. D. House*. All these solvents were tested for their purity before use.

Experimental

Known amounts of sodium stearate were taken in clean dry test tubes and 10 c.c. of one of the solvents were added to it. The concentration of the soap in the gels in pinene, cumene, cymene, nujol, *iso*-propyl alcohol, glycerine and benzyl alcohol was about 0.75 per cent. and in those in *o*-cresol, *m*-cresol, phenol and ethylene glycol was about 4 per cent. The soap-solvent system was heated gradually to a temperature near about the boiling point of the solvent when the soap dissolved completely and a clear mobile solution was obtained. Air bubbles present in the system were removed carefully, and it was then allowed to cool and set in an air thermostat at 30°C. The test-tubes were well corked and sealed to prevent evaporation of the solvent or absorption of moisture, as also to avoid contamination by fungus and dust particles. The gels were examined periodically over a period of 12 months to notice the changes in their structure and behaviour. The observations made are presented in Tables I, II and III.

Discussion

It will be seen from the results presented in Tables I, II and III that the effects of ageing on the behaviour of gels of sodium stearate in the different organic solvents can be classified broadly into the following three categories;

1. The gels synerise profusely and deteriorate completely after a few months, the soap either settling down as a sediment or remaining as a suspension in an extremely finely divided state (cf: Table I.)

2. The gels synerise to a much smaller extent than those above only after a considerable lapse of time, and the shrunken portion exists either in a translucent or in an opaque state (cf: Table II).

3. The gels do not synerise at all and neither do they shrink appreciably; however, there is evidence of the formation of large visible particles (cf: Table III).

It will be seen from Table I that the general behaviour of the gels in cumene, cymene and pinene is very similar to one another. The gels, which are initially clear and transparent, develop opacity after 2 or 3 months and also commence synerising. Subsequent ageing increases the syneresis to 50 per cent. of the total volume of the gel, and large aggregates of soap particles appear in the shrunken gel. The soap "crystals" settle down after 6 to 9 months, and these revealed, on examination through a microscope of $\times 2,000$ magnification the same shape and structure as the original dry soap. The behaviour of the gels in *o*-cresol, *m*-cresol and phenol is very similar to each other but differs from those in cumene, cymene and pinene in two marked respects, namely, (i) no change in the transparency of the gel takes place even when it shrinks, and (ii) no sedimentation of the soap "crystals" occurs even after the gel has broken down completely; it is surmised that the system exists possibly in a "sol" state.

The behaviour of the gels of sodium stearate in phenetole, glycerine, *iso*-propyl alcohol and nujol is the same in all respects, and corresponds approximately after ageing for one year to the behaviour shown by the gels given in Table I during the first few months. No syneresis takes place in the first few months, but a distinct cloudiness is observed which does not appear to increase on further ageing. However, particles separate out from these gels and these appear to be similar to one another when viewed through a high-power magnifying glass and can actually be counted. After ageing for 12 months, these gels synerise to a slight extent, the syneresis decreasing in the order

Nujol < *iso*-propyl alcohol < glycerine < phenetole

It will be seen from Table III that the gel of sodium stearate in benzyl alcohol is initially clear, transparent and colourless,

TABLE I

Period of Ageing, months	Cumene	Cymene	Pinene	<i>o</i> -Cresol	<i>m</i> -Cresol	Phenol
0	Clear, transparent gel; yellowish-orange.	Clear, transparent gel; yellowish-orange.	Clear, transparent gel; colourless.	Clear, transparent gel; wine-colour.	Clear, transparent gel; wine-colour.	Clear, transparent gel; pink.
1	Slight syneresis and a little opacity developed.	Slight syneresis and a little capacity developed.	No syneresis; slight opacity developed.	Slight syneresis; no change in transparency.	Slight syneresis; no change in transparency.	Slight syneresis; no change in transparency.
2	More syneresis (50%); slight opacity.	More syneresis 50%; slight opacity.	No syneresis; crystalline aggregates formed.	Further slight syneresis; still transparent.	Further slight syneresis; still transparent.	Further slight syneresis; still transparent.
3	Syneresis about 50%; crystals formed in remaining shrunken gel.	Syneresis about 50%; crystals formed in shrunken gel.	Larger aggregates formed; visible to naked eye; slight syneresis.	50% syneresis; still transparent.	50% syneresis; still transparent.	50% syneresis; still transparent.
6	Gel completely broken down into a "sol"; soap crystals are sedimented.	Gel completely broken down into a "sol"; soap crystals are sedimented.	50% syneresis; remaining shrunken gel contains large soap crystals.	Gel completely broken down into a "sol"; no sedimented or suspended soap particles; clear solution.	Gel completely broken down into a "sol"; no sedimented or suspended soap particles; clear solution.	System largely broken down; about 30% gel remains in shrunken state.
9	"	"	Gel completely broken down; soap particles are sedimented.	"	"	"
12	"	"	"	"	"	Gel completely broken down into a "sol"; no sedimented or suspended soap particles; clear solution.

TABLE II

Period of Ageing months	Phenetole	Glycerine	1,0-Propyl Alcohol	Nujol
0	Clear, transparent gel; yellowish-orange.	Clear, transparent gel; pale yellow.	Clear, transparent gel; colourless.	Clear, transparent gel; colourless.
1	No change in opacity or syneresis.	No change in opacity or syneresis.	No change in opacity or syneresis.	No change in opacity or syneresis.
2	— do —	— do —	— do —	— do —
3	Slight syneresis and opacity developed.	Slight crystalline growth perceptible; no syneresis.	Very slight syneresis; crystal growth perceptible.	— do —
6	20% syneresis; remaining shrunken gel is translucent.	Crystal growth to a greater extent; particles can be counted; uniformly distributed; no syneresis.	— do —	— do —
9	30% syneresis; remaining shrunken gel is translucent.	Very slight syneresis; larger crystals are visible.	— do —	— do —
12	45% syneresis; remaining shrunken gel is translucent.	Approximately 15% syneresis; distinctly large crystals with a clear structure are visible.	Crystals are slightly larger; syneresis is approximately 10%.	Very slight opacity developed; very slight syneresis; no crystals.

TABLE III

Period of Ageing months	Benzyl Alcohol	Ethylene Glycol
0	Clear, transparent gel; colourless.	Opaque, white gel.
1	No change in opacity or syneresis.	No syneresis or evidence of gel shrinking.
2	— do —	— do —
3	— do —	— do —
6	No change in opacity or syneresis; small spherical particles are formed; no breaking down of structure.	Small spherical particles formed; gel still opaque and shows no signs of breaking down in structure; no syneresis.
9	— do —	— do —
12	Larger particles formed; system translucent; no syneresis.	— do —

and that it remains as such during the first few months. After 6 months, small spherical particles are visible which increase in size on ageing for 12 months; a slight increase in opacity also appears at the same time. The gel of sodium stearate in ethylene glycol is initially opaque and white, and shows the same behaviour on ageing as the gel in benzyl alcohol, the separated particles in this case being visible only at the surface of the container. The appearance of the aged gel is more or less like that of a soft wax.

It will thus be noticed that the effect of ageing on the behaviour of the gels of sodium stearate in different non-aqueous media depends upon the properties of a group of solvents. This leads to the surmise that the effect of ageing may be related in some manner to the physical characteristics of the solvent molecules.

The general behaviour of the several gels can be explained as follows: The micelles in a gel system, which are adsorption complexes, are highly unstable and tend to go over to a more stable state such as that of a molecular solution or of a coarse suspension. Since sodium stearate is practically insoluble at 30°C. in the different organic solvents used in this investigation, it cannot go into solution but its transition to the state of coarse particles is quite possible. Therefore, when the gels of sodium stearate in the different organic solvents are allowed to age, the micelles in the gels either (i) approach nearer to one another, or (ii) readjust themselves in the gel structure, due largely to the internal forces exerted by the solvent molecules. In the former case, they form larger aggregates and thereby cause the

shrinkage of the gel, the squeezing out of the syneretic liquid, and the embrittlement of the gel structure. In the latter case, they go over to the crystalline state and give rise to visible crystals.

Summary

The effect of ageing on soap gels in numerous organic solvents has been examined. In general, ageing of gels results in their shrinkage and in the embrittlement of their structure, this being evidenced by the development of opacity and by the exudation of syneretic liquid. The physical properties of the solvent molecules appear to be responsible for the different behaviour exhibited by gels in different organic media. Thus there is rapid deterioration of the gels resulting in the sedimentation of soap particles in cumene, cymene and pinene, and of the formation of "sols" in *o*-cresol, *m*-cresol and phenol. The deterioration is less in the case of gels in phenetole, glycerine, iso-propyl alcohol and nujol, and is least in benzyl alcohol and ethylene glycol.

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Production of Strontium Carbonate from Indian Celestite

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AMONG the strontium salts employed for technical and other purposes, strontium carbonate is by far the most important. Besides its use in several industrial processes, particularly in the production of high grade steel, it forms the starting material for the preparation of other strontium salts. Strontium oxide and hydroxide are extensively used in the beet-sugar industry; the sulphate is used in paints and as a filler for rubber; the chloride is used in refrigerators. Strontium salts are used also in fireworks, flares, signals, military rockets and tracer bullets. Some strontium salts are used in medicine as sedatives and in the treatment of heart troubles. Several tons of strontium salts are probably imported into India every year; no correct figures can be given for want of data. It is necessary, therefore, that the large-scale production of strontium salts should find an important place in the development plans for the manufacture of heavy chemicals in this country.

The minerals used for the manufacture of strontium salts are celestite (sulphate) and strontianite (carbonate). Only a few countries possess large deposits of these minerals. The biggest source of celestite in the world is the United Kingdom, where the total production during the period of 1884-1935 amounted to 5,00,000 tons. Strontianite occurs in Germany which supplies most of the world's requirements. Several deposits of strontium minerals are found in the United States of America.

Till recently strontium minerals were considered rare in India. Wrath¹ reported the occurrence of celestite in the Uttattur area of cretaceous rocks of Trichinopoly District. Jayaraman and Krishnaswamy² found that strontium sulphate occurs in the phosphatic nodules derived from the same area. Jayaraman³ estimated that about a million tons

of celestite (93 per cent. SrSO_4) were present along with gypsum in an area of about 2,000 acres. A detailed investigation of these deposits has been carried out by Krishnan.⁴

Celestite has been found to occur near Mianwali in the Punjab covering an area of three square miles. It is estimated that half a million tons of this mineral are available in this area. No mention of this occurrence has been reported so far. Celestite occurs in lumps of varying sizes; lumps of 20-30 lbs. are common, and those of 40-50 lbs. are not rare. The lumps contain (i) fibrous, radiating, white opaque crystals and (ii) powdery reddish-grey amorphous withered material. Judged from the examination of a representative sample of about 200 lbs. of the mineral, the average strontium sulphate content of the deposit as a whole is 97 per cent., while that of the crystals is well over 99 per cent. These deposits appear to be richer than most of the foreign and other Indian celestite and are totally free from barium and calcium sulphates, the small quantities of impurities being mostly superficial.

Two methods are mainly employed for the preparation of strontium carbonate from celestite. In the first, celestite is reduced by coal or charcoal in a reverberatory furnace, and the soluble sulphide thus obtained is treated with carbon dioxide or alkali carbonate; in the other, celestite is allowed to react with an aqueous solution of alkali carbonate under specified conditions. In the early days, large quantities of strontium carbonate were made by the first method; the percentage of reduction obtained was 60-80, and the conversion of sulphide to carbonate did not exceed 90 per cent. Recently Shrikantan⁵ adopted this method for the preparation of strontium carbonate from Trichinopoly celestite. The process

suggested by him involves six operations: (i) preliminary concentration and grinding of the ore and mixing it with the requisite quantity of sodium chloride and charcoal, starch being added to form a paste (ii) reducing the ore in a furnace at bright red glow, (iii) powdering the black ash, (iv) lixiviating the black ash with hot water at 100°C. (v) filtration of the leached solution, and (vi) treatment of the filtered liquor with soda ash.

The second method has been employed by a number of early workers (*cf.* Urquhart and Rowell⁶, Mebus and Decastro⁷ and Konther⁸). Piva⁹ obtained strontium carbonate by treating celestite with carbon dioxide and ammonia, the percentage conversion under the best conditions being 82-85 per cent. Bashilov and Sobolev¹⁰ found that the speed of reaction between celestite (Russian) and sodium carbonate was a function of the particle size of the ground ore, temperature and excess of sodium carbonate. Technical conditions for the efficient and economic conversion of celestite were determined by Sobolev¹¹; these details, however, are not available. For the treatment of crushed celestite with sodium carbonate Thomas¹² patented a process which has not been quite successful. Using ammonium carbonate in place of sodium carbonate and optimum conditions of temperature, pressure and excess of carbonate, Gallo¹³ found that only 90.5 per cent. of the celestite was converted into the carbonate. These experiments were repeated by Kobe and Deiglmeier who obtained only 73 per cent. conversion. Elledge and Hirsch¹⁴ attempted the conversion in the presence of sodium hydroxide, while Booth¹⁵ used fused sodium chloride as the medium of reaction; in the latter case a 99.9 per cent. conversion is claimed when 17 per cent. excess of sodium carbonate was employed.

A systematic investigation of the reaction between strontium sulphate and alkali carbonate was conducted by Kobe and Deiglmeier¹⁶ who studied the effects of time, temperature and concentration of alkali carbonates on four different types of strontium sulphate. Under the most favourable conditions they obtained a percentage conversion of 97.5. They designed a pilot plant which could take in a charge of 200 lbs. of ore, 40 lbs. of sodium carbonate (25 per cent. excess) and 15 gallons of water. On maintaining the temperature at 90°C. and keeping the charge

well stirred they obtained 96 per cent. conversion in one hour. 1,400-1,600 lbs. of the ore could be worked up in one day.

Recently Jayaraman³ reported that finely powdered celestite was easily and quantitatively decomposed in 10 per cent. solution of ammonium carbonate on heating for two hours. He also worked out a process for the preparation of strontium carbonate from Trichinopoly celestite and sodium carbonate.

On comparing the efficiencies of the two processes for the conversion of celestite to strontium carbonate, it is found that the former is cumbersome and entails heavy capital and manufacturing costs. The yield is low and the product has often to be refurnished. The second process is simpler and quicker and the conversion is almost quantitative. Only three operations are involved, *viz.* (i) preliminary treatment of the ore, (ii) reaction with a solution of alkali carbonate, and (iii) washing the product free from sodium sulphate. The manipulations are simple and no elaborate machinery is required, the only appliance needed being an efficient shaker.

Theoretically any of the three alkali carbonates should prove equally effective for the conversion of strontium sulphate to carbonate. In practice, however, one of the three has to be selected in preference to others. Potassium carbonate is ruled out as it is neither cheap nor plentiful in India. The advantages in using ammonium carbonate are: (i) the reaction can be carried out at a lower temperature giving the same yield, thus reducing the consumption of fuel and (ii) most of the ammonia can be recovered as ammonium sulphate which is a valuable fertilizer. But the experimental conditions have to be carefully adjusted so that no decomposition or volatilisation of the carbonate takes place. The use of sodium carbonate, which is comparatively cheap, demands no such precautions and the conversion is somewhat higher than that obtained with ammonium carbonate.

Considering the solubilities of strontium carbonate (*cf.* Townley, Whitney and Felsing¹⁷) and strontium sulphate (*cf.* Gallo¹⁸) it would appear that the reaction should proceed to completion even at room temperature, but the actual conversion obtained is only about 80 per cent. It was therefore necessary to study the influence of time,

temperature and concentration of sodium carbonate, the particle size of the ore and the efficiency of stirring the reaction mixture on the conversion of celestite (Mianwali) into carbonate. The results obtained have been discussed from the point of view of (i) economic manufacture of strontium carbonate from celestite, (ii) recovery of by-products, and (iii) possibility of using recovered soda ash and Indian natural soda (efflorescent deposits) as carbonating material.

In the course of this study, it became clear that the percentage of conversion is determined by the efficiency with which the reaction mixture is stirred up. Even the mechanical shaker (giving eccentric motion) employed by Kobe and Deiglmeier was not efficient enough to bring all the particles within the zone of reaction at all times. An efficient stirring device has been designed by us in the course of this investigation.

Experimental

(a) ANALYSIS OF ORE: The results of analyses of two samples of Mianwali celestite are given in Table I.

(b) PRELIMINARY TREATMENT AND CONCENTRATION OF ORE: The ore was ground in a ball-mill to 200-mesh and digested with 9.0 N sulphuric acid for half an hour at 80°C. to remove the impurities. This concentration of acid was necessary for removing the last traces of iron and aluminium oxides and for preventing the loss of strontium sulphate which is soluble in weak solutions (<9.0 N) of the acid. The acid was decanted off and used over again for the treatment of fresh quantities of ore. The treated ore was washed free from sulphuric acid, dried and analysed; the results are given in Table I.

TABLE I.

	Before acid treatment.		After acid treatment.
	Sample 1	Sample 2	
Strontium sulphate	97.88	97.88	99.80
Silica	0.30	0.39	0.20
Calcium carbonate	0.93	0.93	nil
Magnesium carbonate	0.12	0.32	nil
Fe ₂ O ₃ + Al ₂ O ₃	0.16	0.45	trace
Moisture	0.71	0.03	nil

(c) REACTION WITH SODA ASH: The reaction was carried out in hydrogen peroxide bottles provided with porcelain stoppers and iron clasps. The bottles charged with the reac-

tion mixture were first corked, then closed with a rubber washer, porcelain stopper and finally by the iron clasp; rubber washers were wrapped in an oil paper to prevent attack by hot oil of the oil-bath. The bottles were sealed with a mixture of plaster of paris and gum arabic and shaken in an iron shaker rotated on an horizontal axis by an electric motor whose speed could be regulated. The bottles were rotated in such a way that each bottle turned on its vertical axis upside down in each rotation, thus ensuring a thorough mixing of the contents. The shaker and the bottles were immersed in an oil-bath maintained at 100°C (±0.2°C.) by gas fired ring burners. The shaker was connected to the motor by a cog-wheel and chain arrangement as leather belting was attacked by hot oil.

The strontium carbonate formed in the reaction was washed free from sodium sulphate and excess of sodium carbonate and dried. After careful sampling, 0.5 gm. of the strontium carbonate was dissolved in hydrochloric acid solution of known normality and the excess of acid titrated against a standard solution of sodium hydroxide. The amount of the acid used up gives the percentage conversion of strontium sulphate to carbonate. The weight of the unconverted strontium sulphate served as a check for the titration data.

(d) INFLUENCE OF TIME AND OTHER VARIABLE FACTORS ON THE REACTION: The effects of various factors on the progress of reaction were severally determined. The results obtained are given in Tables II-VII. The experimental conditions are indicated in each Table; the following notations have been employed—

- a*, amount of celestite ore in gms.,
- b*, amount of soda ash in gms.,
- r*, speed of the shaker, expressed in revolutions per minute,
- s*, particle size in mesh per sq. inch,
- t*, time of reaction in minutes,
- T*, temperature of oil-bath in °C.,
- v*, cc. of water in the reaction mixture,
- c*, percentage excess of sodium carbonate,
- x*, percentage conversion,
- C*, percentage concentration.

TABLE II.—EFFECT OF TIME.

a: 91.84 gm.; b: 63.60 gm.; v: 500 cc.; T: 100° C.; r: 24 rpm.; s: 200 mesh.; c: 20%.

t:	15	30	45	75	90	120	150	195	240
x:	87.60	92.86	95.34	97.54	98.14	98.28	98.58	98.86	99.02

TABLE III.—EFFECT OF EXCESS OF SODIUM CARBONATE.

a: 91.8 gm.; v: 500 cc.; T: 100° C.; t: 150 mins.; r: 24 rpm.; s: 200 mesh.

c:	5	15	25	40	55	70	85	100
x:	85.70	94.36	98.20	98.68	98.90	99.02	99.54	99.54

TABLE IV.—EFFECT OF CONCENTRATION.

a: 91.84 gm.; b: 66.25 gm.; t: 150 mins.; T: 100° C.; r: 24 rpm.; s: 200 mesh.; c: 25%.

C:	1.92	2.16	2.46	2.87	3.45	4.31	5.74	8.35
x:	99.54	99.54	99.42	99.80	99.42	99.54	99.28	99.10
C:	10.00	11.13	12.53	14.35	17.25	19.72	23.00	27.60
x:	98.92	98.28	98.80	97.32	98.92	98.40	98.18	98.08

TABLE V.—EFFECT OF TEMPERATURE

a: 91.84 gm.; b: 66.25 gm.; t: 150 mins.; v: 500 cc.; f: 24 rpm.; s: 200 mesh.; c: 25%.

T:	33	42	51	62	71	79	86	93	100
x:	76.98	84.54	90.50	95.90	97.24	97.86	98.44	98.28	99.54

TABLE VI.—EFFECT OF PARTICLE SIZE

a: 91.84 gm.; b: 66.25 gm.; t: 150 mins.; T: 100° C.; r: 24 rpm.; v: 500 cc.; c: 25%.

J:	40-60	60-80	80-100	100-120	120-150	150-200
x:	93.18	95.80	97.10	98.44	99.28	99.42

TABLE VII.—EFFECT OF RATE OF SHAKING.

a: 91.84 gm.; b: 66.25 gm.; t: 150 mins.; T: 100° C.; v: 500 cc.; s: 200 mesh.; c: 25%.

r:	10	12	15	18	22	24	26	30	34
x:	97.76	98.30	98.80	99.28	99.42	99.14	98.56	97.82	97.22

The mechanical energy spent for shaking and the consumption of fuel for keeping the reactants at the desired temperature are both determined by the time of the reaction. The results (of Table II) show that the velocity of conversion rises rapidly during the first 75 minutes, when 97.5 per cent. of the ore is converted. Subsequent increase in the conversion is slow reaching 98.5 per cent. in 2—2.5 hours and 99 per cent. in 4 hours.

An excess of sodium carbonate is needed to obtain maximum conversion. It will be observed from Table III that the percentage conversion increases rapidly to 98.2 per cent. with an increase in the excess amount of sodium carbonate upto 25 per cent. With amounts larger than 25 per cent. of sodium carbonate the increase in percentage conversion is slow; it is 99 per cent. when 70 per cent. excess of carbonate is used, and 99.5 per cent. when the excess of sodium carbonate is 100 per cent. An excess of 25 to 30 per

cent. of sodium carbonate is used in subsequent experiments.

The concentration of sodium carbonate employed determines the volume of the reaction mixture and hence the size of the reaction vessel. The effect of this factor on the reaction was studied in the next series of experiments.

It will be seen from Table IV that on increasing the concentration, the percentage conversion is decreased only to a small extent, the decrease being nearly 1.5 per cent. when the concentration is increased from 1 to 30 per cent. This shows that the concentration of sodium carbonate has very little effect on the conversion efficiency, and hence for the economic working of this process as high a concentration of the reactants should be used as practicable. A concentration ranging between 10-15 per cent. would give about 98.5 per cent. conversion.

The percentage conversion increases rapidly with temperature, attaining a value of 96 at 60°C. Thereafter, the increase is slow, being 99.28 per cent. at 93°C and 99.54 per cent. at 100°C. Thus a fairly high conversion takes place at temperatures ranging between 95-100°C. These results (cf Table V) indicate that the rise in velocity of reacting molecules more than compensate for the decrease in the solubility of strontium sulphate above 40°C.

The size of the particle is an important factor in heterogeneous reactions. It will be seen from Table VI that the percentage conversion increases from 93 per cent. to nearly 99 per cent. as the size of the particle is increased from 40-60 mesh to 150-200 mesh. For economic and efficient conversion it is absolutely essential to grind the material to 150-200 mesh; particles of finer sizes than this could be employed with even greater advantage.

With increase in the speed of the shaker (cf Table VII) the percentage conversion at first increases, reaches a maximum value and then decreases; the

TABLE VIII.—Optimum Conditions for Conversion.

Factor	Optimum Conditions.	conversion %
<i>t</i>	120-150 mins.	98.58
<i>c</i>	25-30 %	98.50
<i>C</i>	10-15 %	98.40
<i>T</i>	95-100 °C.	99.20
<i>s</i>	150-200 mesh	99.00
<i>r</i>	22 rpm.	99.40

TABLE IX.

t: 150 min.; *T*: 105°.; *r*: 22 rpm.; *s*: 200 mesh; *c*: 25%; *C*: 10%.

<i>a</i> :	18.36	27.54	36.54	45.90	55.08	64.26	73.44	82.62	91.80	100.98
<i>x</i> :	98.56	99.42	99.28	99.42	99.14	98.66	99.84	98.80	99.14	98.36

maximum conversion of 99.42 per cent. is obtained when the speed is 22 rpm. The decrease in conversion beyond the maximum is due to the fact that when the containers revolve faster than 22 rpm. some particles remain virtually stationary and get little chance to react with the solution.

The results of the experiments described above indicate that the optimum conditions for the conversion of strontium sulphate to carbonate are given in Table VIII

With a view to confirm that maximum conversion is obtained under the conditions given in Table VIII, experiments were

repeated with varying quantities of the ore. The results obtained are given in the Table IX.

It will be observed from the above that the conversion percentages are round about 99.

Economy considerations

The excess of sodium carbonate (25 per cent.) employed in the reaction remains with the sodium sulphate in the final liquor. It is desirable to recover both the carbonate and the sulphate from this liquor; The former could be used over again in the reaction and the latter disposed off as a by-product; this would minimise the cost of production of strontium carbonate.

Attempts were made to separate the components by fractional crystallization (at 20°C. and 40°C.) from representative mixtures of two salts. The crystallisation was stopped when a large amount of sodium carbonate began to separate out along with sodium sulphate. About 89 per cent. of the total sulphate (average purity, about 96 per cent) separated out on chilling the mixture to 20°C.; the separation was not so efficient at 40°C. the percentage recovery and purity being 57 per cent. and 94 per cent. respectively.

In order to examine the usefulness of the sulphate-carbonate liquor as carbonating liquor, experiments were carried out under optimum conditions with mixtures of sulphate

and carbonate in place of straight sodium carbonate solution. The results obtained are given in Table X

TABLE X.—EFFECT OF SODIUM SULPHATE.

% composition of the reaction mixture		
Na_2CO_3	Na_2SO_4	%
94.91	5.09	99.44
90.31	9.69	99.36
86.16	13.84	99.12
82.35	17.65	99.20
78.86	21.14	99.02
75.68	24.32	98.68
72.71	27.29	98.82
69.98	30.02	98.50
67.45	32.55	98.42
65.10	34.90	98.28

It will be observed that there is a drop of about 1.2 per cent. in the conversion as the percentage of sodium sulphate is increased from 5 to 35 per cent. This shows that it will be economical to remove from the liquor obtained in the reaction as much of sodium sulphate as practicable by fractional crystallisation at 20°C. and to use the residual liquor after adding the calculated quantity of soda ash for carbonating a fresh lot of celestite.

Utilisation of Natural Soda *Khar*.

Since the presence of varying quantities of sodium sulphate in the reaction mixture does not affect the conversion of strontium sulphate to carbonate to any great extent, attempts were made to ascertain whether natural soda (*Khar* or *Reh*), which contains sodium chloride and sodium sulphate as impurities, could be satisfactorily employed in the process. Natural soda occurs as efflorescent deposits in many dry regions of India. The proportions of the three salts varies with the locality, the percentage of sodium carbonate in the calcined *khar* varying from 50 to 90 per cent. Representative mixtures, having nearly the same composition as natural soda, were prepared and used in place of sodium carbonate for the conversion of celestite to strontium carbonate. The results obtained under optimum conditions are given in Table XI.

TABLE XI.—EFFECT OF SODIUM CHLORIDE & SULPHATE ON THE REACTION.

Na ₂ CO ₃	% composition of the reaction mixture:		conversion %
	Na ₂ SO ₄	NaCl	
80.99	13.00	6.11	88.28
74.09	11.91	14.00	99.20
68.36	10.90	20.64	99.12
60.54	9.73	29.73	98.92
57.92	9.31	32.77	98.54
71.27	15.28	13.45	98.74
68.64	18.40	12.96	98.56
66.22	21.30	12.48	98.42
63.95	23.99	12.06	98.28
61.83	26.51	11.66	98.20

It will be seen from the above that the presence of sodium sulphate and sodium chloride does not appreciably affect the efficiency of the conversion of celestite to carbonate by sodium carbonate. In the first five experiments, in which the quantities of sodium chloride are considerably increased in the reaction mixture and those of sodium sulphate are nearly constant, the conversion

is lowered from 99.28 to 98.54 per cent. or by 0.7 per cent. In the next five experiments in which the quantities of sodium sulphate are gradually increased and that of sodium chloride kept constant, the conversion, decreases from 98.74 to 98.20 per cent, or by 0.54 per cent.

In the light of the above results it may be safely concluded that the substitution of pure soda by natural soda is a feasible proposition. The slight decrease (0.5-1.0 per cent.) in conversion obtained by using *khar* is overbalanced by the low cost of the carbonating liquor which will appreciably bring down the cost of manufacture of strontium carbonate. The quality of the product obtained would be adequate for the many uses to which strontium carbonate is put. The only drawback in the use of natural soda is poor quality of sodium sulphate that is obtained from the spent liquor. However, in view of the fact that natural soda is abundant and cheap, it may not be worthwhile to recover sodium sulphate from the waste liquor. The employment of *khar* in this reaction will open out a new use for this raw material.

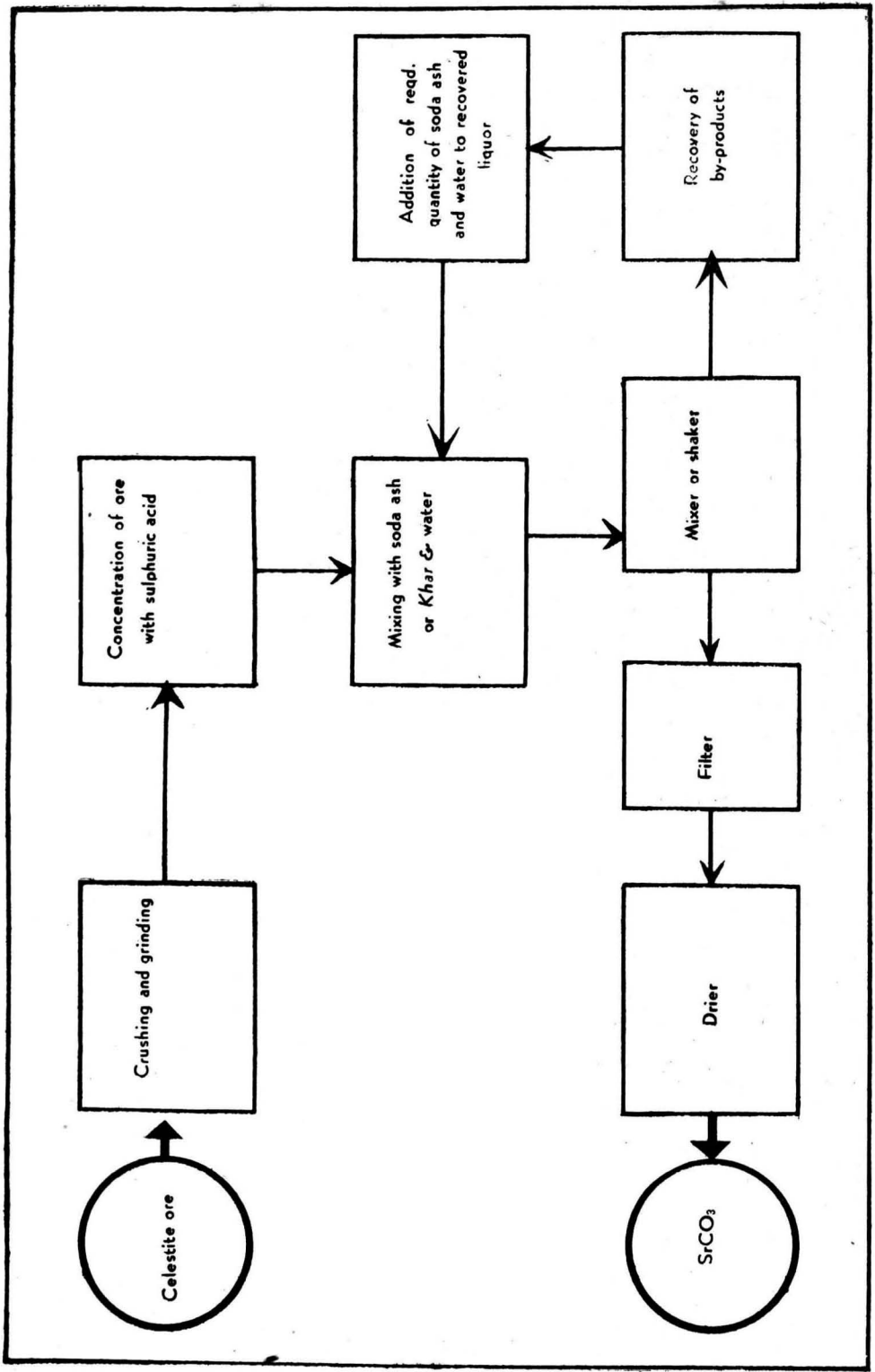
A pilot plant for the production of strontium carbonate from celestite is under construction. A flow-sheet of the processes involved is shown in Fig. 1.

Summary

The investigation deals with the preparation of strontium carbonate from Indian celestite by metathesis with sodium carbonate. A systematic study of the experimental conditions have been made and optimum conditions determined for the conversion of strontium sulphate to carbonate. The economics of the process have been examined, and the possibilities of utilising abundant and cheap raw materials, and of recovering by-products examined.

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