

The Chemical Age

A Weekly Journal Devoted to Industrial and Engineering Chemistry

VOL. XXXII.

June 29, 1935

No. 835

Notes and Comments

Unit Processes

OUR earliest recollections of chemical works recall them as rather queer agglomerations of not always too clean pieces of apparatus of varying sizes and shapes and without much apparent order or scientific design. The process doubtless must have followed upon well-defined lines, or no marketable products could have resulted, but these lines were not readily perceptible to our academically-trained eye. The whole process, in short, seemed to be a jumble into which certain materials were put at one end, and out of which, by some apparently miraculous chance, surprisingly good products emerged at the other end. There must have been many others like us, for the real fun started when something went wrong and the products expected did not materialise. The search for the cause was often exciting and prolonged. It chanced that a little earlier we had had a difficulty—experienced by many better men than ourselves—of mastering the art of differentiation. The mathematics lecturer thereupon wrote large upon our notebook the words: "Divide et imperia"—separate and conquer—a lesson never forgotten. This might well be taken for the motto of chemical engineering of the 1930's. The work of the student, investigator and plant operator has been immensely simplified by the modern method of separating chemical manufacture into "unit processes." Many of these processes are discussed in a series of special articles published in this issue of THE CHEMICAL AGE. In crystallisation, screening, crushing and grinding, evaporation, absorption, adsorption, roasting and leaching, high-speed centrifugal separation drying and autoclaves, each process has been investigated by the well-known tools of modern science and the conditions for satisfactory operation have been laid down. Some chemical plant manufacturers specialise in certain unit processes and do not touch others. It might well be suggested that the British chemical plant manufacturer might, with advantage, make it his practice only to specialise in one, or at most two, of these branches. In that way the amount of specialised knowledge that would become available to the chemical industry would be considerably enhanced. Possibly it is now beyond the power of the B.C.P.M.A. to get their members to do this, but the chemical manufacturer himself could do so by restricting the list of firms to whom he sent inquiries, restricting it to those who really understood their plant and its functions in chemical engineering.

There is to be noted in chemical plant an increasing tendency towards continuous, as opposed to intermittent, methods of operation. That is noticeable in the

processes as a whole and in the unit processes individually. Where a process as a whole is changed from intermittent to continuous, control generally needs to be tighter, if only because anything that affects one stage of the process may cause trouble throughout. On the other hand, a continuous unit process generally needs less control than an intermittent unit process. It is only necessary to keep the condition constant, in most instances, to maintain good operation. The continuous process generally has the additional advantage of lower costs, particularly lower labour costs, and for that reason would be favoured where the demand for the product was sufficiently great to justify the increased cost of plant. On the other hand, the simpler intermittent processes still have their field where a works makes a plurality of products which are required intermittently. Finally, it is of interest to note that practically every unit process of the chemical industry is a physical process. For the proper understanding of every one of the processes listed earlier in this note a knowledge of chemistry is valueless, whilst a knowledge of physics is all important. This hint should be marked by the many students who hope one day to attain a high position in the chemical industry.

Boots' Pensions

THE chemical industry is fortunate in having at the head of many of its leading undertakings men who realise that commercial success owes a great deal to efficiency on the part of the workers and that true efficiency is best achieved by paying due regard to the contentment of the employees and the relief of anxiety as to their future. No better example of the relationship between contentment among the workers and prosperity for the shareholders could be provided than by the experience of Boots Pure Drug Co., Ltd., during the past twelve months. A five-day working week has been permanently established at Beeston, holiday arrangements have been improved, a comprehensive pension scheme for the whole of the staff has been introduced, and—not merely as a coincidence but largely as a direct consequence—the company has more than maintained its trading position. With the coming into operation of the pension scheme all permanent members of the staff of the company and its associated companies are in the happy position of having substantial provision for their retirement.

The capital sum required to finance the scheme will be gradually handed, for investment, over a period of about ten years, to a trustee company, Boots Pensions, Ltd., whose registration as a new company was announced in THE CHEMICAL AGE of June 8. The

pension scheme is divided into three parts. For the men there is a contributory plan under which pensions are graduated in proportion to earnings, the retiring age being fixed at 65, so that those who are entitled to do so will also receive the State pension for themselves and their wives, an important consideration for those receiving the lower scale of pensions. For the women there are two separate schemes, a thrift fund and a non-contributory pension fund. The thrift fund has two objects. One is to provide those who leave to get married with a convenient method for saving for that happy event, and in passing it is of interest to note that nine out of ten leave to get married before the age of 35. The other is to provide those who remain in the company's service with a profitable means of accumulating their savings for their ultimate retirement from work.

The women's pension fund is contributed entirely by the company. For each member with 20 years' service a pension of £1 a week will be provided at the age of 55, which has been fixed as the retiring age. A woman with less than 20 years' service will receive proportionately less. This pension will be reduced by one half when she reaches the age of 65 and becomes entitled to the State pension. The company is also providing the cost of keeping the State pension contributions in force for this ten-year period.

Voluntary Unemployment

LORD TRENT, chairman of Boots Pure Drug Co., Ltd., has for some years made a close study of the problem of extending the basis of employment in industry. He is one of those who believe that the mechanisation of industry, if it is not to condemn an increasing number of men to unemployment, involves the gradual reduction of working hours, by shortening not only the working day or the working week, but also the working year and the working life. The company over which he presides has already successfully inaugurated the five-day week, and the new pension scheme to which we have just referred will do much to shorten the working life of the employees without imposing any hardship upon them. At the company's recent annual meeting he suggested that the goal to be aimed at should include more paid holidays, earlier old age pensions and later entry into industrial life. Such reforms mean the substitution of voluntary unemployment or leisure for the tragedy of involuntary unemployment. They cannot in practice be attained simply because a group of people think them desirable, but once industry recognises them as desirable it can set itself consciously to move in the right direction. That is what the directors of Boots are trying to do.

Having established the five-day week in its factories, the company has turned its attention to the problem of increasing the holidays of its retail staff. The problem is a much more intractable one than was the five-day week, and is complicated by all kinds of difficulties. Some idea of the financial aspect of the problem may be obtained from the fact that when the company introduced an extra week's holiday for shop managers it necessitated the permanent engagement of 40 additional qualified pharmacists. When it tries to plan a scheme involving some 12,000 retail assistants a year, the magnitude of the financial problem will be appreciated. And the cost of the scheme is far from being the only obstacle. The directors are, however,

going into the question carefully and thoroughly, and for some months past they have been experimenting in certain selected districts in order to get actual data to go upon. It may be that the cost will prove prohibitive. It may be the cost will be such that they will find it possible to defray it out of increased profits, as an investment in goodwill. Or it may be that ultimately the solution of the problem will involve some adjustment of prices. If it be found that the cost of bringing people back into employment affects prices then it is clear that no single company could afford to handicap itself by single-handed action. It would be necessary for the State to support such a scheme of paid holidays to create employment by making them compulsory. The point is of first-class importance on account of the increasingly large number of persons employed in the distributive trades.

Chemical Industry and Safety

A BRIEF analysis of the 1934 accident frequency rate for the chemical industry in the United States which we have received from the National Safety Council, reminds us that in spite of the highly commendable safety efforts of the Association of British Chemical Manufacturers and the broader activities of the National Safety-First Association, apart from the official work of the Factories Department of the Home Office, we have not in this country any readily available data upon which to compare British records with those of the United States. The American organisation is able to give us intimate details of outstanding safety records achieved by 24 chemical manufacturing units during 1934, showing, for example, that in their respective groups the Niagara Falls plant of the National Carbon Co. (818,000 man-hours), Charles Lennig and Co. (chlorine and alkali manufacture) (894,000 man-hours), the Nobel explosives plant of Canadian Industries, Ltd. (242,000 man-hours) and the Toronto plastics plant of the same company (201,000 man-hours) worked the highest number of hours without a single disabling accident. The report also analyses the frequency and severity rates and thus presents a complete idea of the degree of safety throughout the industry.

We are not amongst those who want to see any further increase in the already large number of returns which industrial concerns have to prepare, but we would suggest to those who are concerned with the maintenance of a high standard of safety in chemical works that statistics similar to those from the United States would serve as a strong incentive to the prevention of unnecessary risks. For evidence of this we have only to look at the safety measure adopted by Imperial Chemical Industries, Ltd., every issue of whose monthly magazine testifies to the wholesome results of inter-departmental rivalry in the attainment of accident-free records. With the machinery already available we believe it would be possible to collect the necessary information to promote the same sort of rivalry throughout the industry. We suggest, at any rate, that the National Safety-First Association might think about it.

IMPORTS of superphosphate into Sweden in 1934 increased some 35 per cent over 1933, 7,843 tons being reported as compared with 5,827. Meanwhile, exports declined over 50 per cent., from 29,757 tons in 1933 to only 12,675 tons in 1934.

Crystallisation: A Typical Unit Process

By Hugh Griffiths,

B.Sc., A.R.C.S., M.I. Chem. E.

THE separation of materials from solutions by crystallisation is a process worthy of careful investigation. The tendency to regard a crystallising plant simply as a device for abstracting heat or solvent has resulted in many costly failures. Whilst it is correct to say that available knowledge of crystallisation processes is still far from complete, it is beyond question that certain principles have now been established which are of great value to the designer of plant, and it is now possible to design installations for a given production with a certain accuracy, and in many cases to obtain products not only of a high degree of purity, but in the individual crystal form, even from solutions which contain impurities.

In manufacturing processes of the type in which the size and appearance of the crystalline products are not important, the crystallisation plant may be regarded as a cooler or an evaporator. It is, however, not possible to design a crystallisation plant from heat transmission data alone, as in the case of a cooler for a non-crystallising liquid. In many cases, even when agitation is employed, the crystalline material deposits on the cooling surfaces and rapidly reduces the heat transfer. Attempts to overcome this difficulty by means of brushing or scraping agitators have only been partially successful.

Study of the Super-Solubility Data

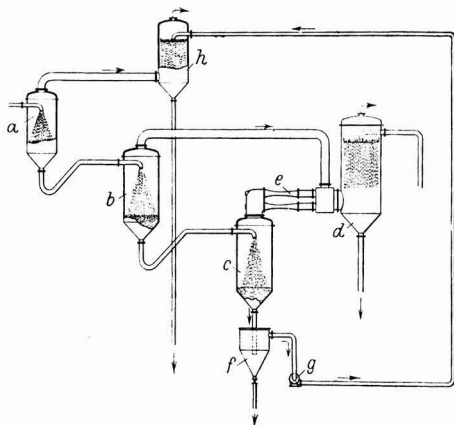
A clear understanding of the nature of this problem can be obtained by a study of the super-solubility data. So long as the solution in contact with the cooling surface can be maintained in the metastable state the deposition of material on the cooling surface will not occur. Whilst the adjustment of the condition does not present any overwhelming difficulty it will be understood that the maintenance of the metastable state necessitates the use of low temperature differences and in consequence for large-scale work vacuum cooling is now very frequently adopted. Even when organic solvents are used, the vacuum crystalliser can be designed more precisely as the heat transfer takes place in a surface condenser where a large heat transfer per unit area can be obtained by the use of a substantial temperature difference. When aqueous solutions are crystallised by vacuum cooling the condensation is preferably effected in a barometric condenser with corresponding advantages in capital cost and freedom from the limitations imposed by heat transfer. More recent installations of this type operate according to a multiple effect principle, enabling the heat contained in the solution to be utilised.

By application of steam jets for augmenting the vacuum attainable under ordinary conditions with cooling water at normal temperature, multi-stage vacuum crystallising plants are now built in which solutions can be cooled and crystallised at temperatures down to -10° C. A scheme of this kind, which is now extensively used on a large scale chiefly in the potash industry, is shown.

Qualities which Command Higher Price

Many products are now sold in the individual crystal form. In the case of sodium sulphite and hypo, for example, the user has learned to associate the regular crystalline quality with purity and good working properties, with the result that such qualities usually command a higher price. There is no doubt whatever that substances which are crystallised in the individual crystal form are usually of astonishing purity, even when derived from mother liquor containing other materials. So far as this country is concerned these products are usually manufactured in rocking crystallisers of the open or of the vacuum type. Whilst in the case of many materials the correct operating conditions are not easy to find, once the conditions have been established the rocking plants are practically automatic and very beautiful products can be obtained continuously and more cheaply than with stationary crystallisers. In America considerable progress has been made with a water-cooled plant of the spiral conveyor type. In the case of the Oslo crystalliser, crystallisation is effected by circulating liquor upwards through a bed of crystals, a cooling or evaporating device being provided in the liquor circuit.

Whilst there is, apparently, a very great difference between these plants, the principles which govern the production of individual crystals must of necessity be the same, and most of the statements claiming special advantages for one particular type are based upon a wrong interpretation of the basic principles. Since every substance possesses a definite rate of deposition per unit area of crystal surface from a metastable solution under specified conditions of temperature and concentration, it is clear that the output per unit volume of crystalliser capacity must of necessity be the same, no matter what type of crystalliser be used, provided that the average size of crystal product is also the same. The smaller the crystals the larger will be the amount of crystal surface available for growth per unit volume of apparatus capacity, or in other words: the output per unit volume of crystalliser capacity will be a product of the rate of crystal growth and the amount of crystal surface available for growth per unit volume. Any attempts to drive the output beyond the value



Lurgi Crystallisation Plant: a Evaporator (stage 1), b Evaporator (stage 2), c Evaporator (stage 3), d condenser, e Steam Jet Ejector, f Clarifying Tank, g pump, h Condenser.

given by this product will result in the production of unstable conditions, whereby spontaneous formation of fresh nuclei will occur and the average crystal size will fall. The adjustment of crystal size will, therefore, take place automatically.

In practice, nucleus formation also takes place by attrition of the crystal charge so that even when plants are operated at considerably lower intensities than the theoretical limit, and the solution is maintained in the metastable state, continuous formation of nuclei will take place and the crystals will not, under practical conditions, increase beyond a certain average size. For special purposes, however, crystallising plants can now be built in which nucleus formation can be controlled.

Whilst, in general, the results of theoretical calculation correspond very closely with practical outputs, some astonishingly high intensities have from time to time been reported, *i.e.*, outputs per unit volume far in excess of the theoretical limit. An examination of the crystals produced under these high intensity conditions leads to the view, however, that they are not regularly grown from metastable solution, and at the highest intensities a formation of granular agglomerates can take place. This process of separation appears to consist in crystallisation from unstable solution followed by granulation, and whilst in some cases this will yield a product of uniform size, the purity would not compare with the products obtained by controlled crystallisation.

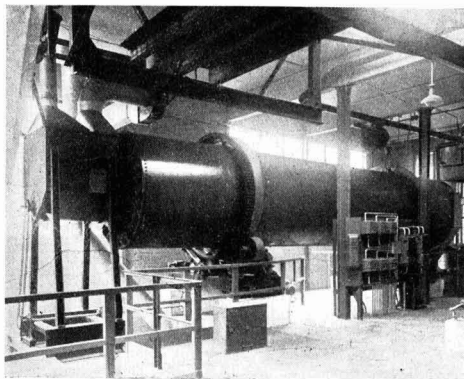
Continuous Drying

By Eustace A. Alliott, B.Sc., M.I.Chem. E.

MANY types of dryer are available to meet modern requirements. Specialised forms of plant continue to be developed year by year. In general, however, it is true to say that the more adapted a plant is to handle a particular material with economy, the less general is its useful application—at any rate until much experience has been gained with it. It is therefore true to say that the types of drying machine which are of the widest interest and use are based on well-known mechanical principles, although detail is being continually improved.

Rotary dryers are still much used wherever continuous operation is desired. There are two main forms: Steam-heated and furnace-heated. The steam air-heated type employs a draught of air up to about 160° or 180° F., and is used mainly for removing small percentages of water from crystallised products. It can be employed for handling materials which are liable to lose water on crystallisation or become otherwise spoiled when heated to 100° to 120° F., or even less, providing that the material is fed through the drying machine in the same direction as the hot air. Under these conditions the dried product comes in contact with comparatively low-temperature air and is naturally itself at an appreciably lower temperature than the air discharged. Such machines usually have only an evaporative capacity up to 1 or 2 cwt. an hour of evaporation in normal size plant. If, however, the shell of the dryer is steam heated, and an internal drum or nest of tubes is placed inside, evaporation of 5 cwt. and 10 cwt. per hour can be obtained in large machines when handling suitable products.

Furnace-heated dryers are used for sludges and slurries, etc., and for materials which are not temperature-sensitive, in cases where high evaporations are required. Products which are too "sticky" at low temperatures may sometimes be handled successfully at high ones. The gases may be simply taken through the machine, a furnace being arranged at one end and a fan at the other, or the furnace brickwork may entirely surround the body of the machine so that the



Large Steam-heated Rotary Dryer, provided with internal nest of steam tubes (Manlove, Alliott and Co., Ltd.).

gases are first heated externally and then are taken through internally in contact with the material.

In another form of the furnace-heated dryer the gases are taken through an internal tube down the centre of the dryer, and then led back in contact with the material, or they may be brought back along external channels (formed in the dryer shell) without touching the product. Such methods are, of course, expensive and are employed mainly in such cases where even the least contamination with furnace gas will injure the product. It is astonishing, however, how little products suffer, even when they are of light colour, when in contact with furnace gases, providing that the furnaces are properly constructed and a suitable fuel used, so that the fuel is adequately burnt and the dust is retained and not carried through into the product. Not long ago it was customary to use coke for heating purposes in these machines, but nowadays they are often oil or gas heated.

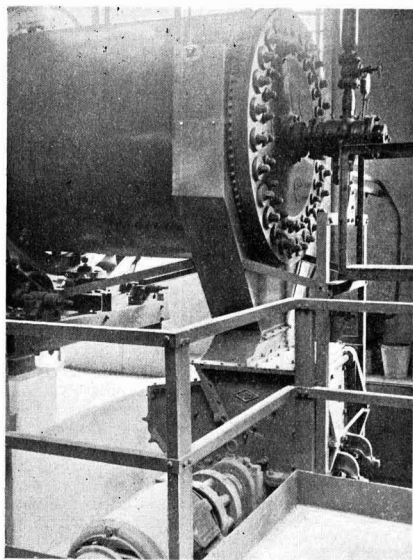
Ten cwt. an hour evaporation would be a low duty for a machine of this class, and several tons evaporation an hour may be handled in large machines when handling suitable materials. A point of interest is that when handling very wet materials it is of great advantage to take the wet feed in at the furnace end. If the reverse process is followed, the moisture in the now cooling gases, which have performed their duty, may be condensed by contact with the cold feed, and with some materials will create a sticky slop at the feed end which will hinder the functioning of the machine.

Interior of the Dryer

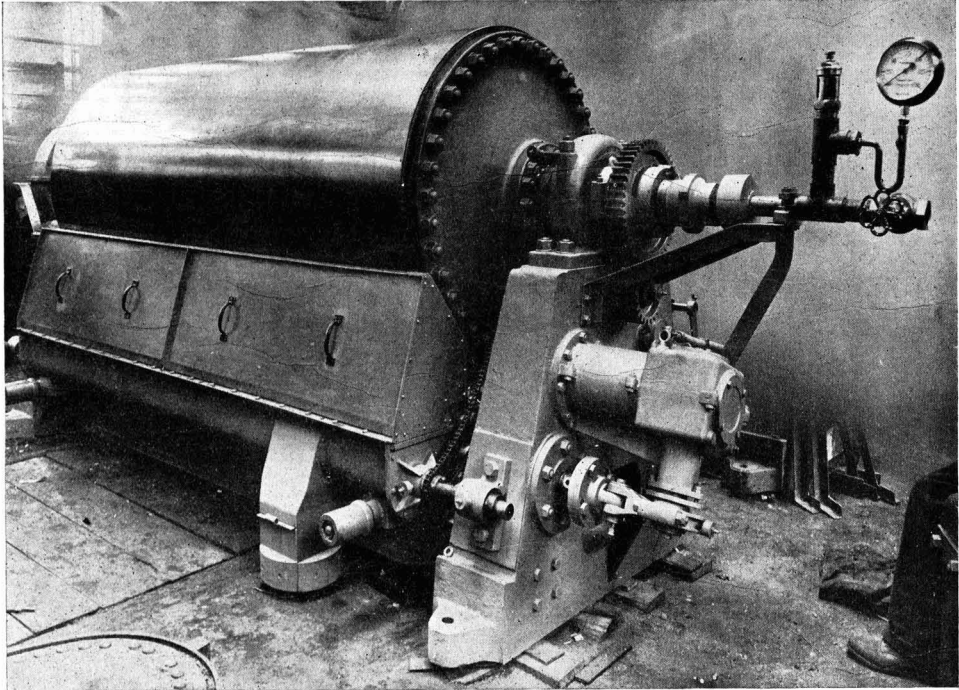
The ordinary dryer tube is fitted with plain shelves, grouped according to the fineness of the material being handled and its tendency to stick. Where the material does not tend to stick or build up on the dryer surfaces, the interior of the dryer may be constructed in cells which break up and scatter the material very effectively. They also act to a large extent as heat exchangers. The portion of the cell wall which is not in contact with the material is receiving heat from the gas, which it passes on to the material during the contact period of its rotation. This principle is being utilised in some directions in fresh ways.

In other types of machine, the shelves are arranged to form a kind of jacket round the interior of the machine through which the hot air or gases are passed. This jacket space is divided into cells controlled by a valve, roughly analogous to a rotary filter, and this ensures that the hot air passes through the grains of the product, thus ensuring very efficient heating. Most of these specialised forms of dryer are, however, possible with certain types of material only, and their functioning is liable to be much hindered if there is any stickiness, etc., to contend with.

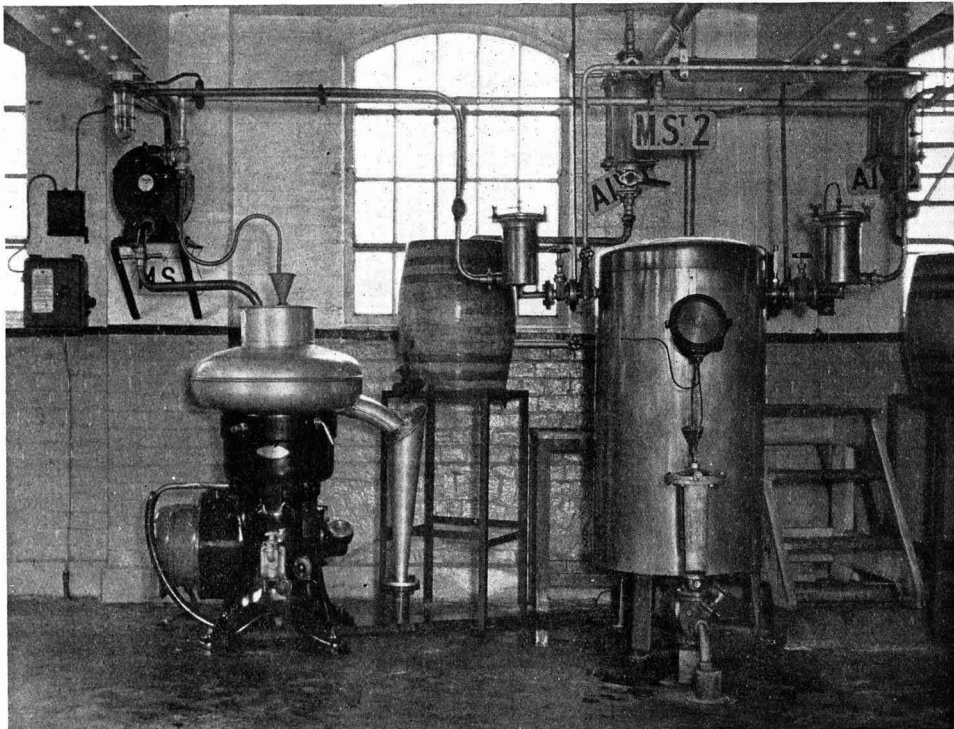
Another type of dryer which is coming into increasing use is the drying cylinder, sometimes called a "film" dryer. This type was originally employed for handling milk or yeast, but is now finding a rapidly increasing scope of application for all kinds of liquid suspensions, colours, etc., which are sensitive to temperature or which offer difficulties in drying in other ways. Since the material to be dried forms a very thin skin or film on the surface of the drying roll,



Large Steam-heated Rotary Dryer, showing gear for discharge of product and steam inlet for internal nest of steam tubes (Manlove, Alliott and Co., Ltd.).



Large Drying Roll, 4ft. diam. by 8ft. 6in. long, suitable for 100 lb. internal pressure, and fitted with a reciprocating "doctor" (Manlove, Alliott and Co., Ltd.).



De Laval Clarifier, together with continuous steriliser, as used for the clarification of molasses in yeast manufacture (Alfa Laval Co., Ltd.).

very rapid drying is possible, so that the period of contact may easily be as low as ten seconds, and in some cases may be as little as three to five seconds.

There are various ways of feeding these machines. The roller may dip into a trough containing the liquid to be dried, but this is crude and unsatisfactory for most purposes. A feed roller may dip in this trough and transfer the liquid to the main roller; for some products this is excellent. In many cases it is more satisfactory to put a small feed trough against the side of the roller, as by this means the amount of contact of the liquid with the main roller can readily be regulated and the amount of material in the trough itself is limited. In double-roller machines the material is usually fed into the gap between the rollers, which is closed by suitable end plates. This acts as a sort of boiling or pre-evaporating trough, and the material which adheres to the rolls is smoothed out into an even film as it passes through the nip between the rollers. This nip is preferably spring-regulated. This method, however, is not necessarily best suited to all products.

Rollers can be made of special iron mixtures, and rollers even four feet in diameter may be used for steam at 100 lb. pressure. They are usually tooled on the inside as well as being polished externally. Much attention, of course, must

be paid to efficient draining, both of condense and of air.

Various types of knives have been in use for such machines. At one time a heavy blade used to be forced up against the roller and adjusted by a number of small screws spaced along its length. This knife was difficult to adjust and it took much time to reset the blade when it was removed for sharpening or other attention. Another scheme consists of a number of small spring blades arranged in an overlapping way—a patented construction. A recent development consists of comparatively few blades of a flexible type in a holder which permits their rapid and true setting. These can be changed and reset in the course of a few minutes only, without any specially skilled attention being required, since the adjustments are few, simple and easily made. Another improvement for special cases, ensuring even wear on both roller and blades, consists of a knife carrier which reciprocates endways, so that the "doctor" has a slicing action on the material to be removed.

Such drying drums will handle products which are very "sticky" or of an insulating nature and present difficulties when handled in other types of machine. Evaporation duties vary from 100 lb. per hour in a small machine, or, with a difficult product, to about 2,500 lb. per hour for a large double-roller machine handling a freely-evaporating product.

Recent Advances in Autoclaves

By V. A. YARDLEY (Chemical Research Laboratory, Teddington)

THE design of autoclaves to meet increasingly severe conditions of temperature, pressure and corrosion has been made possible through the great advancement in the manufacture of alloy steels, and the elements which have been found most useful for alloying are vanadium, chromium, manganese, cobalt, nickel, molybdenum, tungsten and silicon. Nickel, 2 to 4 per cent., increases the strength, yield point and hardness without decreasing the ductility, although much greater additions give the alloy a hard and non-ductile character. The low alloyed nickel-chrome steels with small additions of other elements are most valuable and when appropriately heat treated have a wide range of mechanical properties. A typical analysis of such a steel is: C. 0.3, Si. 0.2, Mn. 0.6, P. and S. 0.03, Ni. 2.5, Cr. 0.6, Mo. 0.6 per cent., with Fe. the remainder.

In the presence of carbon monoxide these steels form iron and nickel carbonyls and vessels of this material are preferably lined with copper or an austenitic steel. Of the more highly alloyed steels use is made of a composition containing approximately 60 per cent. nickel, 12 per cent. chromium and 1 to 4 per cent. tungsten, and vessels have been constructed of this metal to withstand pressures of 1,000 atmospheres at temperatures of 500° C. for over 20,000 hours. This alloy is preferably cast, machined to size and then heat treated. Prevention of hydrogen penetration at high temperatures and pressures is largely overcome by the use of high chromium low carbon alloy steels of typical composition: C. 0.15, Cr. 6.0, Mo. 0.5, Mn. 0.5, Si. 0.5, with Fe the remainder.

For pressures above 100 atmospheres it is usual to employ forged steels, and one such vessel of 18 litres capacity designed to operate at 250 atmospheres and 450° C. is shown in Fig. 1. For pressures below 100 atmospheres electric fusion may be employed and autoclaves can be constructed by this method having wall thicknesses of 3 ins. and internal diameters of 5 ft. capable of operating at 70 atmospheres and 200° C. Toughened cast steel is also used and an autoclave of this material is shown in Fig. 2.

For purity of product autoclaves may be fabricated from the virgin metal and one such vessel, made entirely of nickel and shown in Fig. 3, has an internal diameter of 3 ft. 9 ins. and a working capacity of one ton, and is designed to operate at 50 lb. per sq. in. at 170° C. Where construction in the virgin metal is too costly, steel lined with the desired material is used. One such vessel lined with Monel metal $\frac{1}{2}$ in. thick, internally heated through a coil of the same material, has a capacity of six tons and is operated at 17 atmospheres and 175° C. Incidentally this lining can be chosen to perform a further function by assisting the reaction, and copper linings, in this way, have replaced the use of copper salts. For

pressure reactions with ammonium chloride, linings of silver are preferable, the initial cost being offset by its long life.

Although the nickel-chrome and other alloys have characteristics of strength greatly in excess of mild steel, considerations of safe strength still limits the construction of large capacity autoclaves for service under conditions of high temperatures and pressures, since at high temperatures even these steels rapidly decrease in strength. The following tabulated values¹ illustrate this:—

Steel.	Yield Stress Room Temp. Tons/sq. inch.	Limiting Creep Stress: Tons/sq. inch.		
		300° C.	400° C.	500° C.
Carbon Steel	29.3	29.6	15.6	2.7
Nickel Steel	37.3	32.0	12.8	2.5
Nickel Chrome Steel ...	33.9	30.3	7.6	1.5
Chrome Vanadium Steel	59.0	47.5	18.2	1.8
Staybrite Steel	17.9	—	30.2	8.0
Stainless Steel	35.0	31.5	19.5	4.5

Experience has shown that wall thicknesses of vessels operating at pressures up to 300 atmospheres and 500° C. may be determined from the equation².

$$p = 0.6 f \frac{K_2 - 1}{K^2}$$

where f = safe stress in the walls, K = ratio of external to internal diameter, and p = internal fluid pressure, " f " and " p " being in the same units and due allowance being made in the value of " f " for the operating temperature and the temperature gradient through the walls. For information on this latter point see Luster³.

Very valuable data on the overstrain of metals is now available⁴ and the autofrettage process has done much to further the production of vessels able to withstand internal pressures of 3,000 atmospheres and more. Design for the rest follows past engineering practice. In connection with closures much ingenuity has been displayed and the wave ring joint of Imperial Chemical Industries has proved very successful especially for the smaller joints. Large joints are still made with spigoted flange and thin metal joint ring, but recent practice favours a line contact joint made by the curved side of the spigot against a coned face. For connecting the smaller sized tubes the joint illustrated in Fig. 4 is largely used and is one which may be broken and remade almost indefinitely. Hydraulic testing of pressure vessels is serviceable but does not always reveal faulty material, and, where possible, all highly stressed parts should be subjected to radiological examination especially before entering service for the first time.

Agitation of the reactants is often necessary for good yields and rocking, rotating and shaking methods are in use. Gener-

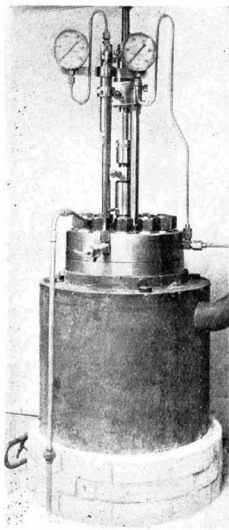


Fig. 1.—Forged Steel Autoclave, working 250 atm. at 450° C., as installed at the Chemical Research Laboratory.

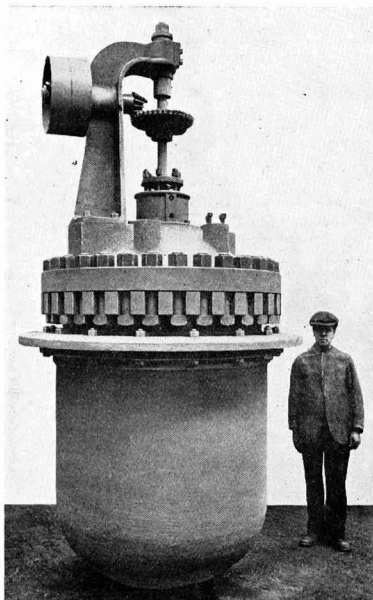


Fig. 2.—Large Cast Steel Autoclave (Hadfields, Ltd.).

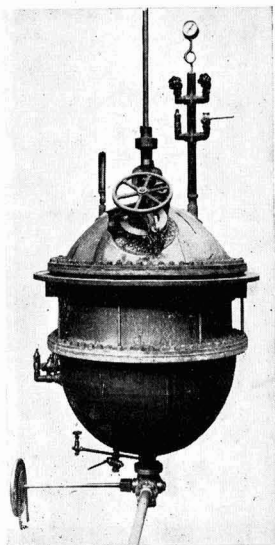


Fig. 13.—Pure Nickel Autoclave (Brierley, Collier and Hartley, Ltd.).

ally this is uneconomic and internal stirring is preferable, and in connection with this the use of a balanced pressure oil-sealed stuffing box containing leather and white metal packing rings has wide application. Heating by external circula-

Temperature measurements are usually obtained by suitably protected pyrometers and may be continuously recorded if desired.

Protection of autoclaves against extraordinary increases of pressure may be secured by the use of bursting discs¹ of platinum, nickel or other metal, which for this purpose are superior to relief valves in many respects. For registering high pressures the manganin wire piezo-electric method is in use, but the Bourdon tube gauge is the most convenient instrument and when protected from contact with hydrogen is quite successful for measuring pressures up to 3,000 atmospheres. Indirect vision is usually employed where possible and such gauges are constructed with a loose back and a heavy metal front between the tube and pointer. Autoclaves working at 3,000 atmospheres are still in the laboratory stage of development and such a vessel is illustrated in Fig. 5.

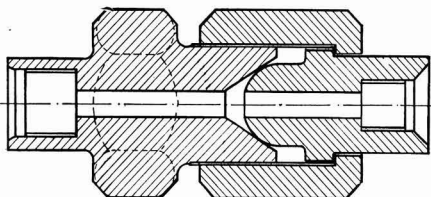


Fig. 4.—Pipe Union for use at internal pressure of 300 atm.

tion of oil under pressure is used for temperatures up to 300° C. and above this diphenyl oxide vapour (C₁₂H₁₀O—C₁₂H₈) has been employed. Electrical heating is also adopted and in some cases the vessel itself is used as the resistance unit.

¹ Tapsell, Johnson and Clenshaw, D.S.I.R. Report No. 18, 1932.
² Cook and Robertson, "Engineering," 1911, p. 786.
³ Luster, "Trans. Amer. Soc. Mech. Eng.," 1931, p. 161.
⁴ Macrae, "Overstrain of Metals" (H.M. Stationery Office), 1930.
⁵ Bonyun, "Chem. Met. Eng.," May, 1935.

German Sulphuric Acid

THE German sulphuric acid industry continues to be burdened with an excess production, resulting especially from the marked acceleration of the zinc industry, in spite of heavy fall in imports during 1934 as compared with 1933 and an equally notable rise in exports. The 1933 imports of 203,081 metric tons fell to 128,648 tons in 1934; exports meanwhile increased from 23,146 tons to 339,257 tons. The same trend has been continued this year, imports for the first two months totalling 17,724 tons, as compared with 20,203 tons for the same period in 1934, and exports rising from 3,738 tons last year to 6,249 in 1935. Upward of 15,000 tons of sulphuric acid is at present being used monthly by producers of synthetic nitrogen in the Ruhr. A marked effect upon the German industry is also being made by the demand from the Saar district, formerly supplied by France, to the extent of about 25,000 tons annually, and from German Upper Silesia, formerly supplied by Poland. The Reich Railways have granted special freight rate reductions for sulphuric acid from the Ruhr to the Saar of around 30 per cent., and from Central Germany to Silesia of about 50 per cent., in order to make German acid from these two principal supplying regions economical in the consumption districts mentioned.

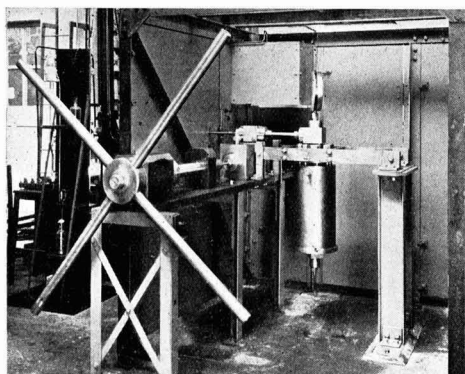


Fig. 5.—Autoclave working at 3,000 atm., as installed at the Chemical Research Laboratory.

Evaporation of Non-Salting Liquors

By H. A. S. GOTHARD, A.M.I.Chem.E.

THE general tendency in modern evaporator design is towards specialisation rather than to rely upon the application of modified standard equipment for use in any specific process where evaporation is a primary factor. In the past it was possible to state, with liberal qualifications, the type of evaporator to be used for any given service, but present-day demands have made necessary the adoption of entirely new standards in order to meet the more exacting requirements of the user. In the majority of cases, the user insists upon the plant fulfilling a definite specification which will provide for a high efficiency combined with increased output and lower operating costs. There is, of course, every justification for these demands and the plant designer has not been slow in taking advantage of the wider knowledge and experience now available in connection with the somewhat complex factors affecting heat-transfer coefficients; neither does he overlook the importance of carefully considering and selecting the material, or combination of materials, of which the plant is to be fabricated.

A typical example of modern practice is to be found in the processing of milk and milk products. Here, as in similar cases where delicate liquors are handled, extreme care has to be exercised in the design and fabrication of the plant in order to provide for such essential features as high percentage evaporation coupled with a minimum time of contact, whilst making ample provision for the prevention of contamination and deterioration of product.

Where food products are being processed the question of rapid concentration is an important one, and particularly is this so where the liquors are heat-sensitive, or where "stewing" is liable to cause rapid deterioration, thus necessitating the shortest possible time contact of the liquor with the heating medium. A development which has proved of undoubted merit and which has solved many of the problems peculiar to heat-sensitive liquors is the introduction of forced circulation. In recent years a forced circulation type of evaporator has come into prominence, and is a type especially suitable where the liquor to be evaporated is viscous, where costly materials have to be used for the heating surfaces, or where the available temperature drop is small. In operation, the liquor is pumped through the tubes with a positive velocity and therefore due to its rapid circulation is in minimum contact with the heating medium.

In an article of this nature it is possible

only to deal with the subject in the briefest manner and a detailed description of plant is therefore limited to one or two examples typical of modern practice.

Having already referred to the processing of milk and milk products the first example to be discussed deals with a forced circulation evaporator of recent design for condensing milk and whey (Fig. 2). This design, which is due to George Scott and Son (London), Ltd., embodies all the features demanded for the ideal milk evaporator, and permits of batches of any desired volume being prepared within very elastic limits, consistent with the designed capacity of the plant. The heating system, or calandria, which is of the tubular type, is external to the evaporator, which is thus free from all internal obstructions, and consequently presents no lodgment points or corners inaccessible for inspection or cleaning. Forced circulation is provided by an impeller of special design located on the underside of the pan, actually being attached to the lower cover of the casing. This cover is hinged and balanced, and when in position for use, is secured by quick-fitting bolts. By a single movement the impeller and impeller shaft may be withdrawn in a moment.

The connection between the calandria and the evaporator is by way of the bottom of the pan, which communicates with the bottom chamber of the calandria, which is also provided

with a hinged and easily removable cover. Handholes are provided at convenient points, and special note should be made of that provided on the vapour pipe at top of the pan. An important feature in this design is the vapour outlet, which is so formed to ensure the non-return of vapour condensate.

In operation, the impeller causes the liquor in process of concentration to pass through the tubes of the calandria at high velocity. In passing through the tubes, it is claimed that the velocity of the liquor is such as to give a temperature rise each circuit of 1° to 2° C. Actually, no evaporation takes place in the tubes themselves, this being in the form of a flash off in the pan into which the liquor is delivered tangentially. By perfecting the cooling system it is possible to cool the product under vacuum while vigorous circulation is maintained, the importance of which is obvious in securing a product of perfectly smooth consistency.

In all cases where milk and similar food products are evaporated, where cleaning and sterilisation are essential after every batch, and accessibility is of

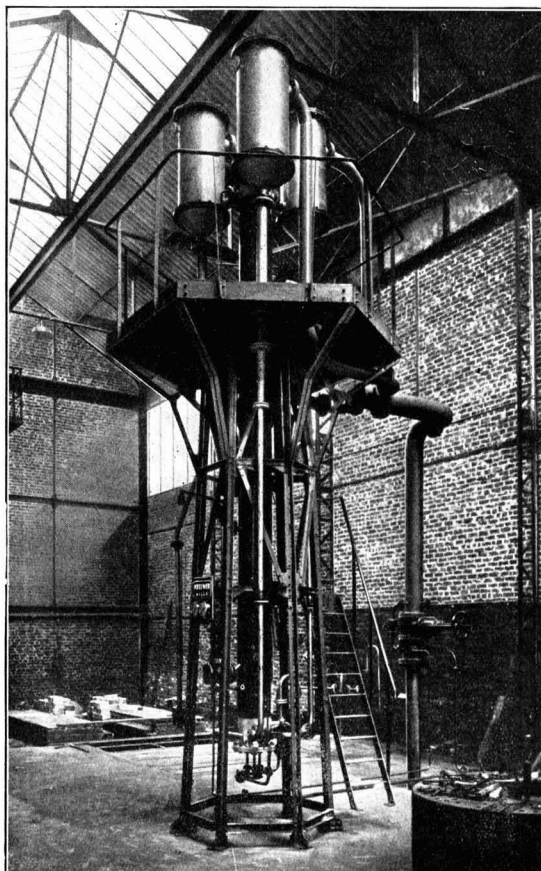


Fig. 1—Kestner Patent Multi-Circulation Type Evaporator (Kestner Evaporator and Engineering Co., Ltd.)

vital importance, and in this, the design under discussion may be regarded as unique.

Another type of evaporator widely employed for the concentration of delicate liquors is the continuous film evaporator which has been developed by the Kestner Engineering and Evaporator Co., Ltd. There are two methods of operation, namely, "climbing," or "falling." In effect, the plant comprises a number of long tubes expanded into upper and lower tube plates, the nest of tubes being contained in a steam jacket. A feed tank, and separator completing the essential features, the latter being located either immediately above or below the evaporator according to whether the plant is of the "climbing" or "falling" film type.

The principle upon which this type of evaporator is based is well known so that only a brief reference to its operation is necessary. Generally speaking, the liquor is fed into the evaporating tubes from a suitably located feed tank. Steam is applied through the jacket to the outer surfaces of the tubes, which causes the liquor rapidly to rise to the separator where the vapour is removed from the concentrated liquor. The velocity of the liquor itself is used by means

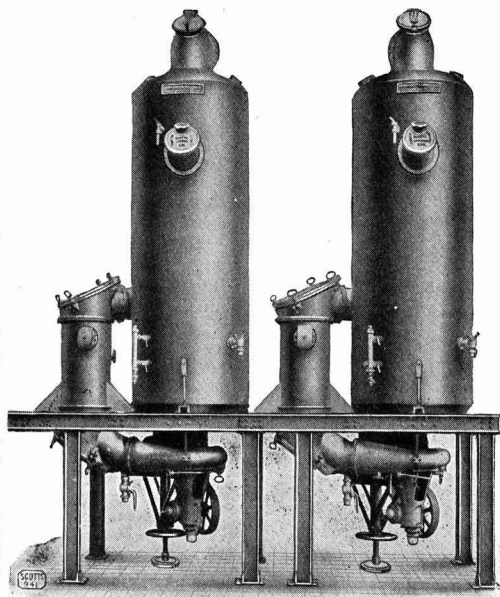


Fig. 3.—Forced Circulation Evaporator for handling condensed milk (George Scott and Son, London, Ltd.).

of centrifugal action to make the separation of the vapour from the liquor complete.

A comparatively recent development of the standard Kestner film evaporator is their multi-circulation type, which essentially consists of two or more climbing film single effects arranged in series and as one unit.

There are many outstanding advantages applicable to this type of evaporator. For example, it enables a high percentage evaporation to be carried out in one passage; the friction drop due to the high velocities is reduced to a minimum, thus ensuring the maximum vacuum through the plant; there is entire absence of entrainment, and short time of contact between the liquor and heating surface. A typical example of the Kestner triple circulation evaporator is shown in Fig. 1, which clearly indicates the simplicity and clean lines of design.

Reference has already been made to the importance of the careful selection of materials and in this connection it should be mentioned that the types of evaporator referred to in this article may be fabricated in stainless steel, aluminium, tinned copper, and glass-lined steel, as well as the usual metals.

Society of Chemical Industry at Glasgow

Fifty-Fourth Annual Meeting opens Next Monday

FINAL details have been issued of the fifty-fourth annual meeting of the Society of Chemical Industry, which opens at Glasgow next Monday evening and continues until Saturday, July 6. A full programme has been arranged by the local section in co-operation with the parent Society, the hon. secretary for the meeting being Dr. I. Vance Hopper, of the Royal Technical College. Following is a summary of the programme:

MONDAY, JULY 1.

8 p.m.—Informal reception, Central Station Hotel.

TUESDAY, JULY 2.

10 a.m.—Royal Technical College. Meeting of council.

10.45 a.m.—Annual general meeting, Examination Hall. Welcome by the Lord Provost of Glasgow, Sir Alexander B. Swan, and Professor G. G. Henderson (on behalf of Glasgow University and the Royal Technical College). Address by president, Edwin Thompson, J.P., "National Water Supplies."

1 p.m.—Luncheon, Central Station Hotel, by invitation of the Glasgow Section.

3 p.m.—Ladies' visit to Glasgow and West of Scotland College of Domestic Science.

3 p.m.—Chemical Engineering Group session, Central Station Hotel. Chairman: Dr. W. R. Ormandy. Paper by Commander J. L. Bedale, R.N., "Some Problems in Chemical Engineering which arise in H.M. Navy."

7.30 p.m.—Civic reception, Municipal Chambers, by the Lord Provost, Magistrates and Town Council of Glasgow.

WEDNESDAY, JULY 3.

9.30 a.m.—Food Group session, Central Station Hotel. Chairman: Dr. L. H. Lampitt, D.Sc., F.I.C. Papers on "How Food is Transported by Rail and Sea," (a) Brig.-Gen. Sir Harold Hartley, C.B.E., Vice-President, L.M.S. Railway;

(b) A. J. M. Smith, Ph.D., M.A., Low Temperature Research Station, Cambridge.

1.0 p.m.—Luncheon of the Food Group, Central Hotel.

11.45 a.m.—Visit to the shalefield and refinery of Scottish Oils, Ltd.

2.30 p.m.—Works visits: (a) Colvilles' Steel Works; (b) Glass Silk Works, Chance Bros. and Co., Ltd., Firhill; (c) Glasgow Corporation Chemical Works, Provanmill; (d) Shanks Works, Barrhead; (e) Dennistoun Bakery (William Beattie, Ltd.); (f) City Bakeries, Ltd.

7.30 p.m.—Annual dinner, Central Station Hotel.

THURSDAY, JULY 4.

10 a.m.—Presentation of the Society Medal to Dr. E. F. Armstrong, who will deliver an address, "The Past, the Present and the Future." Central Station.

10 a.m.—Ladies' excursion to Glasgow University.

3 p.m.—Garden party at Eastwood House, by invitation of Lord and Lady Weir.

8 p.m.—Reception, Royal Technical College, by invitation of Governors.

FRIDAY, JULY 5.

10 a.m.—Sail to Kyles of Bute.

SATURDAY, JULY 6.

9 a.m.—Visit to Ardeer Explosives Factory.

9.30 a.m.—Visit to Auchincruive Experimental Farm.

The Italian Press reports that surface deposits of phosphates covering an area of 35,000 hectares have actually been discovered in Tripolitania, but that the quality of the deposits is still unknown. A commission is being formed which will make careful drillings to ascertain the depth and quality of the rock.

Screening Machinery

By HERBERT V. THOMAS

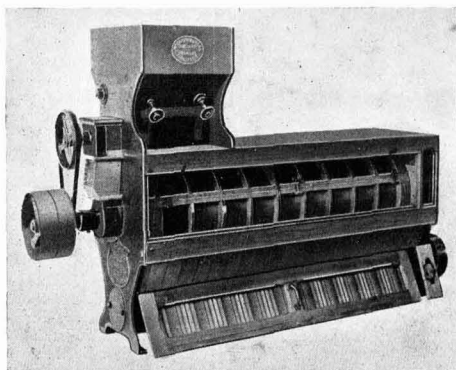
FOR screening coarse or abrasive material the "revolving reel" is now generally employed, the mesh or sieve being arranged in circular or barrel form, slightly inclined from the horizontal and caused to revolve. Here the material is fed at the higher end, and thence continually falls to the bottom of the "reel" whilst travelling towards the lower end, where the coarser material is delivered as "tailings," after the finer particles have passed through the mesh to be collected as "throughs." Although many ideas have been put forward to improve this machine—such as (a) the fitting of angle pieces to lift or carry the material partly round the barrel, and then allowing it fall on to the mesh, (b) an

incorporated in the suspended types of screens in order to ensure steady running.

Reciprocating sieves can now be fitted with a patented driving arrangement, which displaces the usual eccentric shaft and connecting rod. This drive is attached to the suspended sieve itself, and imparts a rapid lateral movement thereto. The drive consists of two weighted disc or flywheels of equal diameter driven at a high velocity in opposite directions and out of their centres of gravity—around a stationary geared spindle. With this drive very little power is absorbed, quite a large machine being driven by a single belt one inch wide; in addition, there is no vibration set up either in the framing or flooring carrying the screen.

A difficulty with all types of screens is found in keeping the meshes clear or open, and frequently hammers or tappers, operated by cams, are employed to rise and fall suddenly on the sieve, thus causing the wedged particles in the mesh to fall; a reel is sometimes constructed in which the barrel is caused to rise and fall with a bump or shock, with the same result. A reciprocating sieve can also be fitted with a brush, operated by an ingenious double screw-threaded shaft, travelling to and fro across the mesh. Where the mesh consists of long narrow slots, rods with thin washers are fitted, the motion of the screen causing the washers to run between the slots, thereby clearing same. The latest device consists of a wire cage placed immediately below the mesh, small resilient rubber balls being inserted between the wires and the under side of the screen; here the travel of the screen causes the balls to bounce against the mesh and thereby clears same. Sometimes lead shot is used on the face of the sieve to assist in passing the material through the mesh.

For most materials the best form of screening is by using a revolving brush in a semi-circular sieve or screen. The chief difficulty with this type of machine was in getting rid of the coarse or foreign material that would not pass the mesh, resulting in frequent stoppage of work in order to remove the brush and clean the sieve. This difficulty was surmounted by the advent of the "Gardner" patent sifter, which by the action of a peculiarly designed spiral brush, not only brushed the material being treated through the sieve but at the same time removed the coarse or foreign matter, automatically expelling same at the end of the machine. It is many years since this machine first appeared, but so far the idea has not been improved upon, and still retains popularity throughout the world. No particular form of screening can be said to be "the best"; it depends on the nature of the material to be treated, as to which type of machine is most advantageously employed.



"Quick Change" Centrifugal Dresser (Wm. Gardner and Sons, Gloucester, Ltd.).

adjustment for varying the angle or fall of the barrel, (c) an ingenious arrangement for altering the spaces of the mesh—most machines in use to-day have the barrel inclined at a fixed angle, and with the exception of improved construction and the angle at which the barrel is set being very much modified, differ very little from the original reels or "bolters."

To meet the demand for much finer screening, the "centrifugal"—a machine similar to the "reel"—was designed. The revolving barrel in this machine is placed horizontally, and the material being treated is impelled against the screen by internal beaters revolving at a much higher speed, these beaters being set spirally in order to cause the material to travel to the "tailings" end. An external brush is usually fitted to the barrel of these machines, in order to keep the mesh clear, and occasionally brushes are employed internally as well as beaters. A "quick-change" type of this machine can be obtained, in which the barrel is constructed in sections, easily removable, so that different size screens or mesh can be substituted when desired. With the idea of saving floor space a "vertical" form of "centrifugal" was attempted, but never became popular.

Another type of screen in use is the rotary sifter, in which the mesh is attached to a frame, suspended on flexible rods or straps, a rotary motion being imparted thereto by a vertical shaft and adjustable crank to vary the "throw" as desired. Where small quantities of valuable powders are being treated, totally-enclosed "drum sieves," consisting of sieve, cover and receptacle (similar to the ordinary hand riddle in shape) are used, these units being placed on the suspended frame and removed as required.

Where several grades or separations are required, the reciprocating type of screen is frequently employed. This machine consists of a sieve frame carried on spring suspenders, which allow of a "to and fro" motion. Here several screens of varying meshes can be placed in the frame, the bulk of the material after the first separation passing on to the screen immediately below it, and so on. Movement is imparted to the sieve frame by an eccentric shaft, bearing and connecting rod, the "travel" of the sieve being determined by the throw of the eccentric. A balancing weight is usually

British Industries Fair, 1936

All Sections to be held in February

It has been decided by the Birmingham Chamber of Commerce to hold the engineering and hardware section of the British Industries Fair next year from February 17-28—the same dates as for the Fair as a whole. This year, when the section was held from May 20-31, was the first time since the section was inaugurated that it had not been opened simultaneously with the rest of the Fair held in London.

After the decision for next year had been made, Mr. J. Percy Plant, chairman of the Fair Management Committee, Birmingham, said: "There has been a feeling for some years that May would be a more convenient month for many exhibitors who show their goods in our section, which is devoted to hardware and the heavier industries, but the generally-held opinion now is that synchronisation of all sections of the Fair outweighs all other considerations."

The Department of Overseas Trade announces that within ten days of the issue of application forms for space in 1936 Fair 309 manufacturers asked for a total area of 151,412 sq. ft. of space, compared with the 241 applications for 96,140 sq. ft. at the corresponding date a year ago.

There are already five applications for 1,725 sq. ft. in the chemicals section and eleven applications for 2,556 sq. ft. in the druggists' sundries section.

High Speed Centrifugal Separation

By R. H. DOLTON, B.Sc., A.I.C.

DURING recent years there has been an increased tendency in the chemical industries to drop out of date intermittent processes and to adopt methods allowing continuous plant operation. In this development new uses have been found for centrifugal separators.

The large plants which have been erected for the hydrogenation of brown coal in Germany and bituminous coal in England have provided a problem which has been successfully solved by the centrifugal separator. This process entails mixing coal and oil to a paste, hydrogenating, distillation of the lighter oil and mixing the residual oil with more coal. The heavy oil thus acts as a carrier liquid and picks up all the ash present in the coal. As a result of extensive experiments with filters and centrifugals of all kinds, a self-discharging De Laval centrifuge was evolved which will continuously separate and discharge ash and other solids from this oil. The separator is of novel design, with a spiral conveyor rotating inside the main separator bowl which collects solid matter as it is separated and discharges it through a nozzle placed in the bowl wall. By coupling up a battery of these centrifugals for purification on the by-pass, it is possible to maintain the ash concentration of the oil at the desired minimum.

Another industry which has been greatly helped by developments in high speed separator design is wool scouring. During the scouring of wool large quantities of grease separate and float on the washing liquor. A good yield of valuable neutral grease can be obtained by passing this liquor through a centrifugal separator, but the large amount of sand and dirt present causes rapid clogging of the separator bowl and consequently the labour charges for cleaning are rather heavy. A few years ago, however, as a result of experiments at a Bradford mill, a separator was produced which would continuously discharge the solid matter as well as separate grease from the washing liquor, and batteries of such machines have now been installed in England, Japan, Australia, South Africa and elsewhere.

Probably one of the biggest fields for centrifugal separators has been found in the refining of petroleum. In this industry large volumes of liquids have to be handled and processed and the advantages of quick separation are many.

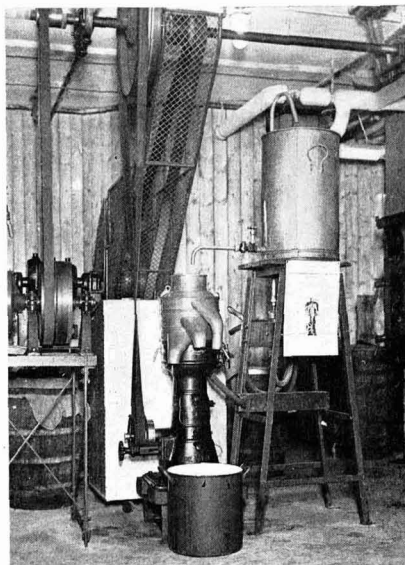
Of particular interest is the refining of cracked distillates with sulphuric acid. Here strong acid is used and the object is to remove gum forming unsaturated bodies whilst leaving the valuable constituents which give the cracked spirit its good "anti-knock" properties. By carefully controlling the contact time between acid and spirit it is possible to reach the desired result, and the method employed is to efficiently mix the two components followed by instantaneous separation in a high speed centrifuge. Machines of vapour-tight construction are used, and acid sludge is discharged continuously from one outlet and gasoline from the other. Further separators are used following on the subsequent soda treatment of the spirit.

Another process in which centrifugals are seen to advantage is in the dewaxing of lubricating and cylinder stocks. The old system of diluting the oil with naphtha followed by chilling and centrifuging is, of course, well known. Recently new processes have been developed in which the waxy oil is diluted trichlorethylene and other heavy solvents. This solution is chilled whereupon the wax separates and floats in the oil-tri solution. The chilled mixture is fed to a centrifuge capable of separating and continuously discharging the wax, whilst the oil-tri solution is passed to a still for recovery of the trichlorethylene.

A development of some importance is the production of the De Laval hermetic separator. This machine was placed on the market about one year ago for clarification and separation of milk, and since that time it has found application in several other industrial fields. In all normal types of centrifugal separators the liquid in the separating bowl is under normal atmospheric pressure. Further, although the liquid receiving covers may be of the closed type air is always present and aeration of the liquid occurs during its discharge from the rotating bowl. With the hermetic separator all these disadvantages are removed. The liquid is fed under pressure to the bowl via the hollow driving spindle and a

specially designed sealing gland prevents any escape of liquid. The liquid after separation is discharged directly into a pipe line, and once again a sealing gland is used to prevent escape of liquid.

This machine offers great advantages to those handling milk and other food products since no contamination with air can occur and all danger of bacterial infection from this source is eliminated. Other applications are for the clarification of carbonated liquids under pressure and for special



De Laval Clarifier, for the clarification of pharmaceutical products, as installed at the works of Potter and Clarke, Ltd. (Alfa Laval Co., Ltd.).

varnishes and other products which are readily oxidised by contact with air.

In addition to the above applications of special interest, centrifugal separators are being increasingly used for all types of water and oil separation problems, the separation of yeast and clarification of molasses for yeast manufacture, clarification of fruit juices and essences, clarification of solvents used for dry-cleaning and in the purification of lubricating oil from all types of power plant, insulating oil and fuel oil. In fact, whenever a difficult separation or filtration problem occurs it is worth while investigating the possibility of using a centrifugal separator, due to its simplicity of operation and ease of handling.

World Production of Dyestuffs

A Correction

LAST week we reproduced (page 553) a chart arranged by the staff of the Chemical Division of the United States Department of Commerce indicating the extent to which cartel participation affects the coal tar dye manufacturer in the producing countries of the world. The chart made it appear that J. W. and T. A. Smith, Ltd., were among the cartel members or companies directly affiliated with the cartel or cartel units.

We are informed that J. W. and T. A. Smith, Ltd., are definitely not connected with any other dyestuff manufacturing concern, but that the company is an entirely private undertaking. We regret that the chart should have conveyed an erroneous impression and welcome the opportunity of correcting the error.



The Copper Leaching Plant of the Inspiration Copper Co., U.S.A., with Dorr thickeners and classifiers, pumps, mixers and agitators, all of acid resisting construction.

Roasting and Leaching

THE mechanical roaster has almost universally superseded the hand-worked types, and since the days of the earliest examples of the former, many advances have been made. Dust, mechanical losses, inefficient roasting—all these and other bogies in great measure have been almost laid. Not necessarily is facility the handmaiden of efficiency, but by patient experiment and long experience, designers have evolved roasting furnaces which embody the two. There are, of course, varied types of roasting furnaces, from those built to burn sulphur-bearing material such as pyrites, where the main product is the sulphur dioxide and the cinder but the minor product, to those in which metallic ores are roasted (with or without external heat), as a step in the recovery of the metal. All types have in common much the same obstacles to overcome, faults noted above as inherent in the early types.

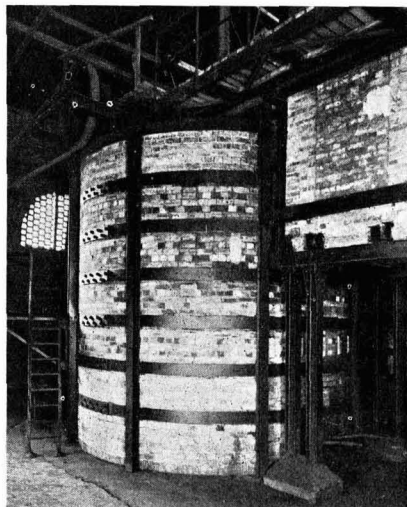
It has always been held against mechanical roasters in which the material is conveyed through the heating zones by rabbling arms, that dust, in some cases vitiating the gases and in others wasting the valuable material, is generated. It has long been recognised that dust is mainly caused by sudden falls of hot material directly in the gas-stream, and for many years furnace users had to be content to attempt to deal with the problem by arresting as much of the dust as possible after it was carried forward. However, the dust problem has been tackled at the source—thus the Harris furnace now incorporates a sealing device attached to the rabbling arms actually conveying the material from bed to bed without permitting it to have contact with the gas-stream whilst falling. After transfer to a fresh bed, rabbling and transit across the bed is resumed and dust-raising is thus limited.

Additionally, haphazard gas-flow, responsible for carrying rabble dust, has been generally eliminated. A further improvement is to be noted in that gas ducts are built into the furnace walls in such a manner that the hot gases leaving one bed at a point immediately below the covering arch are conducted through the ducts under damper control and impinge on to the superimposed bed from its own covering arch. Ducts are alternated on opposite sides of succeeding beds to ensure thorough contact, and passage of gas through the ports negotiated by falling material is reduced to a minimum. It need hardly be said that where complete elimination of dust is necessary, whether for its own value or otherwise, this is usually satisfactorily accomplished by Lodge-Cottrell treatment.

The steel industry has played a part in improving mechanical roasting, for instead of water-cooled cast-iron arms, alloy steels now provide a serviceable material for shafts and arms and permit the almost universal air-cooling. Higher furnace temperatures can be successfully resisted by their use and as

a consequence, water shortage ceases to present a problem and furnace parts last longer, eliminating many stoppages from breakage or water leaks. It should also be noted that the iron and steel industry receives reciprocal benefit—raw material in the form of sintered pyrites cinder is being increasingly made available by the installation of Dwight-Lloyd sintering machines which render a hitherto little-used source of iron suitable for smelting.

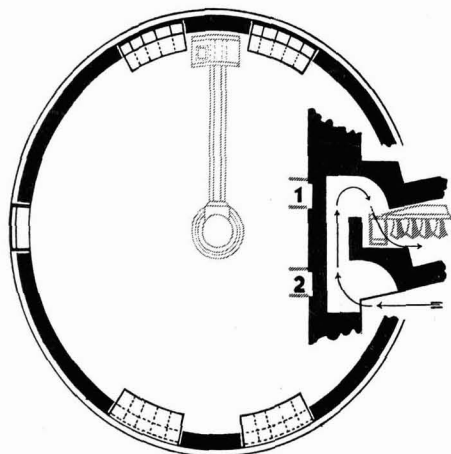
By W. H. Ibbotson



Harris Roasting Furnace (Harris Furnace Co., Ltd.).

Inseparable from the subject of roasting is that of leaching, as applied to the recovery of metals from complex ores, raw and roasted, and of various chemical products. For many years now gold producers have applied the cyanide leaching process for recovery from even low-value ores, and more recently by installation of modern plant, operations have successfully been made continuous instead of intermittent. Probably because of high metallic value, gold leaching has received more attention than has been devoted to leaching

of other metals or chemical products. It is certainly the view of American academic mining opinion that wet-process copper recovery equipment in general has not heretofore approached



Sectional plan of Harris Furnace, showing the gas uptakes on opposite sides are rabble arm fitted with dust-preventing device; also (right) enlarged sectional elevation showing one of the gas uptakes from hearth to hearth.

the perfection attained by the cyanide process, though steps in that direction are being taken. It is, however, indisputable that every year brings nearer the necessity for increased wet-processing, and therefore advances in leaching, notably by continuous processing as opposed to batch treatment are indicated.

Continuous processing involves the use of separation, agitation, and washing plant, the whole being combined in a series which will embody a complete counter-current washing flow. Intermittent operation of leaching plant, be it devoted to metallurgical or chemical practice, necessarily involves high costs and losses, but modern equipment designed for continuous operation can cut these.

As applied to metal recovery other than gold, the usefulness of these methods has been demonstrated as a means of copper ore and slime treatment at Instiration, Arizona. Here, as reported at length in "The Mining Journal," by W. G. Scott, the separation of slimes from the crushed ore permits of a more satisfactory and uniform leach of the bulk ore with separate treatment of slimes, which after preliminary thickening are treated with sulphuric acid in Dorr agitators. The resultant pulp is then treated in a series of Dorr thickeners arranged in a counter-current decantation washing system in which the liquor from the precipitation section, stripped of copper, together with the necessary make-up water, passes through the series as a progressively strengthening copper solution which finally overflows from the first thickener receiving the agitated acid pulp, as a strong copper solution ready for precipitation by scrap iron, whilst the tailings leave the last thickener practically copper free. This treatment is not limited to metallurgical leaching, but is typical of a system applicable to chemical processes in which leaching of a solid or pulp by water or chemical solution is to be resorted to.

Adsorption

By M. B. DONALD, M.Sc., M.I.Chem.E., F.I.C.

THE use of fuller's earth for treating lubricating oils and of bone char for decolorising sugar solutions has been a practical application of adsorption in industry for many years. The article on adsorption in Perry's "Chemical Engineers' Handbook" discusses very fully the relative merits of the various materials obtainable for these purposes. Later developments are the employment of silica gel for removing sulphur compounds from light petroleum fractions, dehydrating air for blast furnaces, air conditioning, etc., and the more recent extensive use of activated carbon. During the war period this activated charcoal came into prominence owing to its valuable properties when used in gas-mask containers. As Griffiths points out in a very instructive recent paper,¹ the development of this material for adsorption in industrial processes owes its origin to a patent taken out by the Bayer Co. in 1916. They found that the only satisfactory method of removing the adsorbed material was by direct steam at 100° C. Heating, vacuum or hot gas only removed 5, 10 and 20 per cent. respectively, whereas steam removed all the adsorbed ether. This has led to its development in the recovery of all types of volatile solvents, such as ether, acetone, alcohol, benzene, etc., from ventilating air. It is used,² for example, for the recovery of naphtha in the rubber-proofing industry.

In comparing silica gel with charcoal it is necessary to remember that adsorbents often have specific properties. Thus, Ray³ showed that activated carbon adsorbs hydrocarbons in preference to water vapour, but with silica gel the reverse is true.

Adsorption versus Absorption

For the recovery of benzol from coke-oven gas the new process using activated charcoal has had to compete with the wash oil absorption plant which is already installed in a large number of works. In view of this fact, a recent analysis by Hollings and Hay⁴ on the relative merits of these two processes is particularly interesting. They came to the conclusion that when high efficiency of benzol extraction is

required, the steam consumption for charcoal adsorption is considerably lower than for wash-oil absorption. Since high recovery is not always desirable, the use of one method or the other will naturally depend on local requirements. Oil washing has to be employed to remove naphthalene whether the benzol is required or not, and it was stated in 1929⁵ that if active charcoal was employed a special preliminary oil scrubbing tower would be required. Griffiths, however, now states "recent experience has shown that this is not necessary and that any ordinary town's gas, from which free sulphuretted hydrogen has been removed, may be successfully and economically treated by the process." Details as to how this may be accomplished are not, however, included in the paper.

Taste and Odour Removal

A very important application of active charcoal from the point of view of the waterworks chemical engineer is for the removal of phenol. Traces of phenol in water supplies are very objectionable, because after chlorination they are converted into chlorophenols which have a very strong taste. Thus Perry states that "in 1927 Chicago experienced contamination of its water supply by this compound, and food cooked in this water in some 200,000 homes tasted so strongly of chlorophenol that it could not be consumed." Until recently it has been very difficult to free gasworks effluents of this compound economically, but a plant using activated carbon has been recently successfully employed at the Partington gasworks, near Manchester. Perry also describes another application of activated charcoal which should do much to reduce litigation, and this lies in the removal of odours from the air in works that give off objectionable smells, *i.e.*, in the production of tallow from slaughter house waste, etc.

¹ "J. Inst. Fuel," 1935, 8, 277.

² "Trans. Inst. Rubber Ind.," 1932, 8, 66.

³ "Chem. Met. Eng., 1923, 28, 977.

⁴ "J. Soc. Chem. Ind.," 1934, 53, 143.

⁵ "Trans. Inst. Chem. Eng.," 1929, 7, 85.

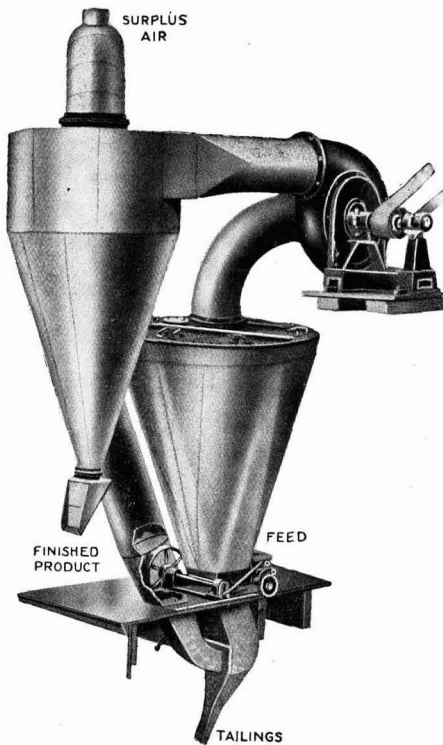
Crushing and Grinding

By W. A. STAPLETON

DURING the past two or three years the co-operation between chemical engineers and manufacturers of milling plant has certainly enabled development to take place at a much quicker rate than heretofore. For instance, we now find combined experience and research leading to such a high level that problems require considerably more technical investigation in order that individual units are correctly chosen to fulfil the necessary duty efficiently and, of course, economically.

Categorising crushing plant alone, great strides have been made in the direction of designing crushers not only to crush materials, say from four inches to one inch, and under, but to be able to produce intermediate size products of approximate quantities that when screened the results show the close percentages of any given sizes required. To accomplish these requirements the makers have designed special equipment which embraces the requisite speed, shape of grinding faces or media, consistent method of feeding to effect the

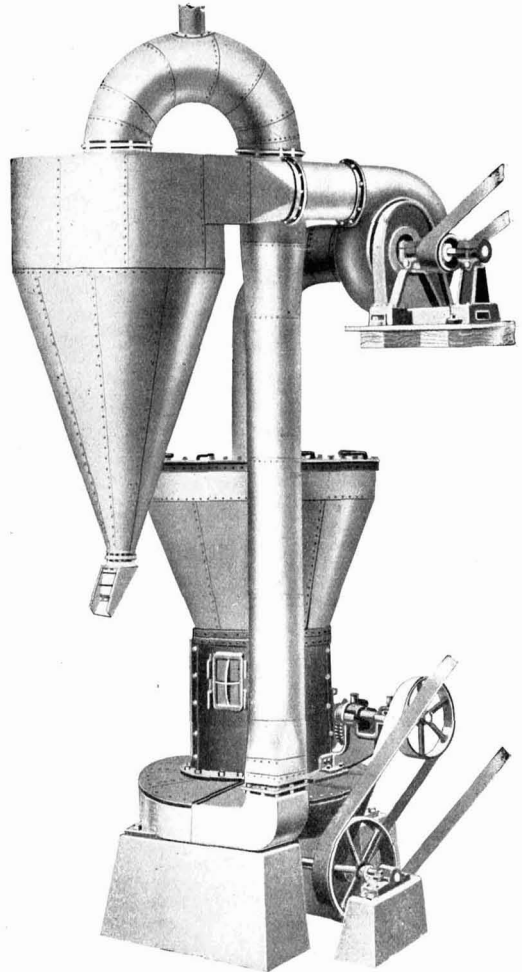
purchase a very compact unit of rugged design embracing a very neat little air plant, enabling the whole machine to operate in one automatic and dustless operation; here the air circuit is entirely a closed one, returning the air from the top of the cyclone dust collector back to the disintegrator. By this method the usual dusty conditions are entirely eliminated, thereby reducing wear and tear on adjacent plant, bearings, belts, etc.; in addition, there is a healthy atmo-



Raymond Vacuum Air Separating Plant (International Combustion, Ltd.).

lowest cost per ton of material handled whether it be gyratory, high-speed impact, or low-speed crushers. The latest developments in the crushing world give the purchaser full measure in which to obtain the correct type to suit the material to be treated, providing he lays all conditions before the makers. If any previous experience is known on the particular material, reference should be made to this, and comparisons made as regards cost per ton of material treated. Initial costs of crushers are usually governed by the grades of material used in their manufacture, and to-day very special steels are made to suit heavy duties continuously.

During the past 12 months we can see a marked improvement in designs, for manufacturers of grinding plant have either been forced to go ahead or go out of business. In regard to the ordinary disintegrator, it is now possible to



Raymond Roller Mill with Air Separation (International Combustion, Ltd.).

sphere in the grinding room which means higher efficiency of the operating staff.

The introduction of hot air into milling systems has recently been the subject of much interest. The application to mills using air separation is now a proved fact in reducing running costs. Previously, rotary dryers were used for pre-drying the material before entering the mill. An important industrial plant is now in operation treating six tons per hour of clay, just as it is quarried and carrying approximately 15 per cent. of moisture. Hot air is introduced into the mill at a temperature of approximately 350° C., the clay is

ground and classified in one automatic operation, the finished product is ground to a fineness of 99 per cent. passing 40-mesh B.S. sieve, and is consistent at all times. Chemical products can also be treated by this method economically and, as the system is mainly under suction, the dust nuisance is reduced to a minimum.

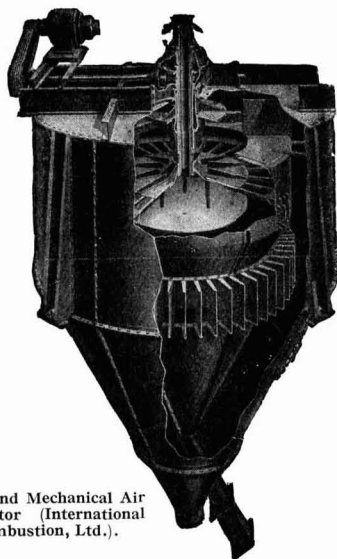
With regard to air separation, the technicians in the grinding industry have now evolved vacuum type separators which are able to classify materials to extreme fineness, whether the separator is worked in closed circuit with a mill or acting as a separate unit. Materials such as titanium dioxide are classified by air flotation methods to a fineness of 99.975 per cent. passing 200-mesh B.S. sieve, and finer, at a very good capacity. Chemical manufacturers and others, it may be added, now specify their requirements very accurately in terms of allowable tolerance on any given mesh screen.

Chemists are getting to learn more of what certain types of mills are capable of producing, and this brings us to the ever-increasing demand for finer products. A great deal depends, of course, upon the grinding characteristics of any material. It is found in some instances that a material may be very easy to grind, but when air-floated the impalpably fine material tends to become coagulated and cause inefficient separation. Special precaution is taken in these cases to allow a sufficient quantity of air and larger-type vacuum separators to keep each particle free in the air flow, in order to effect the very highest efficiency of separation.

Advances have been made recently in the actual construction of vacuum separators to meet the specified requirements of the chemical industry. In one case, fuller's earth was fed to a vacuum air separating plant in a very fine state of division, and the actual requirements of the chemist were fulfilled by making a separation at a theoretical 600-mesh. The feed practically all passed a 300-mesh sieve and the resultant finished product tested 0.5 of 1 per cent. residue on a 600 theoretical mesh, the 300-mesh material passing out of the system as tailings or rejects.

These advancements genuinely prove that collaboration between manufacturers of chemicals and other products, and makers of crushing and grinding plant, leads to perfecting the finished product which in quite a number of cases has

a high commercial value. It should be borne in mind, however, that the processing of quite a number of materials is costly, and thorough investigation should be made to make



Raymond Mechanical Air Separator (International Combustion, Ltd.).

sure that crushing or grinding plant of the correct and latest design to effect a super-quality finished product is installed. In the past, more attention has been given in the direction of initial cost of a plant without studying the real merits of a plant having the latest improvements in order to give a finished product consistently at the lowest cost per ton.

Cooling and Condensing Processes

By BASIL HEASTIE

IN most chemical processes the condensation of vapours and cooling of liquids plays an important rôle, and the choice of suitable plant to meet the many varied conditions is often very difficult. Probably the commonest condensation problem is that of condensing steam; here the designer has an extensive literature to consult. An enormous amount of experimental and theoretical work has been carried out in order to obtain the highest possible efficiency, and little improvement may be expected on the types now in use in large power stations.

The chemical engineer usually has to deal with complex vapours, often having entirely different physical properties from water, thus experience or direct experiment is his only guide. Some interesting work on the dropwise condensing of steam has been done recently by Nagle and Drew in America, which sheds a new light on the phenomena of condensation of steam upon metallic surfaces. Their investigation was carried out to explain observations made during a study of the water-side coefficient of heat transfer in a vertical condenser. Over a twelve-hour continuous test the capacity of the condenser was repeatedly found to increase about 60 per cent. from the initial value of 90 lb. steam per hour per sq. ft. to 145 lb., all operating conditions being unchanged. The cause of this behaviour was found to be an increase of the steam-side heat-transfer coefficient, which might be due to a change from film to drop-wise condensation.

Further experiments were carried out on a condenser consisting of a copper pipe $2\frac{1}{2}$ in. internal diameter exposed for 24 in. of its length, boiler steam at a pressure of about 5 lb. per sq. in. being condensed on its outer surface. This surface was cleaned with fine emery cloth and a solution of $ZnCl_2$ and HCl before beginning the run. Four runs were carried

out. In the first one the steam-side heat-transfer coefficient increased in nine hours from 630 to 1,070. The last test was taken after the steam chamber had been open to the air for 14 days. At half an hour from the start of the run the steam-side heat-transfer coefficient was roughly 1,400 B.Th.U., increasing to 3,700 B.Th.U. nine hours after the start.

Other careful experiments taken on a small condenser having a 1-in. outside diameter tube, 6 in. effective heating length, showed that the heat transfer often increased by fifty per cent. when the condensation changed from film to drop-wise. On smooth surfaces a thin film of oil or grease had a large effect in promoting dropwise condensation, roughness in general is unfavourable, whilst probably the best surface for inducing dropwise condensation is chromium-plated one.

Fatty acids and fatty oils have a greater tendency to adhere to a metal surface than has water or mineral oil, and this was borne out by the above tests, in which it was found that oleic acid and other fatty material were most effective in promoting dropwise condensation.

Some remarkable results were obtained by Spoelstra when testing the fouled tubes of evaporators in Javanese sugar mills; copper and brass tubes from the first effects actually showed a decrease in heat transfer after cleaning with naphtha. Analysis showed that the scale contained 15 to 30 per cent. of oil substances which were largely removed by the naphtha. In one instance the overall heat transfer was reduced from 508 to 346 by cleaning the tube. It appears, therefore, that the presence of oil in steam, especially if the oil is vegetable, not mineral, will improve the heat transfer. This is directly opposed to the older view that any oil carried over from exhaust or back-pressure engines is fatal to good heat transfer, and led to fitting oil separators as standard

practice. The chief practical conclusions from their investigations are that smooth tubes should be employed for condensers and that the presence of small quantities of oil in the steam may even be an advantage.

A recent development of an old invention is the cooling of water by water vapour refrigeration. The first refrigeration machine was of the vacuum type; it was invented by Dr. William Cullen in 1755, and consisted of an air pump for exhausting a receiver containing water and evaporating a portion under vacuum, thereby cooling it. The modern plant employs a steam ejector in place of the air pump and, owing to the great improvements made in the design of steam ejectors during the past six years, it is now possible to obtain vacuum within 0.36 in. of mercury, corresponding to a boiling point of 50° F. Thus, when water at some higher temperature is sprayed into the receiver it is partially evaporated until its temperature drops to 50° F.

The cooling plant consists essentially of a flashing vessel into which the water to be cooled is sprayed. A high vacuum is maintained on the vessel by means of a steam-operated air ejector augmentor, which discharges this evaporated vapour and steam into a barometric jet type condenser connected in turn to a 2-stage steam ejector for extracting the condensate and any incondensable gases or air. A plant designed for cooling water at the rate of 100 gal. per minute from an initial temperature of 70° F. to 60° F. would require about 4 b.h.p. for extracting the cooled water from the flashing vessel, and use about 1,100 lb. steam at 50 lb. gauge pressure when the barometric condenser is supplied with cooling

water at 70° F. The steam consumption would be much reduced if a higher steam pressure were used, and where possible steam at 100 to 150 lb. per sq. in. would be employed. The chief advantages of steam jet refrigeration are its simplicity, the absence of moving parts and of chemicals. The application of this system cannot be applied efficiently for cooling water lower than about 48° F. owing to the extremely high vacuum necessary in the flashing vessel.

The cooling of viscous fluids, such as oils, grease, etc., is usually a difficult problem, first due to the impossibility of obtaining anything approaching turbulent flow, and secondly to the extremely low thermal conductivity of oils and greases which are of the order of one-seventh that of water. In order to improve the heat transfer the passages for the oil or grease should be narrow, *i.e.*, the ratio of heating surface to cross-sectional area should be large; this is attained in the "filter press" type by passing the liquid through shallow rectangular passages machined in thick plates and separated by thin ones, as adopted by the Aluminium Plant and Vessel Co. in its plate coolers.

Another type of cooler recently designed by the writer for cooling grease consists of a water-cooled cylinder revolving inside a jacketed outer cylinder through which cooling water also passes. The grease passes through the narrow annulus formed by the inner and outer cylinders. To break up the stream-line flow of the grease, corrugated strips were welded to the inner and outer surfaces of both cylinders, the inner ones revolving between the outer fixed ones.

The Technique of Filtration

By J. A. PICKARD, A.R.C.S., B.Sc., F.I.C.

THE filtering of liquids is an operation which enters into practically every manufacture, and sometimes at several stages in the same manufacture. The quality of many products depends essentially on the critical excellence of the filtration of the liquids from which they are produced, and yet in the great majority of manufacturers the initiation and development of the business derives from technical considerations fundamentally different from those involved in filtration. For instance, if we take the brewing industry, perfection in filtration of the final product is often of the greatest importance; yet in the whole gamut of the numerous operations united to produce a genuinely fine beverage—malting, mashing, selection of water, choice of yeast, conditions of fermentation, storage and conditioning—it will be easily seen that filtration is but a minor though important matter. A brewer, accordingly, will concentrate his studies and attention more particularly on the matters specifically and individually concerning his art, and for this reason affairs of a more general application, such as filtering, will tend to be entrusted to the hands of routine operators, if not neglected. The same is true in almost any industry, and as a result the technique of filtration is often a matter to which too little attention is given in the technical direction of many businesses.

The following brief notes indicate some of the elementary factors to be considered when settling a filtration difficulty. It is hoped that they may be found illuminating by some who are concerned with more recondit operations in any manufacture in which filtration plays an ancillary part.

In the first place, the output from any filter whatever must fall off gradually as filtration proceeds. What is so often asked for—a filter "to do so many gallons per hour"—is really impossible. If the filter will do so many gallons per hour at the commencement it will do less after some hours' running because of the accumulation on the filtering surface of the material which it has removed. It is often overlooked that what determines the output of a filter is the material which stays inside it, and not the clear liquid which passes from it. Falling output from the filter can be to some extent overcome by increasing the feed pressure of the liquid to the filter, but after a time either the pressure will have to rise to an inconveniently high degree, or else the output will fall off, and at this point the filter has finished its useful life and will have to be cleaned.

Filtrations can be roughly placed in two categories: (1) Where there is a relatively large amount of solid matter to be removed, and (2) where a high degree of brilliance is required in the filtrate, resulting from the removal of a trace of suspended matter.

In the first category the nature of the material to be removed may vary a good deal. If it is hard and the particles are of uniform size the law of filtration is a fairly simple one, as the output is proportional to the pressure and inversely proportional to the thickness of the cake; but if the suspended matter is of a soft nature, such as particles of undissolved gum or partly nitrated cotton, the behaviour is not so simple. In this case increase of pressure on the prefilter may result in deformation of the suspended particles in the layer which has been removed, with the result that an almost impervious coating is formed. In such a case low pressures will produce a greater output than high pressures. Again, if the solids consist of particles of very different sizes, settling can take place in the filter and this generally has the result of building up uneven cakes, those parts at the bottom of the filter being thicker and consisting of the coarser material.

There may also be cases where the particles are not only of different sizes but of a different nature, and one of the commonest suggestions put forward is that the filter manufacturer should increase the output of his filters by taking advantage of preliminary settling. This idea is fallacious unless the particles are of a hard and relatively uniform kind. If the precipitate consists of a small proportion of very fine matter (the balance being coarser) it will often be found that no advantage—in fact, the opposite—results from settling.

Filtration does not consist in mechanical straining. A strainer operates in virtue of the size of the orifices through it being larger than the particles suspended in the liquid which has to pass through. It is thus positive and definite; but filters will remove particles which are smaller than the dimensions of the crevices running through them and, in fact, it is found that the efficiency of particle removal bears a relation to the thickness of the filtering layer. This appears to be because the removal of the particles in the filtering layer is due to their catching up and wedging in narrow corners and spaces between the constituent grains, and, naturally, the thicker the layer is the more corners offer themselves and the more complete is filtration.

Other factors also enter into filtration, more particularly in

the case of filtrations falling into the second category, and it is quite possible to remove, by filtering, particles which are so small that they cannot be easily observed under the highest powers of the microscope. To get rid of particles of this sort it is necessary to use a material for the filtering medium which has a surface attraction for the particular type of particle to be removed. As an example, in the filtration of gelatine a satisfactory degree of clarity can be got by filtering through paper pulp, but materials which from the point of view of dimensions are just as fine or even finer (for instance, kieselguhr) will not produce an equally good clarification. This is because the particles spoiling the clarity of the gelatine have a special attraction to the surface of the cotton pulp but not to the surface of the kieselguhr.

Filtrations in which adsorption is employed as above do not follow quite the same course as ordinary granular filtrations. With adsorption the efficiency of the filter comes to an end when the whole of the surface has been covered with particles, and after this cloudy liquid may come through; but in the case of other types of filtration cloudy filtrate is not produced towards the end and the filter is only cleaned and re-started because the output has become too slow to be convenient.

The methods and devices for increasing the output of filters

which are required to deal with relatively small amounts of highly choking material are many and various. The commonest of all is to mix with the liquid undergoing filtration an extra quantity of some porous material, such as paper pulp, kieselguhr, or charcoal, which is in itself of a light, porous nature. As a result of this substance mixing with the clogging material which is being removed, the average porosity of the layer on top of the filter medium is increased, and accordingly, liquid can pass through easily and the life of the filter is prolonged. A simple point which is often overlooked here is that it is impossible to restore to a better output the filtering rate of a filter which has dropped to a low figure by introducing porous material in this way. It is obvious that once the filter surface has been covered up, nothing which is deposited on top of it can make it more porous. To produce its proper effect the porous material must be added during the period when the choking layer on the surface would be formed.

There are also many other ways of dealing with troublesome hazes and traces of matter in suspension, such as coagulating them by mixing material of suitable electric charge with the liquid, centrifuging, agitation, aeration and other devices, but these cannot be gone into fully within the limits of this article.

Absorption, in Theory and Practice

By M. B. DONALD, M.Sc., M.I.Chem.E., F.I.C.

At first sight it would appear that an absorption tower is a very easy item of plant to design. In practice, however, it is found that numerous problems have to be solved. The usual method of expressing the performance of an absorption tower is by the equation :

$$W/t = k A \Delta p,$$

where W/t = weight of material W absorbed in time "t,"
 A = area of interface exposed, Δp = difference in vapour pressure of the material to be absorbed in the gas and its pressure over the solution, *i.e.*, the driving force tending to make the transfer take place, and k = mass transfer coefficient. To consider the correct method of design it is advisable to examine each of these factors in its turn and the interfacial area is one which is now yielding interesting results.

Interfacial Area

As long ago as 1893, Hurter¹ came to the conclusion that, in most technical processes, the volume of the gas was some 100 to 1,000 times larger than the volume of the liquid. It was therefore obviously indicated in these cases to subdivide the gas into bubbles in preference to converting the liquid into a spray. In actual practice a packed tower provided a cheaper alternative to creating a bubbling device and its consequent foaming troubles. He recommended the use of the fraction-surface of filling material/gas volume rate, as a method of comparing performances of absorption towers. The various characteristics of commercially available packing material have been admirably summarised by Butcher².

The I.C.I. have very recently obtained two patents³ for packing material, which they claim give very good results, and which consist of specially arranged slats. Care has always been taken to secure adequate distribution of the liquid on the top of packed towers, but recent research shows that it would have been more profitable to have spent more time in studying its subsequent history. Kirschbaum⁴ carried out some experiments in packed columns when rectifying alcohol-water mixtures. He found that the liquid reflux had a tendency to go to the walls of the tower with a result that the packing in the centre was soon denuded of liquid. Weimann⁵ gives a series of curves showing how this effect is related to the height of the tower, and this led Kirschbaum to devise a method of bringing the liquid back to the centre of the column at stated intervals down it. The spread is also affected by the size of the packing unit and Weimann suggests a minimum

ratio of tower diameter to packing diameter of 25 to 1. A paper read before the American Institution of Chemical Engineers, in May, by Baker, Chilton and Vernon, indicates, however, that this spreading effect is greater in 3 in. and 6 in. diameter columns and not so marked in 12 in. and 24 in. columns.

The second point to consider is the pressure gradient. The use of moderate pressures to increase the rate of absorption and also the quantity of material absorbable by the stripping agent has been in use for a number of years⁶ in the petroleum industry for the removal of the lighter fractions of petrol from natural gas. Most gases dissolve in liquids according to Henry's law, which means that by using a pressure of, say, four atmospheres it is possible to make the exit solution four times as concentrated as it would be when working under ordinary atmospheric conditions. As long as the pressures employed are not so high as to necessitate very radical alterations in the design, this is an excellent method for increasing plant capacity.

Mass Transfer Coefficient

The final item is the mass transfer coefficient. It has been known for a considerable time that there exists a streamline film on each side of a liquid-gas boundary through which the materials have to diffuse, and that in practice this is a very slow process. Whitman and Keats in 1922⁷ made the proposal to consider this overall effect in its constituent parts, *i.e.*, the liquid film and the gas film. It has also been known that in order to decrease the thickness of these films and to hasten thereby the rate of material transfer it is necessary to have high velocities. These high velocities cause high pressure drops which are undesirable. For any given pressure drop it is possible to have a small depth of packing and high velocity, or large depth of packing and a slow velocity. Naturally each case has to be considered on its own economic merits.

The rates of diffusion of vapours in gases are proportional to the square root of the density of the gas, which means (excluding hydrogen) that most gases diffuse at roughly the same rate. One method of increasing the rate of absorption of ammonia in water employed in a well-known make of domestic refrigerator is to use hydrogen as a carrier gas. The rates of diffusion of vapours and gases in liquids are also proportional to the square root of the density but also depend upon the solubility of the gas in the liquid, as was shown by Exner⁸ as long ago as 1876. Thus a possible method of

¹ "J. Soc. Chem. Ind.," 1893, p. 227.

² "Ind. Chem.," Nov. 1928 and 1929.

³ Eng. Pats. 424,414 and 426,560.

⁴ "Z. Ver. Deut. Ing.," 1931, 75, 1212.

⁵ Beihet No. 6, Ver. Deut. Chem., 1933.

⁶ "Chem. Met. Eng.," 1927, 34, 671.

⁷ "J. Ind. Eng. Chem.," 1922, 14, 186.

⁸ "Pogg. Ann.," 1876, 165, 321.

increasing the rate of absorption is to increase the solubility of the gas in the liquid. This can be done by lowering the temperature or by altering the nature of the carrier liquid. A curious case was found⁹ when absorbing isobutene in 60 per cent. sulphuric acid. The rate of absorption was faster when the liquid was kept at rest than when it was stirred. This was due to a film of the reaction product—*tert* butyl alcohol—being formed at the surface in which olefine was more soluble than in the sulphuric acid.

To consider a few practical cases of recent interest, one must mention the recent work done on the elimination of oxides of sulphur from power station flue gases¹⁰. A method of recovering sulphur dioxide from waste gases by absorbing

⁹ "J. Amer. Chem. Soc.," 1930, 52, 3747.

¹⁰ "Ind. Chem.," 1935, 111, 149; "J. Inst. Fuel.," Jan., 1935.

in ammonium sulphite and heating the resulting bisulphite solution would seem to have many possibilities¹¹.

The use of a water wash has been found¹² to give very good results in the reduction of sulphur trioxide in the exit gas from a sulphuric acid plant from 1.1 down to 0.30 grain per cub. ft. The limit set by the Alkali Act is 4.0. With purer power station flue gases perhaps the use of sodium and potassium carbonates for the absorption of carbon dioxide to produce bicarbonate, which will release pure carbon dioxide on subsequent heating, will receive more attention. A timely contribution¹³ which summarises and correlates the work of previous experimenters in this field has recently appeared.

¹¹ "J. Ind. Eng. Chem.," 1935, 27, 650.

¹² "J. Soc. Chem. Ind.," 1935, 54, 181.

¹³ "J. Ind. Eng. Chem.," 1935, 27, 728.

Chemical Stoneware, Old and New

By FELIX SINGER, Dr.-Ing., Dr.-Phil., F.A.C.S.

In 1921, when I took up my work in the German stoneware industry, I examined the then existing stoneware bodies and recorded the physical properties which I found. These figures are given below, in comparison with those determined for material manufactured twelve¹ years later, *i.e.*, in 1933.

Compression strength: kg/cm ²	1921. 5816	1933. 8210
Tensile strength: kg/cm ²	116	528
Bending resistance: kg/cm ²	416	953
Elastic modulus: kg/mm ²	4175	4175
Torsional resistance: kg/cm ²	251	323
Impact strength: cmkg/cm ²	1.9	4.97
Abrasion test: loss in cm ³	3.0	0.6
Water absorption: %	0.5	nil
Coefficient of expansion: x 10 ⁻⁶	4.1	0.15
Thermal conductivity: kg.cal.m ⁻¹ . h ⁻¹ . °C ⁻¹	1.35	3.95

If normal stoneware bodies, approximately characterised in this country by the German figures of 1921, have other materials added to them, the physical properties of the finished product, change with the composition.² All elements, oxides, carbides, nitrides, salts, etc., which, at 1,400° C., neither vapourise nor burn, neither decompose nor suffer any appreciable changes through reduction, can be added to normal stoneware bodies and influence the physical characteristics, chiefly within the limits shown in the above table. Further changes follow through alteration of the firing temperature, the preparation, etc.

Characteristics of Modern Stoneware

This short account is quite sufficient to show that to Wood's definition of stoneware, correct in itself, should be added: "Modern chemical stoneware is a perfectly vitreous, white or coloured, non-translucent, opaque, ceramic body, the chemical composition of which can vary within the widest limits, because in a suitably-prepared stoneware body can be introduced all materials which are all non-combustible, do not decompose or evaporate and cannot be reduced at about 1,400° C. These elements or compounds, alone or in the desired mixtures, can be added in small or large quantities and thus can physical characteristics be controlled and altered over a very wide range."

There is consequently not "one stoneware" only, but besides the ordinary stoneware for chemical purposes, as Wood so excellently describes it, a special stoneware should be demanded for each particular purpose. In this, there is the assumption that the user of the stoneware informs his supplier of the conditions for its use. Only then can the different stoneware bodies be made which are needed for many special new purposes in the chemical industry. A typical example is "Alchemite," the first British stoneware

¹ Felix Singer: "Die Bedeutung des saurefesten Steinzeugs fuer die Kunstseiden-Industrie" (The Importance of acid-proof Stoneware for the Artificial Silk Industry). "Deutsche Kunstseiden-Zeitung," No. 417, April 11, 1933.

² Felix Singer: "Das Steinzeug" (Stoneware), published by Friedr. Vieweg and Sohn A.-G., Braunschweig, 1929, page 36.

³ Made by Doulton and Co., Ltd. See Felix Singer: "Alchemite, a New Ceramic Ware with a Water Absorption of Nil," THE CHEMICAL AGE, June 30, 1934.

body with a water absorption of nil.³ Another example is "white chemical stoneware."

In spite of this great variety of the different kinds of special stoneware, one characteristic is common to all ceramic bodies worthy of the name of "stoneware": they possess an unrivalled resistance to acids of all kinds (with the exception, already mentioned, of hydrofluoric acid) concentrated and diluted liquid acids, acid solutions of salts, acid gases, etc. This has been the immemorial characteristic quality of "stoneware." It was already being used about 2,000 years ago by the Romans for technical purposes (water conduits). Stoneware is therefore probably the oldest or one of the oldest engineering materials.

Stoneware⁴ is a vitrified ceramic material not only perfectly insoluble in acids, but is so little attacked and altered by most of the other usual chemicals that it has been the most suitable material since the existence of the chemical industry to serve all purposes of application. The very first beginnings of chemical manufacture were founded on the use of stoneware as an engineering material. So, parallel with the brilliant history of the chemical industry, runs the steady development of stoneware for chemical purposes.

Uses in the Chemical Industry

The production and development of sulphuric acid, hydrochloric and nitric acid was based on the use of this material. These industries employ stoneware in the form of cooling and washing towers, absorption and reaction towers, together with the appropriate fillings, well-contrived distributors of liquids and numerous other appliances. Condenser jars, receivers used in countless various cases, and coils, must satisfy the special condition of a rapid heat transfer without prejudice to their chemical and mechanical resistance. For the movement and mixing of chemically-active gases and fluids numerous apparatus and mechanical contrivances are necessary, such as injectors, elevators, emulsors, acid eggs, in which this is effected by steam or compressed air, or exhaustors, centrifugal and force pumps which can also work as vacuum pumps or compressors. For their constructional perfection a specially accurate knowledge of the mechanical properties of the material is assumed. Hollow vessels in the form of pans, vats, tubs, tanks, jars, bottles, stirring dishes and vessels for the transport and working up of chemicals of all kinds are adapted in the most varied forms to the purpose for which they are destined, and manufactured in one piece with a capacity up to several hundred gallons. Regulating devices, such as cocks, valves, throttles and flanges and other junctions, require the greatest accuracy of design which, thanks to the good "workability" of stoneware, can be attained by grinding.

Whilst the density of stoneware in instances hitherto has played a decisive part, in other cases the great hardness and toughness come also into operation, for example, in mortars, flat and hollow, pebble mills, etc. Hardness, strength, density and chemical resistance make stoneware a valuable

⁴ Felix Singer: "Steinzeug als Werkstoff" (Stoneware as an Engineering Material), published by "Die Chemische Fabrik," Verlag Chemie G.m.b.H., Berlin.

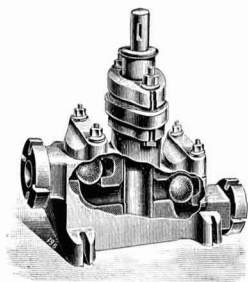
engineering material for the construction of rollers of all kinds as successfully used for different technical purposes, for example, in the textile industry; for bleaching plants; as coating rolls in the manufacture of photographic papers; as triturating rolls in the preparation of oil colours; further, as crushing and homogenising rolls, particularly in the provision industry (milling and chocolate making).

According to the latest scientific research which has given an insight into the chemical and physical constitution of stoneware, it consists, in the fired state for the greater part, of glassy constituents in addition to crystallites which are partly introduced through the raw material and are partly formed anew. The physical and chemical characteristics depend to a far-reaching degree on the extent of the formation of the glassy components and crystallites, and on their relative relation one to the other. Their investigation and the knowledge of the causes of their formation to-day bear witness very largely to the development of the chemical stoneware industry.

Moving Hot Hydrochloric Acid

A Trouble-Free Pump of British Manufacture

WHILE little or no difficulty is experienced at chemical works in the moving of sulphuric acid, no really efficient method of dealing with hydrochloric acid had been adopted, until the introduction of Hargreaves and Robinson's patent pump, although many complicated and fragile forms of pumps and elevators have been designed and introduced. In drawing the attention of chemical works to this patent pump, the



Bailey's Hydrochloric Acid Pump.

makers, Sir W. H. Bailey and Co., Ltd., unhesitatingly affirm that it is the only pump that will satisfactorily raise hydrochloric acid at a boiling heat. The pump is made of a specially-prepared white metal, with the wearing parts carefully strengthened, and the pump as a complete unit is as strong as it is possible to make it. One user, Golding, Davis and Co., Ltd., of Widnes, states that this hydrochloric acid pump answers their purpose admirably; it "pumps acid at a high temperature, and after twelve months' use there has been no perceptible wear." Three sizes are available, giving deliveries of 400, 550 and 750 gallons per hour.

John Benn Hostel Banquet

Record Sum Collected

THE record sum of £1,172 was collected for the John Benn Hostel at the annual dinner of the East End Hostels Association held at Stationers' Hall, London, on June 20. The occasion was also notable for the reading of a message from the Prince of Wales in reply to birthday greetings which Sir Ernest Benn, who presided at the dinner, had sent on behalf of the members of the Association. The Prince's letter was as follows: "Please convey my sincere thanks to members and friends of the East End Hostels Association for their birthday congratulations which I much appreciate. I am always glad to hear news of the John Benn Hostel, and I take this opportunity of sending my best wishes for

the continued success of the Association's work. I hope, too, that you are all having an enjoyable annual banquet."

Mr. SPENCER LEESON, the new headmaster of Winchester, in proposing the toast of "The London Boy," referred to the Prince of Wales's appeal for the Jubilee Trust. He said that public opinion on the subject of boys' clubs had been thoroughly aroused by the Prince's appeal, which had profoundly stirred the imagination of the country. He spoke of the toughness of the London boy, his readiness to make friends, his infinite tolerance, and his superb cheerfulness.

Lord HEWART, Lord Chief Justice, replying to the toast, spoke of himself as "a Lancashire lad." The London boy, as he understood him, was a small apple-eating animal who was to be found in the John Benn Hostel.

Miss IRENE VANBRUGH, giving the toast of the John Benn Hostel, said that, perhaps because she was "a rogue and a vagabond," she could appreciate for what the East End Hostels Association stood. The Hostel was turning out useful citizens and workers with ideals, equipped with health of body and mind, and able to look the world straight in the face.

Mr. WEDGWOOD BENN, responding to the toast, described the Hostel as the home of adventure and romance. It was also an academy of art, for it was a place where people were taught the art of living.

Sir GERVAIS RENTOUL submitted the health of the Company of Stationers and Newspaper Makers, by whose courtesy the dinner was held in their historic hall. Mr. R. D. Blumenfeld, acting master of the Company, replied. Sir Ernest Benn was thanked for his services in the chair on the proposition of the Mayor of Stepney, in whose area at Bower Street the John Benn Hostel is situated.

The I.C.I. Scheme

Petition to be Heard on July 9

IN the Chancery Division on Tuesday, Mr. Justice Eve had before him an application on the petition by Imperial Chemical Industries, Ltd., for confirmation by the Court of a proposed reduction of its capital from £95,000,000 to £89,565,859, to fix a date for the hearing.

The petition is opposed by a number of deferred shareholders.

Mr. Lionel Cohen, K.C., appeared for the company and asked that, in addition to fixing a day for the hearing, his lordship should also fix a time for the delivery of the evidence in opposition.

His lordship said he understood that the opposition fell into two categories—irregularities at the meetings and that it was an unfair scheme.

Mr. H. J. Wallington, K.C., appeared for the opponents to the scheme and said there were one or two other matters and his clients, rightly or wrongly, submitted that it was a case of such an unusual character that the Court should order "discovery." The scheme, they now knew, had been under the consideration of the board since January, 1933. During that time the persons who bought shares knew nothing about it, but bought under the old conditions.

At some time a large number of these deferred shares had been bought from directors or past-directors, and there were two very serious questions for the Court to consider, *viz.*, whether in all the circumstances the shareholders were fully informed by the circular sent out by the directors, and whether they were in part misled at the meeting when the polls were taken.

Continuing, counsel said there was not the slightest idea in anybody's mind that there had been any want of good faith at all, but he wanted to convey in language incapable of being misunderstood that this was a claim in which the petitioners were saying: "We do not suggest that the capital has been lost or is unrepresented by available assets or that there is any question of insolvency; what we must be careful about is to have reserves for depreciation and obsolescence, and it would be very convenient for the directors to have a capital sum to draw upon instead of drawing upon revenue."

Mr. Cohen, in reply, said with reference to the holdings of the directors no director had either bought or sold a single deferred share since the scheme was formulated.

His lordship said that the matter would stand over until July 9, when he would fix a date for the hearing.

Personal Notes

MR. WILLIAM A. HAMOR, assistant director of Mellon Institute of Industrial Research, has received from the University of Pittsburgh the honorary degree of Doctor of Science.

MR. DONALD HICKS, principal of the Government Coal Survey Laboratory, Treforest, Glam., was married last week at Cardiff to Miss May Sainsbury, Chepstow.

SIR WILLIAM HENRY HOUGHTON GASTRELL, Clarence Terrace, Regent's Park, N.W., a director of J. C. and J. Field, Ltd., manufacturers of candles, soap, etc., left £51,468, with net personality £49,433.

MR. CHARLES FREDERICK CROSS, F.R.S., New Court, Lincoln's Inn, W.C., and King's Gardens, Hove, Sussex, discoverer with the late Mr. E. J. Bevan of viscose, which made possible the production of artificial silk on a commercial basis, left £22,691 (net personality £22,628).

SIR WILLIAM LINGUARD GOULDING, BT., a prominent figure in Irish banking and railway circles, died in London on June 20 at the age of 51 years. He was a director of the National Smelting Co.

MR. J. L. WILSON GOODE, British Trade Commissioner at Vancouver, is in this country on an official visit. Mr. Wilson Goode will be available at the Department of Overseas Trade during the period July 1 to 12 for the purpose of interviewing manufacturers and merchants interested in the export of United Kingdom goods to Western Canada. At a later date he will visit a number of industrial centres in the provinces. Firms desiring an interview with Mr. Wilson Goode in London or information regarding the provincial centres he will visit should apply to the Department of Overseas Trade, 35 Old Queen Street, London, S.W.1, quoting reference 12689/35.

Continental Chemical Notes

Roumania

FURTHER CAPITAL IS BEING RAISED by the Seta Company for the purpose of entering the rayon manufacturing field.

BLEACHING AND DYEWORKS for cotton textiles are under construction at Temesvar by the Romitex Co., a subsidiary of the Milan house of Rossi and Varzi.

Germany

NAPHTHENIC ACIDS AND THEIR SALTS were formerly used solely in soap manufacture and as agents for breaking up water-petroleum emulsions. Many new uses have, however, been developed during the last few years. These, according to Dr. I. von Braun ("Chem.-Zeitung," June 15) include reduction of viscosity of colloidal solutions, solution and regeneration of rubber, retardation of tung oil gelation and incorporation in insecticides. The glycerin esters are useful components of plastic masses and lacquers. On reduction to the corresponding alcohols and reaction with sulphuric or chlorosulphonic acid, valuable wetting and dispersing agents are formed. The sodium salts increase the viscosity and lubricating value of oils and exercise a stabilising action upon aqueous emulsions. The copper salts serve as antiseptic impregnating agents for timber while other heavy metal salts are now extensively used as paint driers.

Russia

IT HAS BEEN DECIDED to proceed with construction of two ammonium nitrate plants in Transcaucasia, located at Baku and Brodzelnii respectively.

GUTTAPERCHA IS BEING EXTRACTED on a considerable scale from a plant ("SG"), discovered to be exceptionally rich in this material. The factory is located at Umani.

ALUMINIUM SULPHATE IS IN RISING DEMAND, the anticipated annual consumption at the end of the Second Five Year Plan being over 100,000 tons. This figure contrasts with a maximum capacity of only 50,000 tons on the part of the existing plants.

AMBITIOUS VITAMIN-PRODUCING PLANS are announced embracing vitamins A, B, C and D. The first will be extracted from carrots at a factory in Leningrad where B and D will also be derived from yeast. Vitamin D manufacture from dried yeast is also planned at two Moscow factories.

ANNOUNCEMENT OF THE DISCOVERY of a naturally-occurring precious metal alloy was made recently, by the Russian Academy of Sciences, by Professor Zwjaginzeft. Iridium is the predominant ingredient (52 per cent.), followed by osmium (25 per cent.), gold (19 per cent.), and ruthenium (3.5 per cent.). Aurosmerid, as the product has been named by its discoverer, is sufficiently hard to scratch agate and is extremely resistant to the action of strong acids.

Italy

A CONCESSION FOR THE ERECTION of a tin oxide plant has been granted to Mario Laurenti (Milan).

PRODUCTION OF SULPHURIC ACID, superphosphate and copper sulphate is to be increased by Soc. Concimi Industrie Affini (Florence).

RAYON PRODUCTION CONTINUES ITS UPWARD TREND, the output of 15,000 tons for the first quarter of 1935 comparing with 10,000 tons in the last corresponding period. Expansion of the staple fibre department is planned by the three leading producers: S. A. Superstessile, Snia Viscosa and Soc. Gen. Italiana della Viscosa.

Prices of Chemical Products

Current Market Conditions

IN the general chemical market prices have remained unchanged from last week. Unless otherwise stated the prices below cover fair quantities net and naked at sellers' works. The prices for fertilisers of all kinds remain unchanged for delivery up to June 30. Up to the present no prices have been announced for delivery beyond June 30, and as a consequence there is no present interest in these products.

LONDON.—Prices still remain steady with a fair general demand. White lead is quoted at £39 per ton. There is no change to report in the prices of coal tar products. Pitch is quoted at about 37s. 6d. per ton f.o.b. East Coast port, for next season's delivery.

MANCHESTER.—The movements of chemical products on the Manchester market are maintaining a steady course so far as deliveries of the leading heavy materials are concerned, and fair quantities of the alkalies and certain of the potash products, as well as numerous miscellaneous chemicals, are being taken up against contracts. From now on, however, for the next couple of months the aggregate weight of specifications will be adversely affected to some extent by the holidays, from the end of the present week one Lancashire town succeeding another for the annual stoppage. New business this week has been on moderate lines, with a sprinkling of forward contracts extending over the next few months. Prices remain on a generally steady basis, although in the case of the by-products several weak spots continue to make their appearance.

SCOTLAND.—Bryce and Rumpff report that business in chemicals has been rather quiet during the week both for home trade and export. There have been practically no changes in prices, all of which continue very steady at about previous figures. Charles Tennant and Co., Ltd., state that the Scottish heavy chemical market continues to show improvement.

All prices remain as quoted in THE CHEMICAL AGE last week (pages 560-561) with the exception of the following:—

General Chemicals

ACID, TARTARIC.—1s. per lb. less 5%, carriage paid for lots of 5 cwt. and upwards. SCOTLAND: 1s. 0½d. less 5%. MANCHESTER: 1s. 0½d. per lb.

LEAD, WHITE.—SCOTLAND: £39 per ton, carriage paid. LONDON: £39.

POTASSIUM CHLORATE.—LONDON: £37 to £40 per ton. SCOTLAND: 99½/100%, powder, £37. MANCHESTER: £38.

Chemical and Allied Stocks and Shares

Current Quotations

The following table shows this week's Stock Exchange quotations of chemical and allied stocks and shares compared with those of last week. Except where otherwise shown the shares are of £1 denomination.

Name	June 25.	June 18.	Name	June 25.	June 18.
Anglo-Persian Oil Co., Ltd. Ord.	61/3	61/10½	English Velvet & Cord Dyers' Association, Ltd. Ord.	4/4½	4/4½
.. 8% Cum. Pref.	37/-	37/6	.. 5% Cum. Pref.	8/1½	8/1½
.. 9% Cum. Pref.	38/-	38/6	.. 4% First Mort. Deb. Red. (£100)	£65	£65
Associated Dyers and Cleaners, Ltd. Ord.	1/10½	1/10½	Fison, Packard & Prentice, Ltd. Ord.	38/9	38/9
.. 6½% Cum. Pref.	4/8½	4/8½	.. 7% Non-Cum. Pref.	30/-	30/-
Associated Portland Cement Manufacturers, Ltd. Ord.	54/6	54/-	.. 4½% Debs. (Reg.) Red. (£100)	£107	£107
.. 5½% Cum. Pref.	27/3	27/3	Gas Light & Coke Co. Ord.	28/-	28/-
Benzol & By-Products, Ltd. 6% Cum. Part Pref.	2/6	2/6	.. 3½% Maximum Stock (£100) ..	£87/10/-	£87/10/-
Berger (Lewis) & Sons, Ltd. Ord.	61/3	60/7½	.. 4% Consolidated Pref. Stock (£100)	£108/10/-	£108/10/-
Bleachers' Association, Ltd. Ord.	6/-	6/3	.. 3% Consolidated Deb. Stock Irred. £100	£89/10/-	£89/10/-
.. 5½% Cum. Pref.	8/9	8/9	.. 5% Deb. Stock, Red. (£100) ..	£115/10/-	£115/10/-
Boake, A., Roberts & Co., Ltd. 5% Pref. (Cum.)	21/3	21/3	.. 4½% Red. Deb. Stock (1900-65) (£100)	£111/10/-	£111/10/-
Boots Pure Drug Co., Ltd. Ord. (5/-) ...	49/3	49/3	Goodlass Wall & Lead Industries, Ltd. Ord. (10/-)	12/6	12/6
Borax Consolidated, Ltd. Pfd. Ord. (£) ..	97/6	97/6	.. 7% Prefd. Ord. (10/-)	13/1½	13/1½
.. Defd. Ord.	15/9	15/9	.. 7% Cum. Pref.	28/9	27/6
.. 5½% Cum. Pref. (£10)	£11 2/6	£11 5/-	Gossage, William, & Sons, Ltd. 5% 1st Cum. Pref.	24/4½	24/4½
.. 4½% Deb. (1st Mort.) Red. (£100)	£109	£109	.. 6½% Cum. Pref.	28/9	28/9
.. 4½% 2nd Mort. Deb. Red. (£100)	£103	£103	Imperial Chemical Industries, Ltd. Ord. ...	35/9	37/-
Bradford Dyers' Association, Ltd. Ord. ...	8/9	8/9	.. Deferred (10/-)	8/8½	9/1½
.. 5% Cum. Pref.	11/10½	10/11½	.. 7% Cum. Pref.	33/6	34/-
.. 4% 1st Mort. Perp. Deb. (£100) ..	£82/10/-	£82/10/-	Imperial Smelting Corporation, Ltd. Ord.	13/9	15/-
British Celanese, Ltd. 7% 1st. Cum. Pref.	27/-	26/6	.. 6½% Pref. (Cum.)	23/9	24/4½
.. 7½% Part. 2nd Cum. Pref.	22/9	21/9	International Nickel Co. of Canada, Ltd. Cum.	\$28½	\$28
British Cotton & Wool Dyers' Association Ltd. Ord. (5/-)	5/-	5/-	Johnson, Matthey & Co., Ltd. 5% Cum. Pref. (£5)	95/-	95/-
.. 4% 1st Mort. Deb. Red. (£100) ..	£91	£91	.. 4% Mort. Deb. Red. (£100) ..	£98/10/-	£98/10/-
British Cyanides Co., Ltd. Ord. (2/-)	3/7½	2/10½	Laporte, B., Ltd. Ord.	107/6	107/6
British Drug Houses, Ltd., Ord.	20/-	18/9	Lawes Chemical Manure Co., Ltd. Ord. (1/-)	5/7½	5/7½
.. 5% Cum. Pref.	22/6	22/6	.. 7% Non-Cum. Part Pref. (10/-) ..	10/-	10/-
British Glues and Chemicals, Ltd. Ord. (4/-)	4/3	4/3	Lever Bros., Ltd. 7% Cum. Pref.	32/6	32/3
.. 8% Pref. (Cum. and Part.) ...	26/10½	26/10½	.. 8% Cum. "A" Pref.	32/9	32/9
British Oil and Cake Mills, Ltd. Cum. Pfd. Ord.	48/9	48/1½	.. 20% Cum. Prefd. Ord.	79/4½	79/4½
.. 5½% Cum. Pref.	26/3	26/3	.. 5% Cons. Deb. (£100)	£109/10/-	£109/10/-
.. 4½% First Mort. Deb. Red. (£100) ..	£107/10/-	£108/10/-	.. 4% Cons. Deb. (£100)	£105	£105
British Oxygen Co., Ltd. Ord.	117/6	107/6	Magadi Soda Co., Ltd. 12½% Pref. Ord. (5/-)	1/3	1/3
.. 6½% Cum. Pref.	31/10½	31/10½	.. 6% 2nd Pref. (5/-)	5d.	5d.
British Portland Cement Manufacturers, Ltd. Ord.	90/-	88/9	.. 6% 1st Debs. (Reg.)	58/-	58/-
.. 6% Cum. Pref.	30/-	30/-	Major & Co., Ltd. Ord. (5/-)	7½d	7½d
Bryant & May, Ltd. Pref.	67/6	67/6	.. 8% Part. Prefd. Ord. (10/-) ...	8d.	8d.
Burt, Boulton & Haywood, Ltd. Ord.	20/-	20/-	.. 7½% Cum. Pref.	1/6½	1/6½
.. 7% Cum. Pref.	27/6	27/6	Mond Nickel Co., Ltd. 5½% Mort. Deb. Red. (£100)	—	£103
.. 6% 1st Mort. Deb. Red. (£100) ..	£105/10/-	£105/10/-	Pinchin, Johnson & Co., Ltd. Ord. (10/-) ..	44/-	44/-
Bush, W. J., & Co., Ltd. 5% Cum. Pref. (£5)	105/-	105/-	.. 7% Cum. Pref.	39/1½	39/1½
.. 4% 1st Mort. Deb. Red. (£100) ..	£96/10/-	£96/10/-	Potash Syndicate of Germany (Deutsches Kalisyndikat (G.m.b.H.) 7% Gld. Ln. Sr. "A" and "B" Rd.	69/-	67/-
Calico Printers' Association, Ltd. Ord. ...	10/-	9/4½	Reckitt & Sons, Ltd. Ord.	113/9	113/1½
.. 5% Pref. (Cum.)	17/6	16/10½	.. 4½% Cum. 1st Pref.	26/-	25/-
Cellulose Acetate Silk Co., Ltd. Ord.	12/-	12/6	Salt Union, Ltd. Ord.	41/3	41/3
.. Deferred (1/-)	2/4½	2/7½	.. Pref.	46/3	46/3
Consett Iron Co., Ltd. Ord.	7/3	7/3	.. 4½ Deb. (£100)	£109/10/-	£109/10/-
.. 8% Pref.	23/1½	23/1½	South Metropolitan Gas Co., Ord. (£100) ..	£125/10/-	£129/10/-
.. 6% First Deb. stock, Red. (£100) ..	£103	£122	.. 6% Irred. Pref. (£100)	£149/10/-	£149/10/-
Cooper, McDougall & Robertson, Ltd. Ord.	36/3	36/3	.. 4% Pref. (Irred.) (£100)	£106/10/-	£106/10/-
.. 7% Cum. Pref.	29/6	29/6	.. Perpetual 3% Deb. (£100)	£89/10/-	£89/10/-
Courtaulds, Ltd. Ord.	59/6	58/9	.. 5% Red. Deb. 1950-60 (£100) ..	£115/10/-	£115/10/-
.. 5% Cum.	26/3	26/3	Staveley Coal & Iron Co., Ltd. Ord.	44/4½	44/4½
Crosfield, Joseph, & Sons, Ltd. 5% Cum. Pre-Pref.	25/-	25/-	Stevenson & Howell, Ltd., 6½% Cum. Pref.	26/3	26/3
.. Cum. 6% Pref.	28/9	28/9	Triplex Safety Glass Co. Ltd. Ord. (10/-) ..	70/7½	70/-
.. 6½% Cum. Pref.	28/9	28/9	Unilever, Ltd. Ord.	29/9	30/7½
.. 7½% "A" Cum. Pref.	30/7½	30/7½	.. 7% Cum. Pref.	29/9	29/9
Distillers Co., Ltd. Ord.	95/6	95/6	United Glass Bottle Manufacturers, Ltd. Ord.	42/6	42/6
.. 6% Pref. Stock Cum.	32/-	32/-	.. 7½% Cum. Pref.	33/-	33/-
Dorman Long & Co., Ltd. Ord.	19/4½	17/6	United Molasses Co., Ltd. Ord. (6/8)	20/7½	20/7½
.. Prefd. Ord.	22/-	15/7½	.. 6% Cum. Pref.	25/-	25/-
.. 6½% Non-Cum. 1st. Pfd.	21/9	20/6	United Premier Oil & Cake Co., Ltd. Ord. (5/-)	6/9	6/3
.. 8% Non-Cum. 2nd Pref.	20/7½	16/10½	.. 7% Cum. Pref.	23/9	23/9
.. 4% First Mort. Perp. Deb. (£100) ..	£102/10/-	£101/10/-	.. 6% Deb. Red. (£100)	£101	£102
.. 5% 1st Mort. Red. Deb. (£100) ..	£103/10/-	£103			

Inventions in the Chemical Industry

Patent Specifications and Applications

THE following information is prepared from the Official Patents Journal. Printed copies of Specifications accepted may be obtained from the Patent Office, 25 Southampton Buildings, London, W.C.2, at 1s. each. The numbers given under "Applications for Patents" are for reference in all correspondence up to the acceptance of the Complete Specification.

Applications for Patents

(June 6 to 12 inclusive.)

DYES, manufacture.—B. Beilenson and Kodak, Ltd. 16775.
SACCHARATES, manufacture.—Carboxhyd. (Germany, June 14, '34.) 16938.
PROCESS FOR POLYMERISING ACETYLENE.—A. Carpmal (I. G. Farbenindustrie). 16631.
DYEING WITH VAT, ETC., DYESTUFFS.—A. Carpmal (I. G. Farbenindustrie). 16632.
HYDROXYALKYL-AMINO-AMINOENZINES, manufacture.—A. Carpmal (I. G. Farbenindustrie). 16728.
NITROGEN COMPOUNDS, manufacture.—A. Carpmal (I. G. Farbenindustrie). 16729.
LAKE COLOURS, preparation.—S. F. W. Crundall, A. Hancock, P. Spence and Sons, Ltd. 16891.
ARTIFICIAL WAXES, ETC., manufacture.—Deutsche Hydrierwerke (Germany, June 6, '34.) 16496.
CHEMICAL PROCESSES.—H. Dreyfus. 16924.
AGRICULTURAL SPRAY MATERIALS, manufacture.—E. I. du Pont de Nemours and Co. (United States, June 9, '34.) 16672.
LUBRICATING OIL.—E. I. du Pont de Nemours and Co. (United States, June 15, '34.) 16978.
AZO DYESTUFFS, manufacture.—W. W. Groves (I. G. Farbenindustrie). 16629.
ROTARY FILTERS.—W. F. Harlow and International Combustion, Ltd. 16843.
STABLE SOLUTIONS OF dihydroxy-diamino-arsenobenzenes, etc., manufacture.—F. Hoffmann-La Roche and Co. (Switzerland, July 6, '34.) 16688.
THERAPEUTIC AGENTS, manufacture.—I. G. Farbenindustrie (Germany, June 7, '34.) 16627.
THERAPEUTIC AGENTS, manufacture.—I. G. Farbenindustrie (Germany, Oct. 18, '34.) 16628.
OXARYL-AMINOANTHRACENE DERIVATIVES, manufacture.—I. G. Farbenindustrie (Germany, June 23, '34.) 16941.
VAT DYESTUFFS.—Imperial Chemical Industries, Ltd., and C. Shaw. 16509.
CHLORINATED RUBBER, manufacture.—Imperial Chemical Industries, Ltd., and T. N. Montgomery. 16510.
VAT DYESTUFFS.—F. Irving. 16509.
HALOGEN COMPOUNDS OF 2-hydroxy-3-naphthoic acid, manufacture.—J. Y. Johnson (I. G. Farbenindustrie). 16576.
AZO COMPOUNDS, manufacture.—J. Y. Johnson (I. G. Farbenindustrie). 16820.
VAT DYESTUFFS, manufacture.—J. Y. Johnson (I. G. Farbenindustrie). 16821.
PIGMENT DYESTUFFS, manufacture.—J. Y. Johnson (I. G. Farbenindustrie). 16822.
REACTION OF OXIDES OF CARBON with hydrogen.—J. Y. Johnson (I. G. Farbenindustrie). 16823.
ORGANIC SULPHUR COMPOUNDS, manufacture.—J. Y. Johnson (I. G. Farbenindustrie). 16928.
VAT DYESTUFFS, manufacture.—J. Y. Johnson (I. G. Farbenindustrie). 16929.
CHLORBUTADIENE, manufacture.—J. Y. Johnson (I. G. Farbenindustrie). 16930.
DERIVATIVES OF PYRAZINE-MONOCARBOXYLIC ACID, manufacture.—E. Merck (firm of), F. Merck, K. Merck, L. Merck, and W. Merck. (Germany, July 7, '34.) 16970.
LOW-TEMPERATURE CARBONISATION OF COAL, ETC.—C. B. Winzer. 16983.

Complete Specifications Open to Public Inspection

ASPHALT BITUMEN free from paraffin, production.—K. Kell and W. H. Schmitz. Dec. 4, 1933. 21566/34.
DYEING PELTS.—I. G. Farbenindustrie. Dec. 7, 1933. 21879/34.
HYDROCYANIC ACID, manufacture.—E. I. du Pont de Nemours and Co. Dec. 7, 1933. 30641/34.
EXTRACTION OF PRODUCTS in solution by means of solvents, process and apparatus.—Usines de Melle. Dec. 7, 1933. 34827/34.
TRANSFORMING MIXTURES OF ALCOHOLS and fatty or aromatic hydrocarbons into highly anti-knock economical fuels for internal-combustion engines.—Soc. Anon. Carburanti Italia, and E. Livraghi. Dec. 4, 1933. 34877/34.
CONCENTRATED PHOSPHORIC ACID, manufacture.—R. Moritz. Dec. 5, 1933. 35000/34.
OESTROGENOUS PRODUCTS, manufacture.—Schering-Kahlbaum A.-G. Dec. 6, 1933. 35106/34.
DYED FILAMENTS AND FILMS, manufacture.—I. G. Farbenindustrie. Dec. 6, 1933. 35110/34.

DYEING WITH VAT-DYESTUFFS.—I. G. Farbenindustrie. Dec. 9, 1933. 35203/34.
DYEING LEATHER.—J. R. Geigy A.-G. Dec. 7, 1933. 35222/34.
WETTING AGENTS suitable for use in alkaline baths.—Soc. of Chemical Industry in Basle. Dec. 9, 1933. 35224/34.
CONVERSION OF OLEFINS into sulphuric esters.—E. I. du Pont de Nemours and Co. Dec. 7, 1933. 35262/34.
WATER-INSOLUBLE AZO DYESTUFFS and intermediate products therefor, manufacture.—I. G. Farbenindustrie. Dec. 8, 1933. 35282/34.
THERAPEUTICALLY-VALUABLE SATURATED ALCOHOLS from germinal gland hormones, production.—Schering-Kahlbaum A.-G. Dec. 7, 1933. 35287/34.
ALKALI ORTHOPHOSPHATES, production.—Kali-Forschungs-Anstalt Ges. Dec. 9, 1933. 35427/34.
PERFUME-EMITTING MATERIALS, manufacture.—E. I. du Pont de Nemours and Co. Dec. 8, 1933. 35477/34.

Specifications Accepted with Date of Application

POLYMERISATION PRODUCTS of vinyl chloride, process for making foils of decreased brittleness.—Dynamit A.-G. Nov. 14, 1933. 429,480.
FLUORINATION OF ORGANIC COMPOUNDS.—E. I. du Pont de Nemours and Co. Sept. 10, 1932. 429,591.
LIQUID ANTHELMINTICS, manufacture of solutions.—I. G. Farbenindustrie. Oct. 25, 1932. 429,594.
COMBINED CRACKING AND DISTILLATION of carbonaceous materials. E. W. Brocklebank, W. B. Mitford and C. H. Lander. Nov. 28, 1933. 429,757.
DYEING PROCESS.—Imperial Chemical Industries, Ltd., N. H. Haddock, F. Lodge, and C. H. Lumsden. Dec. 1, 1933. 429,681.
RUBBER DISPERSIONS, manufacture of products.—W. J. Tennant (Vultex Corporation of America). Dec. 2, 1933. 429,607.
HEAVY METAL COMPLEX COMPOUNDS of mercapto pyrimidines, manufacture.—I. G. Farbenindustrie. Dec. 3, 1932. 429,613.
LIQUID-OXYGEN EXPLOSIVES.—L. Mellersh-Jackson (L'Air Liquide, Soc. Anon. pour L'Etude et L'Exploitation des Procédes G. Claude). Dec. 4, 1933. 429,617.
DIAZOIMINO COMPOUNDS and their application in dyeing and printing, manufacture.—E. I. du Pont de Nemours and Co. Dec. 3, 1932. 429,618.
SUGAR FACTORY AND REFINERY JUICES, purification.—D. Teatini. Dec. 5, 1933. 429,691.
FUEL OIL.—E. I. du Pont de Nemours and Co. Dec. 6, 1932. 429,763.
FILM-FORMING COMPOSITIONS.—I. G. Farbenindustrie. Dec. 6, 1932. 429,764.
SULPHUR DYESTUFFS which dye deep black shades, manufacture.—Soc. of Chemical Industry in Basle. Feb. 25, 1933. 429,642.
PECTIN FROM SUGAR BEET, process of producing.—W. A. Büchtinger. Aug. 13, 1934. 429,718.
DECOLORISED FLAVOURING MATERIAL, process of preparing.—A. A. Levinson. Oct. 26, 1934. 429,664.
EVAPORATION, distillation, or concentration of aqueous hydrochloric-acid solutions, method and apparatus.—Dr. F. Raschig Ges. Nov. 27, 1933. 429,816.
CELULOSE ESTERS, manufacture.—British Celanese, Ltd. Dec. 5, 1933. 429,739.
PURIFYING ZINC METAL.—Improved Metallurgy, Ltd. Dec. 28, 1933. 429,820.
HYDROGENATION PRODUCTS of follicle hormones, manufacture.—Schering-Kahlbaum A.-G. Oct. 26, 1933. 429,747.

Chemical Trade Inquiries

The following trade inquiries are abstracted from the "Board of Trade Journal." Names and addresses may be obtained from the Department of Overseas Trade (Development and Intelligence), 35 Old Queen Street, London, S.W.1 (quote reference number).

Argentina.—The Commercial Counsellor to H.M. Embassy at Buenos Aires reports that the Argentine State Oilfields Directorate are calling for tenders, to be presented in Buenos Aires by July 26, 1935, for the supply of a portable arc-welding equipment comprising a petrol motor 25/30 h.p. coupled to a 200-amp. d.c. generator, complete with all accessories. A portable emery grinder for operation from a 115-volt d.c. generator driven by the above petrol motor is also required. (Ref. A.Y. 13148.)

From Week to Week

THE CLAYTON ANILINE CO., LTD., has donated a hundred guineas to Manchester's fund for the King George Jubilee Trust.

THE ELEVENTH INTERNATIONAL EXHIBITION OF INVENTIONS will take place at the Central Hall, Westminster, London, from October 2 to 12, and will be transferred to St. George's Drill Hall, Newcastle-on-Tyne, from November 20 to 30 inclusive.

REPRESENTATIVES OF THE INTERNATIONAL NITRATE CARTEL met at Zurich on June 24. The extension of the international convention regulating the production of nitrates and their release to world markets, was the main subject of discussion. The present agreement expires on June 30.

WHILE AT WORK IN THE LABORATORY ROOM at the works of Hamilton, Bale and Co., chemical manufacturers, Crownpoint Road, Glasgow, William M'Guffog (20), a machine minder, received burning injuries from which he died later. It appears that M'Guffog poured some water into a tin containing phenol, and when he attempted to remove the phenol a quantity of the liquid splashed about his head and face.

THE PRODUCTION OF CHEMICALS AND ALLIED PRODUCTS in Canada during 1934 amounted to \$105,568,027, an increase of 13.7 per cent. during the year. A total of 712 plants were in operation. The industry was capitalised at \$155,600,148, and employed 16,751 persons earning in all \$20,764,260. Imports of chemicals advanced by \$4,000,000 to a total of \$28,149,508, inclusive of \$6,164,660, representing the value of purchases from the United Kingdom. Exports of Canadian chemical products advanced from \$12,604,040 to \$14,349,689, of which 22.7 per cent. was shipped to the United Kingdom.

NIPAH DISTILLERIES OF MALAYA, LTD., announces that the distillery commenced working in the last week of February, and during March, April and May the output amounted to 23,886 gallons from the nera collected from only 160 acres out of 1,906 acres of mature palms. The recovery of alcohol from the nera has worked out at 8.72 per cent., compared with the original estimate of 6½ per cent. To the end of May over 4,000 gallons of alcohol have been sold in the form of methylated spirits and rectified spirit at satisfactory prices. In addition, 70 tons of sugar have been produced and sold in the local market.

THE BRITISH DRUG HOUSES, LTD., have issued an illustrated booklet for distribution to public health authorities and private owners who purify the water in bathing pools by chlorination, and desire to control this operation. For the successful purification by chlorination of the water in swimming pools the water should contain, after the addition of the chlorination agent, from 0.2 to 0.5 part of chlorine per million parts of water. Too little chlorine is useless and too much is objectionable, but when the water contains an excess of chlorine between the above-mentioned limits, it will be practically free from bacterial contamination and from unpleasant odour, and it will not affect the eyes. By means of the B.D.H. Chlorotex reagent it is now possible to determine easily whether the correct amount of chlorine has been used.

A LETTER FROM MR. P. M. STEWART, Commissioner for Special Areas, to Mr. Lewis Jones, M.P., for Swansea West, which was published on Monday, states that a grant of £2,500 has been offered to the South Wales Industrial Development Council for an investigation into processes for the production of oil from coal, and that further grants to a total of £7,000 have been offered for other activities. Some years ago an ambitious scheme for the erection of hydrogenation plants was placed before the council, as well as an alternative scheme for the production of oil by low-temperature carbonisation. The costliness of the schemes ruled them out at the time, but the claim of South Wales for Government assistance on the lines of the Billingham experiment was strongly pleaded before Sir Wyndham Portal (now Lord Portal) during his investigation of industrial conditions in the area last year, and again before Mr. P. M. Stewart.

STATED TO BE A BACHELOR OF SCIENCE and the member of the British Association of Chemists, John Rees Bundoock, 24, a chemist, of Bensham Lane, Thornton Heath, was at Wimbledon, on June 20, sent to prison for one month for possessing firearms without a licence, and two months for stealing a car, the sentences to run concurrently. Mr. W. C. Sharpe, assistant solicitor, Scotland Yard, said Bundoock registered a fictitious car in the name of Edwards, obtained a log book, took out a licence in the name of Clements, and had number plates made. Then he registered the sale of a car from Edwards to himself in his proper name. Later he hired a car from a Wimbledon garage in the name of Clements, replaced the registration plates with those made for the fictitious car, and changed the chassis number for the one on his father's car. Then he sold the car in his own name. Inquiries revealed the existence of another car of the same chassis, and the police were informed. Police evidence was that the firearms were found at an address at St. Pancras Road. There was no suggestion that they were for any improper purpose. Bundoock said they belonged to his brother in Africa. The defendant has no connection with the R.B. Technical Service, of which Mr. John R. Bundoock, B.Sc., was the founder.

HOWARDS AND SONS, LTD., of Ilford, have contributed £105 to the Quetta Earthquake Relief Fund which is being raised by the Lord Mayor of London.

THE NOMINAL CAPITAL OF Fullers Earth Union, Ltd., Tower House, 40 Trinity Square, London, E.C.3, has been increased by the addition of £50,000 in £1 ordinary shares beyond the registered capital of £150,000.

A SURPLUS OF £51,100 was EFFECTED in the chemical section of Glasgow Corporation Gas Department during the year 1934-35. Bailie John Young told members of the committee that the year's trading represented the best return for the past three years.

IN ORDER TO BALANCE THE SWISS BUDGET, the Swiss Federal Council have decided to increase the duty on several imported commodities. The duty on sugar will be raised 15 centimes per kg., that on petrol and zenbol by 8f. per 100 kg., and the duty on heavy oil used as fuel for motor vehicles will be increased to 16f. per 100 kilograms. The new duties come into force at once.

THE "LIGNITE PETROL CO.," which was established on October 26, 1934, by German lignite producers, under the auspices of the Minister of Economics, to produce petrol and lubricants from lignite, announces that the fiscal period ended December 31 last closed without loss or profit. The establishment of the first hydrogenation plant, near Boehlen, Saxony, is progressing satisfactorily, and preparations for a second plant near Magdeburg are nearly complete.

THE GOVERNMENT OF INDIA has rejected the Tariff Board's recommendation to give protection to the Indian glass industry on the ground that no adequate source of Indian soda ash has been developed. The Government has, however, decided to give the industry a measure of relief during the next three years, pending further inquiry into the merits of the case for protection. The present revenue duty on soda ash of Empire origin is to be refunded to Indian glass manufacturers who import it for their manufacture, or, alternatively, an excess over 10 per cent. of the duty on foreign soda ash. The principle of Imperial Preference is thereby maintained. The present revenue duty on soda ash is 20 per cent in the case of British origin and 30 per cent. for foreign origin. Soda ash represents 70 to 75 per cent. of the cost of the materials required by the glass industry.

LORD LEVERHULMF, who has been on a three months' tour of the overseas associated companies of Lever Brothers, Ltd., arrived at Liverpool on June 18, from Canada. Leaving England on February 28 with Mr. Edward Quin, the technical adviser, he visited the company's new plant in Bombay, which represents the latest word in the equipment of a plant for the special needs of a climate like that of India. The Calcutta factory has also been enlarged and modernised. At Bangkok, Siam, he inspected the recently-acquired and reconstructed business of Siam Industries, Ltd., and in Batavia, Dutch East Indies, he saw the recently-opened factory embodying a new method of tropical works construction. In China, where Lever Brothers are represented by the China Soap Company, trade is passing through a critical period, owing to the silver policy of the United States. During a two-days' visit to New York, Lord Leverhulme met the president of their American company, and saw, for the first time, the new plant for the manufacture of edible fats erected by Lever Bros. at Edgewater, New Jersey. Business prospects both in America and Canada were most satisfactory.

New Chemical Trade Marks

Compiled from official sources by Gee and Co., patent and trade mark agents, Staple House, 51 and 52 Chancery Lane, London, W.C.2.

Opposition to the registration of the following trade marks can be lodged up to July 5, 1935.

Neutro. 549,987. Class 1. Chemical substances for use as emulsifiers in manufactures. Amoa Chemical Co., Ltd., 9 Marvels Parade, Marvels Lane, Grove Park, Lee, London, S.E.12. April 3, 1934.

Durazol. 558,119. Class 1. Mineral dyes. British Dyestuffs Corporation, Ltd., Imperial Chemical House, Millbank, London, S.W.1. February 19, 1935. To be associated with Nos. 381991 (2099), 558120 (2984) iv and others.

Durazol. 558,120. Class 4. Dyes (not mineral and not for toilet purposes). British Dyestuffs Corporation, Ltd., Imperial Chemical House, Millbank, London, S.W.1., February 19, 1935.

Supersorbion. 558,689. Class 1. Chemical substances used in manufactures, photography or philosophical research, and anti-corrosives, but not including mineral dyes and not including any goods of a like kind to mineral dyes. British Carbo-Union, Ltd., 52 Grosvenor Gardens, London, S.W.1. March 11, 1935.

Kalsol. 558,725. Class 1. Water softening preparations. Pan Britannica Industries, Ltd., 14 Waterloo Place, London, S.W.1. March 12, 1935.

Commercial Intelligence

The following are taken from printed reports, but we cannot be responsible for any errors that may occur.

Mortgages and Charges

(NOTE.—The Companies Consolidation Act of 1908 provides that every Mortgage or Charge, as described therein, shall be registered within 21 days after its creation, otherwise it shall be void against the liquidator and any creditor. The Act also provides that every company shall, in making its Annual Summary, specify the total amount of debt due from the company in respect of all Mortgages or Charges. The following Mortgages and Charges have been so registered. In each case the total debt, as specified in the last available Annual Summary, is also given—marked with an *—followed by the date of the Summary, but such total may have been reduced.)

CUSSONS, SONS AND CO., LTD., Manchester, chemists, etc. (M., 29/6/35.) Reg. June 15, deb., to Mosley Street Nominees, Ltd., 35 Mosley Street, Manchester, securing all moneys due or to become due from the company to Williams Deacon's Bank, Ltd.; general charge. *Nil. Dec. 31, 1934.

ILLINGWORTH CARBONIZATION CO., LTD., Manchester. (M., 29/6/35.) Reg. June 15, £2,700 debts., part of £50,000 (not ex.) already reg. *£33,500. Dec. 28, 1934.

KNAPMAN BROTHERS, LTD., Bristol, varnish manufacturers, etc. (M., 29/6/35.) Reg. June 13, deb., to Lloyds Bank, Ltd., securing all moneys due or to become due to the bank; gen. charge.

NORSIL, LTD., London, S.E., chemical engineers, etc. (M., 29/6/35.) Reg. June 15, £450 debts. and 30 per cent. premium; general charge. *Nil. Jan. 14, 1935.

Satisfactions

ANCHOR CHEMICAL CO., LTD., Manchester. (M.S., 29/6/35.) Satisfaction reg. June 13, £1,000, reg. May 2, 1907.

CHANCE AND HUNT, LTD., London, S.W., alkali and chemical manufacturers. (M.S., 29/6/35.) Satisfaction reg. June 19, £175,000 outstanding July 1, 1908.

County Court Judgments

(NOTE.—The publication of extracts from the "Registry of County Court Judgments" does not imply inability to pay on the part of the persons named. Many of the judgments may have been settled between the parties or paid. Registered judgments are not necessarily for debts. They may be for damages or otherwise, and the result of bona-fide contested actions. But the Registry makes no distinction of the cases. Judgments are not returned to the Registry if satisfied in the Court books within twenty-one days. When a debtor has made arrangements with his creditors we do not report subsequent County Court Judgments against him.)

ANGLO-EUROPEAN MANUFACTURING CO. (1933), LTD., chemists, 4 Denmark Terrace, Holmdale Road, N.15. (C.C., 29/6/35.) £13 13s. 4d. May 17.

Company News

Edgar Allen and Co.—A revenue balance of £58,831 is reported for the year to March 31. This compares with £10,703 for 1933-34, and with respective debits of £16,309, £8,015 and £29,911 in the three previous periods. Tax and depreciation absorb £20,548, and a net balance of £26,658 is carried forward, after paying the preference dividend for the year at the reduced rate of 5 per cent., less tax.

Phosferine (Ashton & Parsons).—The report for the year to April 30, shows a trading profit, including dividends and interests, of £44,330 (against £41,959). After providing for depreciation, loss on exchange, fees, etc., there is a net available balance of £41,680. An excess dividend of $\frac{1}{2}$ per cent. (same) is declared on 8 per cent. participating ordinary shares, and payment of 4 per cent. (same) on deferred shares. The carry-forward is £8,262 (£9,582).

A. Boake Roberts & Co.—The report for year to March 31 shows profit, after depreciation and debenture interest, £63,876 (against £89,176), with £76,851 brought in this makes £140,726. Fees, tax, preference dividends, etc., take £44,383; final ordinary dividend 2 per cent., tax free, making 8 per cent. (against 10 per cent.); to pensions reserve, £10,000; to general reserve, £10,000; forward, £70,343. Meeting, Carpenters Road, Stratford, E.15, July 3, at 12 noon.

Palestine Potash.—The report for 1934 shows a gross profit, including transfer fees, of £23,176. London and Palestine expenses totalled £22,282, fees £2,417, interest and charges £4,518, and repairs £6,343, resulting in a net loss of £12,384. After adding a debit of £3,129 brought in, there is a total adverse balance of £15,513. As the company is still in development stage of production no provision has been made this year for amortisation or depreciation. Potash produced by the company secured a ready sale, but prices suffered from acute competition prevailing.

British Bitumen Emulsions.—The trading profit for the year, before depreciation is £3,817, against £1,423, plus increase from and profit on sale of investments £1,289 (£1,407). After provision for directors' fees and depreciation £3,664 (£8,011), there is a net profit of £1,440 (against a loss of £5,181). Directors report that long outstanding claim against Bitumen Corporation has proved irrecoverable. It was therefore necessary to write off net amount of debt £3,097. As a result the debit £1,525 brought in is increased to £3,181. Meeting, Winchester House, E.C., June 25, at 10 a.m.

British Plaster Board.—The directors recommend a final dividend of 25 per cent., making 40 per cent., less tax, for the year ended April 30, 1935. The dividend will be payable on July 23. For 1933-34, 30 per cent. was paid in two distributions of 15 per cent., the first on a capital of £100,000, and the second payment on a capital of £208,000. In February last, the authorised capital was again increased to £500,000 for the purpose of acquiring a controlling interest in the Gotham Company. The shares allotted in this respect are entitled to a third of the distribution for 1934-35.

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Metallurgical Section

January 5, 1935

Silver as an Engineering Material

AMERICAN silver producers have recently established a research associateship at the United States Bureau of Standards with the object of surveying the existing and potential uses of silver as an engineering material. The results of this survey will be of special interest to the chemical industry, for the true value of silver-lined equipment is not so fully realised as it might be. Strong alkalis, for instance, exert a vigorous action upon base metals and refractories, but can be handled readily in pure silver. Sodium and potassium hydroxides can be melted and cast in silver vessels without any appreciable contamination. Silver equipment has been used where dilute hydrochloric acid is one of the products, but it cannot be considered suitable for general use in the manufacture of hydrochloric acid. On the other hand, chlorine, which also attacks silver, can be handled in silver equipment in both wet and dry conditions because an adherent and insoluble coating of silver chloride is formed and thereafter protects the metal against further attack. Nearly all organic acids can be handled successfully in silver equipment; even the hot vapours of acetic acid do not attack the metal, and for this reason silver-lined condensers are ideal for acetic acid distillation plant. Glycerine intended for pharmaceutical use is often shipped in steel barrels which are lined with silver in order to maintain a high degree of purity.

Distillation of Metals in High Vacuum

APPARATUS for the distillation of metals in high vacuum, using the electric furnace, is described by W. Kroll in "Metallw. Metallwiss.," October 19, 1934. It is claimed to be possible to distil aluminium, beryllium, chromium and silicon in quantities of the order of half-a-kilogram. In the case of aluminium the separation of impurities by distillation is very complete; manganese distils over almost completely in the first fraction, and silicon, iron, copper and titanium are concentrated in the residue. There are, however, a few difficulties to be overcome, the chief trouble being due to release of gas (in considerable volume) and consequent splashing. Oxide skins may also form if atmospheric oxygen gains admission to the apparatus, and these oxide skins are so dense that there is little possibility of re-melting them without the aid of a flux. In the case of beryllium, difficulties are reduced because of the relatively low distillation temperature, and because smaller quantities of gas are liberated. It is pointed out by the author that the separation of metals by distillation is not only dependent on the absolute vapour pressure of the individual components but also on the mutual chemico-physical behaviour. Mutual vapour pressure reduction can be brought about by solution phenomena and by the formation of compounds, and

even volatile constituents may be left behind in the residue. The mutual activity of impurities is small so long as the quantities involved are small, but it increases as soon as the residue becomes enriched in the course of the distillation.

Metallic Lithium.

METALLIC lithium is now produced very efficiently by the electrolysis of fused lithium chloride, the product being 99.5 per cent. pure. Lithium alloys are also capable of being deposited, lithium-calcium alloys being commercial materials. These lithium-calcium alloys find industrial application in giving graphite refinement and increased strength for cast iron, whilst lithium itself improves the machinability of stainless steel, and is usefully employed as a de-oxidiser for producing oxygen-free copper and as a hardener for lead alloys and aluminium-zinc alloys. According to H. Osborg, in a paper read at the Autumn meeting of the American Electrochemical Society, lithium hydride (LiH)—formed by direct combination of lithium and hydrogen at elevated temperatures—is a product for which there is commercial possibilities. It reacts with water, evolving hydrogen, and as the gross weight of the hydride is much less than that of a steel cylinder housing an equal volume of gas this particular product should become of importance as a portable source of hydrogen.

Sponge Iron in Russia

THE problem of producing sponge iron by direct reduction of iron ore without fusion—that is, without using coke—is claimed to have been solved in the Soviet Union. The first experimental plant in which iron will be obtained without the blast furnace process, started working at Ivanovo at the beginning of June. The method of direct reduction of iron ore without fusion is comparatively new. Beginning from 1927, various installations were tested in different countries. All these turned out a product which was less expensive than pig iron, but more expensive than commercial scrap iron, and therefore had no great industrial importance. The method is of extreme importance to the Soviet Union, where there are large deposits of iron ore and not sufficient quantities of coking coals necessary for the blast furnace process. The question of applying the new process was first raised in 1931, and in 1932 steps were taken to put it into practice. A revolving furnace, designed by Trautman and Grum-Grimailo, a Soviet engineering concern, has been installed at the Ivanovo works. Whilst blast furnaces required at least 0.8 ton of coke per ton of pig iron, only 0.5 to 0.6 ton of carbon fuel in the form of anthracite smalls, peat or fuel waste is needed per ton of sponge iron melted in the electric furnaces of the new

plant. Sponge iron is obtained at moderate temperatures from 800 to 1,050° C., requiring, however, a great amount of electricity. The production of sponge iron from the Khalilovo ores, which contain nickel chrome, titanium and vanadium will be of particular interest. As proved by laboratory experiment, a most valuable metal can be obtained, which can be extensively applied in the automobile and tractor industries, in aviation and in other branches of engineering.

Rhenium-Plated Acid Drums

RHENIUM, which was discovered in 1925 by the German chemist, Naddack, is very resistant to hydrochloric acid. That fact has been known almost since the time when the metal was first isolated, but it was only at a recent meeting of the American Electrochemical Society that the possibility of utilising this valuable property was first announced. Professor C. G. Fink and Mr. P. Deren, of Columbia University, so we are told, have now discovered a method by which rhenium may be deposited upon copper, brass and other metals by an electrolytic method, and it seems probable that rhenium-plated drums and tanks may be used for the transport of hydrochloric acid. Unlike nitric and sulphuric acids, which can be transported in suitable metal containers, hydrochloric acid has hitherto demanded the use of glass bottles protected by heavy wooden crates, or rubber-lined metal drums and tanks. Pure rhenium, for plating purposes, is at present procurable at a nominal price, the source of supply being the slime wastes from copper refineries in which the metal is present to the extent of one part per million.

Electrolytic Recovery of Zinc

INVESTIGATIONS carried out at Trail by metallurgists of the Consolidated Mining and Smelting Co., of Canada, have recently demonstrated the deleterious effects of antimony, tin and germanium in the zinc fume and have shown that these metals can be removed by zinc dust and copper sulphate at 70°–80° C. Fluorine derived from the electrolyte of the Betts lead refinery process has caused very high corrosion of the aluminium cathodes, but the presence of aluminium in solution inhibits corrosion. Chlorine, in forms other than chlorides, is destructive to the lead anode. Cobalt, hitherto regarded as highly objectionable, may be beneficial when present in suitable amounts, giving a zinc of low lead content with no loss of current efficiency. The use of rubber lined electrolytic cells is also proving very satisfactory, and concentrate-burning in place of hearth-roasting has been found to be of great value. These are only a few of the outstanding developments which have taken place in the electrolytic refining of zinc during the past two years.

Heat-Treated Aluminium Alloys

A RECENT thesis by P. A. Portevin on the heat treatment of metallurgical products ("Aciers Spéciaux," 1934) gives useful indications as a guide to the choice of heat treatable aluminium alloys. Such alloys are not only of industrial importance; they are also of scientific interest in that they have afforded the first example of structural hardening phenomena due to variation of solubility for one constituent. Considered generally, the alloys in question may contain additions of magnesium, copper and silicon. The addition of silicon, and more particularly of copper, favours

corrosion. Quenching subsequent to heating increases the tensile strength and the electrical resistance simultaneously. On the other hand, working increases the tensile strength much more than it does the electrical resistance, but it also diminishes the ductility to a considerable extent, whereas heat treatment conserves ductility. To meet cases where the maximum tensile strength is required, aluminium-copper-magnesium-silicon alloys are heat treated and, if necessary, are also worked. Aluminium-magnesium alloys, with 10 to 15 per cent. magnesium, are also valuable in this connection. Where high tensile strength and also good chemical resistance are required, however, aluminium-magnesium alloys should be selected. Aluminium-magnesium-copper-nickel alloys give the best results for good electrical conductivity in conjunction with corrosion resistance and tensile strength.

Extraction of Cadmium from Flue Dust

THE separation of cadmium from furnace products, flue dust or bag-house dust, has also been recently improved. The process, as now adopted in the United States, consists in treating the cadmium-bearing material with sulphuric acid or spent electrolyte (from a subsequent stage of the process), then heating it at 600°–800° C. to drive off excess acid and volatile arsenic and to render the zinc insoluble, and finally leaching the ground product with water. Cadmium sulphate thereby passes into solution, and the residue from the leaching process contains lead sulphate and the insoluble zinc. The crude solution of cadmium sulphate is treated with cadmium sulphide in order to precipitate lead, copper, bismuth, mercury and part of the arsenic, and is adjusted in concentration to a specific gravity of 1.30. Iron is then removed by heating the solution, previously oxidised with sodium chlorate and neutralised with lime, the remaining part of the arsenic being removed with the iron. Thallium, if present, is removed by adding sodium chromate, the excess chromate being removed by the addition of lead sulphate or by reduction to chromic sulphate with sodium sulphide and precipitation with caustic soda. The purified solution of cadmium sulphate, at a concentration of 100 grams of cadmium per litre, is then electrolysed using a ferro-silicon anode and sheet cadmium as cathode.

Institute of Metals

Election of Members

THE following members and student members of the Institute of Metals were elected on December 13:

Members.—William O. Adams, Melbourne, Australia; Alfred C. Beatty, London; William C. Beschorman, New York; Professor R. Breckpot, Blanden, Belgium; Aubrey F. Burstall, London; Gerard E. Claussen, Sheffield; Dr. Charles E. Guillaume, Sèvres, France; William J. van Heteren, Utrecht, Holland; Reginald Jones, Slough, Buckinghamshire; Professor W. Köster, Stuttgart; Dr. Ing. Jaroslav A. Malkovsky, Prague; Jean Matter, Paris; Richard F. Miller, Conn., U.S.A.; Herbert Nicholls, Hounslow; Eric Pulleyn, Hayes; Dr. Ing. Alfred Schimmel, Finow/Mark; Harold Seddon, Bradford; Gosta E. V. Siljeholm, Stockholm; Kenneth M. Spring, Uplands; Harold Tindale, Sydney, N.S.W.; Lewis L. Wannier, Wisconsin, U.S.A.; Dr. Ing. Friedrich Weibke, Hannover.

Student Members.—Osmer J. Blau, Sydney, N.S.W.; George A. Finch, London; William L. Hall, St. Albans; Harry M. Hurst, Sheffield; Edward H. Marks, Melbourne; Geoffrey D. Showell, Birmingham; Gordon J. Thomas.

The British Cast Iron Research Association

Annual Report for 1933-34

ACCORDING to the report of the British Cast Iron Research Association for the year ending June 30, 1934, the most important developments of the year have been the means of achieving a greater degree of graphite refinement in cast iron. These developments are likely to apply to both pig and cast irons, but while the immediate application is to grey irons, the principles involved will apply to the white, chilled, and malleable irons. The marked effect of size and distribution of graphite on the properties of cast iron is generally recognised.

Graphite Refinement

Much of the advance made in the past few years on strength of cast iron has been made by reducing graphite size, and this has been rendered possible mainly by the reduction of the total carbon content. The lowering of the total carbon, however, brings certain founding difficulties in its train. The metal is more liable to be mottled or white on pouring, has greater shrinkage in the foundry, and requires melting at higher temperatures, which may increase the difficulties with respect to refractoriness of moulding sands. The range of temperatures over which the metal is fluid enough to pour into sound castings is shorter. A few years ago the Association's senior metallurgist was able to demonstrate that by suitably controlling conditions of melting it was possible to secure irons both not only with graphite in the ordinary flaky condition but also in an extremely finely divided condition known as "supercooled." Subsequently, the effect of various gases in the metal was studied and it was found possible to change the structure from one type to the other by treatment with suitable gases. The matter was carried further and it has been possible to evolve a process in which, by a suitable addition to the metal and a comparatively simple after-treatment while molten, it is practicable on a laboratory scale to secure graphite in the extremely finely divided supercooled form, regardless of the original total carbon content. Previous attempts to secure this finely divided graphite throughout a heavy section have been only partially successful.

Patent protection for the process has been applied for in the interests of members, and commercial trials are being undertaken in members' foundries as far as the limited staff available permits. It is sufficient, however, to state that it has been possible, on laboratory melts of 100 lb. or 200 lb., to increase mechanical properties of an ordinary No. 3 pig iron by 50 per cent. without alteration of composition, simply by virtue of the treatment. It is also of particular interest to note that the reverse process, that of producing flake graphite from supercooled graphite, has now also been accomplished and it is now practicable to produce refined or coarsened graphite as required.

Alloy Cast Irons

Further work has been done and several reports circulated on the heat-resisting cast irons, Silal and Nicrosilal. About a dozen members of the Association are licensed to produce these alloys and their application in service presents a number of problems of considerable variety and interest. The original work carried out in the laboratories of the Association has now been confirmed in papers presented to scientific societies in or published in the technical press of Germany, France, and Belgium, the latest paper being that by Professor Thyssen, of Liège, on the occasion of the recent visit of the Iron and Steel Institute to Luxembourg. A beginning has been made on the study of the effect of molybdenum, an effect which is generally acknowledged to be of a remarkable character for the size of the addition made.

Further experiments have been made during the year in conjunction with members on the production of high quality alloy cast irons made by the inoculation process and members have been satisfied that the production of such iron is commercially quite practicable. One such iron containing about 1 per cent. nickel, was reported at the spring meeting of the Iron and Steel Institute as having a tensile strength of nearly 29 tons per sq. in. This iron is a low carbon iron containing 1 per cent. nickel.

During the year a report on Recommended Methods for the Testing and Control of Foundry Moulding Sands has been issued and widely circulated, and it is now possible for any foundry to embark on the testing of moulding sand with access to all the necessary information on apparatus and technique. Full details of apparatus required and methods of procedure are given in the report and a large part of this apparatus has been designed and evolved by the Association.

Melting Practice

The balanced blast cupola makes very satisfactory progress. In the last report the number of cupolas installed or under construction was forty-one, having a total hourly tonnage of 275 tons. At present the number of cupolas installed or under construction is sixty-one, having a total hourly tonnage of 386 tons. Very satisfactory reports continue to come from users. One of these furnaces has been erected within a few minutes of the Association's headquarters at the foundry of Preston and Bishop, Ltd., Clement Street, Birmingham. The cupola has an internal diameter of 24 in. and a rated output of 2.35 tons per hour. It forms an important addition to the Association's experimental resources, not only for making experimental melts, but also for tests on fuels and refractories.

At the close of the year the total number of ordinary and trade members was 308 and of associate members 61. Affiliated associations of manufacturers have a membership of 39, the total subscribing membership thus being 408.

Mineral Production in Canada

Increased Activity Reported for 1934

A MARKED expansion of activity in the mining industry of Canada has been witnessed during 1934. The Dominion's mineral resources include gold, silver, nickel, lead, zinc, copper and coal, and the mining industry is destined to play an increasingly important part in the development of the country. Production of nickel, lead, zinc and copper during 1934 has been on a scale never before equalled, while, so far as value is concerned, the output of gold also has created a new high record.

According to statistics compiled by the Dominion Bureau of Statistics, the total estimated value of mineral production for the year is \$278,337,000, an increase of 27 per cent. on the previous year's value of \$221,495,000. Metals alone accounted for \$192,668,000, which is the highest total ever recorded. It compares with \$147,015,500 for the previous year, and is about 25 per cent. better than the old record, which was established in 1929. Gold is still the most important contributor, although output has fallen a little short of the total for 1933. The total is 2,964,500 ounces, valued at \$61,279,000 at the standard rate of exchange. After making allowance for the profit on exchange, however, the value in current Canadian funds is increased to \$102,242,000.

During 1934 the average value of gold, in Canadian funds, was \$34.49 an ounce, against \$28.60 in 1933. The increase in price this year led the mills to use ore with a lower gold content, resulting in a reduction of 1 per cent. in the production for the first half of the year. Towards the end of the year new mills came into operation and compensated for the reduction in the output of the older properties.

Aluminium Prospects in India

THERE are now about fifteen aluminium factories in India and of their production, Calcutta absorbs 30 per cent., Bombay 35 per cent., Madras and Rangoon 15 per cent. The total number of workers in the industry is 8,000 and the total production was nearly 175,000 maunds, worth about Rs. 150 lakhs. Owing to depression at the present moment, the factories were working at half their capacity, but things are anticipated to improve at an early date.

The Production of Refined Antimonial Lead

Present-Day Methods in Australia

THE production of refined antimonial lead at the works of the Electrolytic Refining and Smelting Co. of Australia, Ltd., Port Kembla, New South Wales, is described by Mr. G. J. Brittingham, in "Chemical Engineering and Mining Review," August, 1934. For the greater portion of the 26 years of this plant's activities it has been the largest electrolytic copper refinery in the British Empire, and has, during this period, produced high-grade electrolytic copper under the trade name of E.S.A. The control of this company was acquired by the Broken Hill Associated Smelters Pty., Ltd., in 1928, and at a later date the activities were extended to the treatment of certain by-products resulting from the lead smelting and refining operations carried on at Port Pirie, South Australia, by the latter company. One of these by-products—antimonial slag—is now being regularly treated at Port Kembla for the production of antimonial lead.

Antimonial slag is a by-product obtained during the smelting and refining of lead concentrate, which, in the first instance, is produced from the Broken Hill mines. The crude ore is subjected to a flotation treatment, whereby the valuable metals—lead, silver and zinc—are concentrated into two products—a lead-silver concentrate and a zinc concentrate. The latter, after roasting, is shipped to the Electrolytic Zinc Co.'s plant at Risdon, Tasmania, for the production of electrolytic zinc, while the former is railed to the Broken Hill Associated Smelters, at Port Pirie, for the recovery of lead and silver contents in metallic form.

The Smelting Operation

Both lead and silver are subjected to very thorough refining processes, and it is during the refining of the lead that the antimony, together with a quantity of lead and other impurities, is removed in the form of a liquid slag, which, on solidification, is broken into lumps suitable for easy handling. This antimonial slag is despatched to Port Kembla for the production of rough cast antimonial lead, which is subsequently refined, either to be sold as antimonial lead or used in the manufacture of subsidiary products. The antimonial slag, together with fluxes and coke, is fed to a blast furnace, where the majority of the arsenic is removed preparatory to forming a rough cast bullion which is subsequently refined and cast into ingots for market.

Since the quantity of antimonial slag available is limited, it is customary to carry on the blast furnace smelting in campaigns of five or six hundred tons, some ten to fourteen days being occupied with this work. The furnace used is of very low shaft, being only 8 ft. 6 in. from tuyere level to the charging floor, thus allowing the use of a low blast pressure, six ounces being quite sufficient to keep the furnace operating efficiently. The furnace shaft is composed of 4-in. mild steel water jackets bolted together, and has eight tuyeres let into the side jackets by means of 4-in. boiler tube welded into position. The water jackets are supported on the brickwork of the crucible, the capacity of which is 10.5 tons of lead.

The automatic syphon for the discharge of the molten antimonial lead is situated centrally on one side of the furnace, the outlet rising from the bottom of the crucible through the brickwork, and discharging through a small cast iron launder into the moulds. The slag taphole is on the opposite side of the furnace and consists of a cast iron water jacket built into the crucible brickwork.

Removal of Arsenic

On arrival at Port Kembla, the antimonial slag, in common with the other components of the furnace burden, is tipped on to concrete floors. From here the slag is loaded into side-tipping, narrow gauge trucks, together with the required amount of limestone and ironstone for fluxing, and the coke necessary for smelting. The charges, weighing some 2,500 lb., are tipped into the top of the blast furnace, the level of the burden being maintained at 18 in. to 24 in. below the charging floor. Scrap cast iron is then added directly to the furnace in varying quantities determined by the arsenic tenor of the slag. The purpose of this component of the charge is to remove the arsenic as a speiss. This is necessary because the arsenic in lead for battery makers must be at a very low

figure. Great care is also taken that the scrap iron itself is not contaminated with copper, as is frequently the case, for almost the entire copper content of the blast furnace charge is reduced into the lead.

The antimonial lead bullion produced during this smelting process is tapped from the lead well through the syphon and a short launder, finally running into moulds holding approximately 600 lb. each. The moulds are on trucks which can be moved along under the launder as required by means of a winch. The sampling of this bullion is done by taking a small ladle full of metal from the running stream and chill-casting this immediately in an iron mould 4 in. in diam. and $\frac{1}{2}$ in. deep; this type of mould gives very satisfactory results as it overcomes segregation. The output of the furnace is weighed and assayed shift by shift, each lot being marked separately and then stacked under the lead refinery crane ready for refining.

The Refining Kettle

The refining kettle for the rough cast antimonial lead is a hemispherical cast iron vessel mounted in a brick setting and heated by means of gas from a gas producer. Gas heating has been incorporated in the design of this kettle to permit of quick heating and cooling of the metal. The kettle is equipped with a portable, electrically-driven shrouded stirrer mounted on two I-beams, and the overhead crane, which traverses both stockyard and kettle, can be utilised for lifting the stirring mechanism both into and out of the kettle, as desired. The whole unit is self-contained and various speeds of agitation, as well as reverse, can be procured by means of the gear box and reversing switches, which have been embodied in the unit.

The charge having been calculated to produce the grade of refined metal required, the rough cast antimonial lead is loaded into the kettle by an overhead crane; the gas producer is started and the melting of the metal is commenced. After some hours the bullion is melted and the agitator is then lifted into the kettle and started. This is done before any dross is skimmed, so that all the dross in the rough cast bullion may be washed clean of the metal by being swirled about in it. Finally, a "dry" or entirely non-metallic dross comes to the surface and can be removed readily by means of perforated long-handled shovels, which have been found by experience to make the most convenient skimming tools. Skimming is done while the agitator is running in the opposite direction to that previously employed, so that the dross is forced out towards the sides of the kettle.

Removal of Copper

The subsequent treatment of the bullion depends on its antimony and copper contents, the arsenic having been reduced below the limit at the blast furnace stage. If the copper tenor is too high the metal must be treated with sulphur, which element preferentially removes the copper as the sulphide. This is accomplished in the following manner: The agitator is again started, the direction of rotation being such that the metal is being continuously sucked down the cylindrical central portion, so that a vortex is formed into which crushed lump sulphur can be easily fed by means of a shovel.

The speed of the mixer must be such that this sulphur is immediately drawn into the metal before it can burst into flame and burn away. Some 50 lb. of sulphur is added in this way over a period of 15 or 20 minutes, by which time a heavy metallic dross can be seen moving about the kettle tending to rise to the surface, but all the time being sucked back by the vortex into the metal again. The agitator is then allowed to run for a further 15 or 20 minutes when fine sawdust—pine or oregon being the most suitable wood—is slowly added until the heavy dross previously seen tends, as it rises to the surface, to burst after the nature of a bubble, revealing a black "dry" or powdery dross. Soon the whole surface of the kettle becomes covered with this dry dross and the agitator is stopped, preparatory to being reversed.

When it is running in the opposite direction the dross, now quite powdery and consequently floating very readily, is

forced out towards the sides of the kettle, where it is skimmed into the side tipping trucks placed ready to receive it. The skimming is aided considerably by floating on the surface of the metal a piece of hardwood and jamming this between the agitator frame and the side of the kettle, thus assisting to keep the dross in a mass on the side of the kettle where the skimming is being carried out.

One point of very great importance is the controlling of the temperature of the metal bath during this period. This is done by means of a Cambridge immersion type of thermocouple pyrometer, which is left in the metal during the complete cycle of operations. This instrument is carefully calibrated, as its readings must be reliable for the process to be operated efficiently, for if the temperature is allowed to exceed 340° C. it is not found possible to remove the copper by sulphur treatment. If, however, the temperature falls below about 320° C., surface tension, viscosity and other factors will not permit the formation of a dry dross, with the result that a much greater amount of metallic dross, which is very difficult to skim, is formed. As the dross skimmed is returned to the blast furnace for re-melting it is obviously not an economic proposition to remove it in this form.

Adjustment of Antimony Content

The dross, having now been completely removed, the metal is again sampled and assayed for copper and antimony. If the copper tenor is not yet sufficiently low the sulphur treatment is again repeated using 40 or 50 lb. of sulphur. Once it is seen that the copper has been removed, the antimony content is adjusted by adding sufficient Broken Hill Associated Smelters' soft lead to reduce it to the amount required, and a further sample is taken and assayed for antimony, copper,

arsenic and silver. As the majority of the output goes to battery makers, most of the metal is cast as the standard 10 per cent. antimonial lead. Numerous other grades are also manufactured for various purposes, among these being 5 per cent., 6 per cent. and 13 per cent. For use in the alloy department a further grade is made carrying some 14.5 or 15 per cent. of antimony.

Casting the Metal

The casting of the metal, the composition of which has already been checked, is carried out as soon as the metal is sufficiently hot, 380° C. being a good casting temperature for 10 per cent. metal. By this time a syphon has been heated, by floating in the metal itself, and the "banjo"—a horizontal 1½-in. pipe attached to a short vertical cylinder, some 6 in. diameter, open at the top, and seated in a swivel chair—is heated separately in a fire. When both are ready the syphon is filled and the valves at both ends shut; this is then lifted by means of the overhead crane and placed so that it hangs over the side of the kettle, the inclined leg terminating at the bottom of the kettle, while the vertical leg just enters the cylindrical portion of the "banjo," which is placed centrally in front of, and below, the kettle.

The moulds, set on rails bent into a semi-circle of about 10 ft. diameter, are each filled in turn from the "banjo," which is gradually moved from one mould to another. When the metal has solidified the moulds are tipped and the pigs stacked in piles, containing approximately one ton, and subsequently lifted on to narrow-gauge trucks, ready to be hauled away to be weighed, before being stacked in the stock pile. Each pig is given a paint mark so that the various lots of metal can be distinguished.

Some Recent Metallurgical Patents

Tungsten Carbide Alloys

ALLOYS containing carbides, borides, silicides, or tellurides of tungsten, tantalum, or molybdenum, particularly tungsten carbide and one or more of the metals iron, nickel, and cobalt, are made by mixing the powdered components, heating the compacted mixture to incipient fusion or reaction temperature, removing the highly heated mass from the furnace, and pressing or centrifugally casting it during the ensuing rapid cooling. (See Specification No. 416,468, of J. H. L. de Bats.)

Chromium Alloys

ALLOYS of chromium with one or more of the elements phosphorus, aluminium, manganese, titanium, tungsten, vanadium, molybdenum, cobalt, or nickel, and which may also contain iron, are obtained by reducing chromium-bearing substances such as chromium ores or chromium oxide, say, in an electric furnace, in admixture with carbon or coal and one or more reducible compounds such as phosphates, clay, bauxite, manganese ores, rutile, tungsten, vanadium, or molybdenum ores, or cobalt or nickel ores. Silica or lime-bearing substances may be added during the production of the alloys. (See Specification No. 416,624, of H. D. Elkington.)

Heat Treating White Cast Iron

In a method of heat treating white cast iron, a retarding agent such as manganese is added to a white iron melt of normal composition, and the cast iron produced is heated to a temperature above the critical temperature for a sufficient length of time to decompose the cementite into iron and temper carbon, is then cooled to a temperature below the critical temperature and then reheated to a temperature below the critical temperature so as to permit the retarding agent to effect a retarded reaction of decomposition or readjustment of the pearlitic cementite to produce a spheroidised structure in the iron. As applied to a white cast iron containing 1.20 to 0.7 per cent. of silicon, and 0.6 to 1.5 of manganese, and the difference between the manganese content and twice the sulphur content is between 0.4 and 1.25, the iron is heated to 1,700° F. for 18 to 36 hours, cooled and heated again to 1,150° to 1,375° F. The heatings may be carried out in a non-oxidising atmosphere. (See Specification No. 415,080, of the Allied Process Corporation.)

Magnesium Alloys

In the making and refining of high-percentage magnesium alloys as described in the parent specification the alloying metals, such as zinc or aluminium, are introduced into a molten bath of magnesium metal which already contains in solution the whole of the manganese required for refining. The manganese may be introduced into the magnesium by adding manganese salts to the electrolyte employed for the production of magnesium. (See Specification No. 411,324, of I. G. Farbenindustrie A.-G.)

Ferro-Vanadium

SLAGS containing iron and vanadium obtained in the aluminothermic production of ferrovanadium are reduced in an electric furnace with coal, coke, etc., without addition of slag-forming materials, an impure ferrovanadium and a marketable corundum being obtained. The ferrovanadium is oxidised by heating to incandescence, and a refined ferrovanadium is obtained from the product by an aluminothermic or other known method. (See Specification No. 417,081, of Otavi Minen- und Eisenbahn Ges.)

Hardening Steels

A BATH for the hardening of steels, especially tool steels, comprises one or more alkaline or alkaline earth halides which are stable at 1,000° C., an amount not exceeding 10 per cent. of one or more metal oxides such as magnesium or aluminium oxide or compounds adapted to form such oxides at the working temperatures of the bath, e.g., 730° to 1,400° C. and one or more boron or like compounds adapted to facilitate the solution of the metal oxides and their action at the surface of the steels, such as borax in crystalline form, pyrophosphates, fluorine compounds and tungstates. Examples of compounds which are reduced to oxides are magnesium carbonate and pure or natural cerium chloride. The temperatures used for the hardening are between 730° C. and 1,400° C. and the steels after being heated in the bath are quenched and then, if desired, annealed. In an example, the bath for tool steel comprises 71 parts of barium chloride, 20 of sodium chloride, 8 of borax and 1 of magnesium oxide. (See Specification No. 415,846, of Weber and Co., Zweigniederlassung der L. Soest and Co. Zu Dusseldorf-Reisholz.)

Reducing Non-Ferrous Ores

NON-FERROUS metals are obtained in the form of conglomerated coarse particles from ores of a sulphidic or arsenidic nature which contain iron or are mixed with iron or iron compounds by heating the ores in a non-oxidising atmosphere at a temperature substantially below their melting points. The process may be carried out in a stream of an inert gas such as nitrogen, or a reducing gas or a mixture of such gases. Suitable reducing gases are hydrogen, carbon monoxide, illuminating gas, water gas, etc., with or without steam. (See Specification No. 416,728, of C. Goetz.)

Modified Alloys

ALLOYS of aluminium, silicon, and antimony are "modified" by adding sodium carbonate or bicarbonate, preferably in the anhydrous form, to the molten alloy and stirring it into the molten alloy at a temperature within 50° C. on either side of 1,000° C. The alloy preferably contains 5 to 15 per cent. silicon and not more than 3 per cent. antimony, the treatment of an alloy of aluminium with 7 to 8 per cent. silicon and 0.5 to 1 per cent. antimony being described. The treated alloys may be used for cast bearings, e.g., as bushes or liners for journal bearings. According to the provisional specification the modification may be effected by treatment with the alkali metals or their salts. (See Specification No. 414,783, of W. Jolley and Associated Electrical Industries, Ltd.)

Refining Metals

METALS such as iron, steel, nickel, copper, lead, and tin are refined by treating the molten metal with an alloy of aluminium with one or more of the metals calcium, barium, and strontium, for example, one containing 20 per cent. of calcium, and removing the layer of impurities which is formed. The aluminium alloy may contain also as further constituents a metal capable of combining with some of the impurities, or some of the same metal as that to be refined. Copper may be treated with a calcium-cadmium alloy in addition to the aluminium alloy, and lead may be treated with a calcium-aluminium-lead alloy. The aluminium alloy may be left in contact with the metal to be refined for only sufficient time to take up the impurities to be removed. (See Specification No. 416,789, of G. N. Kirsebom and Calloy, Ltd.)

Refining Copper

To lower the bismuth content of copper matte molten metallic copper is agitated with the molten copper matte and then allowed to settle out; the molten copper collects the bismuth from the matte. In a method of carrying out the process a molten matte is charged into a converter and blown until a portion of the contents is converted into metallic copper, thorough agitation taking place during the operation. Blowing is then discontinued and the molten copper allowed to settle, carrying the bismuth with it. The purified matte is poured into a second converter and blown to metallic copper. In modified methods molten metallic copper or a proportion of copper oxide may be added to the matte; cuprous sulphide reacts with the oxide producing metallic copper. (See Specification No. 413,394 of Roan Antelope Copper Mines, Ltd.)

Beryllium Alloys

BERYLLIUM alloys are produced by causing beryllium oxide to react with carbon, either *in vacuo* or in an atmosphere consisting mainly of hydrogen, in contact with a molten bath of the metal or metals to be alloyed with beryllium. When metals are used in which carbon is soluble, the carbon may previously be dissolved in the bath; an excess of carbon remaining may be eliminated by treating the product with a further amount of beryllium oxide or with another oxide such as magnesia. The carbon may be dissolved in the bath in the form of beryllium carbide or calcium or other carbide. Alloys with one or more of the following metals, iron, nickel, cobalt, manganese, chromium, molybdenum, tungsten, uranium, copper, are mentioned. The hearth or furnace lining may itself be made of beryllium oxide and the metal with carbon or in the form of carbide introduced therein or in the case of copper, in which carbon is not soluble, the copper is melted in a carbon crucible and beryllium oxide with or without calcium carbide added. (See Specification No. 415,066, of The Heraeus-Vacuum-Schmelze A.-G.)

Nitrogenising Iron Alloys

THE passive film on rustless chromium or nickel-chromium iron or steel alloys is removed, before nitrogenising, by treating the alloys with an acid which is capable of removing the film without attacking the alloys, such as phosphoric acid or a salt of such acid such as a phosphate. A phosphoric acid solution of zinc phosphate may be used or the salt in powder form may be sprinkled over the alloys. Boric acid may be used instead of phosphoric acid and cadmium, bismuth or cobalt phosphates instead of zinc phosphate. (See Specification No. 410,400, of Nitralloy, Ltd.)

Sintered Alloys

SINTERED hard alloys are produced from a powdered mixture comprising tungsten carbide and up to 30 per cent. of one or more alloys of iron nickel or cobalt with one of the metals titanium, zirconium, hafnium, tantalum, niobium, vanadium or molybdenum, the mixture being sintered at a high temperature, e.g., 1,400° to 1,700° C. for the time necessary for the production of the final alloy. The sintering may be carried out in an indifferent atmosphere. The alloys of iron, etc., are produced by mixing the two components in stoichiometric proportions and sintering the mixture in hydrogen at 1,200° to 1,600° C. (See Specification No. 412,098, of Wolfram and Molybdaen A.-G.)

Tantalum Carbide Alloys

ALLOYS of tantalum carbide, nickel, and either tungsten or molybdenum, particularly for tools, are made by heating a mixture of the finely-divided constituents in an inert atmosphere such as a vacuum at not over 1,400° C., preferably about 1,380° C. The tantalum carbide may be made by heating a mixture of finely-divided tantalum and carbon in hydrogen or in a vacuum to about 2,000° C., and the nickel is preferably added by grinding the other constituents by means of nickel grinders in the presence of a hydrocarbon such as naphtha. After heating the mixture to about 1,100° C., the temperature may be slowly raised to about 1,380° C. The alloy preferably contains 75 to 90 per cent. of tantalum carbide, for example, 80 per cent. of tantalum carbide, 11 per cent. of nickel, and 9 per cent. of tungsten or molybdenum. (See Specification No. 416,353, of the Fansteel Products Co.)

The Independent Fellowship

Widening the Fight for Liberty

WIDESPREAD interest has attended the formation by a group of convinced individualists of the Independent Movement. For years the movement has been gathering strength and has already done much good work to preserve and extend the love of political and economic liberty which is still, notwithstanding many assaults upon it, a marked characteristic of the British race. But hitherto there has been no direct link, or form of status for adherents of individualism in all parties, or none, and while the Fellowship is not a new and complex organisation it provides the common name and meeting ground for all who believe in liberty in its old invigorating sense. In the introductory stages the Fellowship's purpose is to do no more than compile a list of supporters, and to establish a register, as the basis of future activities. Anyone who will sign the "Liberty Pledge"—"I recognise that the State depends upon the man, and not the man upon the State, and undertake to do all in my power to revive affection for the spirit of liberty," will gladly be registered as a member of the Independent Fellowship.

The Fellowship consists of those who (1) undertake to do all in their power to revive affection for the spirit of liberty, (2) recognise that the State depends upon the man and not the man upon the State, and (3) support the efforts of Sir Ernest Benn and "The Independent" to revive interest in this essential principle. Every original life member of the Independent Fellowship will, upon payment of £5, be entered as a life subscriber to "The Independent," which will be sent to him by post every Friday so long as the paper is published. The main purpose of the Fellowship at present is to consolidate the support which the defence of liberty can command throughout the land. Those who desire to enrol should write the simple pledge, printed above, upon a post-card, add their name and address, and send it to Sir Ernest Benn, Bouverie House, Fleet Street, London, E.C.4.

Metallurgical Section

February 2, 1935

Co-operative Research on Electro-Deposition

DURING the past ten years a considerable amount of work on the electro-deposition of nickel and other metals has been carried out at the Research Department, Woolwich, and at the Royal Aircraft Establishment, Farnborough. This work has greatly increased our knowledge of the theory and practice of electro-deposition and has also found direct industrial applications. The cost of the work, however, has been defrayed from Government funds, and the Department concerned is now of the opinion that research of this kind, which may have a direct bearing upon industry, should be maintained by the particular branches of industry which will ultimately benefit by the results. It has therefore been proposed that the British Non-Ferrous Metals Research Association should take over the work and thereby ensure the continuance of Government support to an extent dependent on the amount of funds actually forthcoming from industrial sources.

The most recently published results of work which has been carried out at Woolwich deal with the influence of oxidising agents in the electro-deposition of nickel ("Transactions of the Faraday Society," 1934, 30, 1079), additions of pure hydrogen peroxide and nickel nitrate being in question, whilst effects were observed in respect of cathode efficiency hardness and appearance of the deposit, cathode potential and hydrogen gas discharge. The solutions employed were prepared from purified materials and were buffered with boric acid or ammonium sulphate. The action of the oxidising agents appeared to be primarily one of hydrogen depolarisation. Cathode efficiency was decreased with increasing concentration. Hardness, stress and brightness of the deposits increased and the deposits, in consequence, tended to crack and exfoliate. With increasing quantities of oxidising agent the amount of hydrogen discharged at the cathode was gradually reduced to zero, and no gas was discharged over a range of increasing concentration. With still further additions, the hydrogen discharge was found to recommence in all cases except that of nitrate additions to the solution buffered with ammonium sulphate. These effects appeared to be associated with a reduction in nickel ion concentration at the cathode face consequent upon the precipitation of a considerable quantity of basic matter, and it was observed that a marked rise in cathode potential coincided with the recommencement of gas discharge.

The action of hydrogen peroxide and nitrate additions in preventing pitting in pure solutions appeared to be identical with their effects in inhibiting gas discharge. An alternative mechanism by which hydrogen peroxide can function to prevent "pitting" in solutions containing impurities was found to consist in the oxidation and precipitation of iron compounds which removed the impurities by absorption.

A photomicrographic study of the adhesion of electro-deposited metals has recently been placed on record ("Bulletin de la Société Française Electriciens," 1934, 5th Ser., 4, 1137). This paper deals with the influence of the first layers which are deposited, the effect of foreign films between the base metal and the plating at the commencement of deposition, the structure and mechanical properties of the surface of the base after plating, and the mechanical properties of the plating, its thickness and degree of internal stress. Additional data is presented by the micrographic examination of unbroken junctions between the plating and the base, and of areas of plating and base in the immediate vicinity of the junction surface.

In further prosecution of the comprehensive series of tests in progress under the auspices of the American Electroplaters' Society, the American Society for Testing Materials, and the United States Bureau of Standards, a tentative programme has been drawn up for exposure tests on plated coatings deposited on non-ferrous bases, and for the comparison of non-ferrous with ferrous-base samples. All specimens will be plated under strictly controlled conditions, in order to provide coatings of uniform quality and known thickness. Atmospheric exposure tests will be made at six stations, and accelerated and other laboratory tests will be made on parallel samples. The schedule provides for the study of the influence of composition and condition of base metal, type and thickness of the exterior chromium coating and of the nickel and copper underlays and methods of preparation of the plated samples. Three main sets of tests will be carried out on steels, brasses and zinc-base foundations respectively.

The accelerated testing of nickel and chromium plating on a steel base is reported upon in a recent contribution from the United States Bureau of Standards ("Journal of Research," 1934, 13, 519). This investigation was carried out with the object of making a closer determination of the validity of laboratory tests as a criterion of service behaviour. Salt spray (20 per cent. sodium chloride solution applied at 35° C.) and intermittent immersion in a similar solution were the selected methods of test. The time required to produce incipient slight rusting under these conditions was found to be inconsistent and to bear no direct relation to the protective value of the coatings as evidenced by the weathering exposure tests. The degree of rusting at the end of a definite period of 100 hours showed a relative rating closely approximating to that assigned in the atmospheric tests. Both types of accelerated test may therefore be regarded as useful for determining relative quality, especially porosity, but they do not closely reproduce the corrosive attack present in the atmosphere and do not serve to detect minor variations in quality.

The drafting of specifications, based on the results which were obtained during tests carried out under the auspices of the American Electroplaters' Society and the American Society for Testing Materials, has been discussed at a recent conference in the United States. In the case of nickel and chromium coatings on steel, two grades of plating were considered, and special emphasis was placed on minimum thickness on "significant" surfaces. It was recommended that the salt spray test should be conducted at a controlled temperature, and that failure should be defined in terms of the number and size of the rust spots.

Grain Size Control

THE December issue of the "Transactions of the American Society for Metals" is devoted to twelve papers which were presented at a symposium on grain size, held in New York during the 16th annual convention of the Society, October, 1934. Dealing with the grain size control of open hearth carbon steels, the joint authors, S. Epstein, J. H. Need and T. S. Washburn, point out that, given ordinarily good furnace practice, the positive production of coarse or fine grain carbon steel at will can be attained by a controlled ladle addition of aluminium and a controlled reactive oxygen content, which in turn depends largely on the carbon, manganese and silicon content of the steel. For a range of carbon steel between 0.15 and 0.5 per cent., for a manganese content of 0.5 per cent. and above, and for a silicon content of about 0.15 per cent. and above, a fine grained type of steel was invariably obtained by means of an aluminium addition in the ladle to the extent of about 1 lb. per ton. A coarse grained steel was obtained by omitting the aluminium or by using considerably less of it; in general, the addition of less than $\frac{1}{2}$ lb. of aluminium per ton to a steel containing less than 0.1 per cent. silicon results in a coarse grained type of steel.

The production of intermediate grain size to schedule in a nominally plain carbon steel, with standard basic open-hearth melting practice, requires reduction of reactive oxygen below the amount that is utilised in making the fine grain steel; this requires a higher content of manganese and/or silicon and is really equivalent to making a low alloy steel. Microscopic inclusion counts and oxide analysis indicated that the moderate amounts of aluminium required to give a fine grain steel did not increase the number of larger inclusions or adversely affect the cleanness of the steel. This would indicate that satisfactory grain size control by means of aluminium can be accomplished without detriment to the quality of the steel. Further experiments are being conducted on the use of titanium or zirconium in conjunction with aluminium.

Grain Growth Tendencies

ANOTHER joint paper by E. S. Davenport and E. C. Bain, deals with steels which (although of similar composition) develop different characteristic austenitic grain size at various heating temperatures alike for all. These individual grain growth tendencies correlate well with hardenability and certain mechanical properties, the coarser grained steels being deeper hardening and less tough. Methods for estimating grain size in various types of steel are described as well as the factors controlling the grain growth characteristics. It is believed that dispersed particles are the primary course of

restricted grain growth and that these obstructions, acting as transformation nuclei, accelerate transformation and hence decrease hardenability. A manifestation of the nucleation effect of dispersed particles is found in low carbon steels, case carbonised and slowly cooled.

Basic Bessemer Steel at Corby

THE first of the three converters for making basic Bessemer steel at the new works of Stewarts and Lloyds, Ltd., at Corby, Northamptonshire, was put into operation early last month, and high grade steel suitable for the manufacture of tubes was made from this first heat. The process involved was invented by Thomas and Gilchrist in 1878, and although it was taken up in England, considerably more enterprise was shown in Germany, France and Belgium from which countries large annual exports of the steel were sent to England. With the present revival of the process at Corby, the immense iron ore deposits in Northamptonshire will be opened up and worked, thereby providing additional employment in the mining industry. Constructional activity at Corby began about two years ago, but the new works are not yet completed. It is anticipated that the tube-making plant will be ready for production by the end of May. Other sections of the works include ore-treating plant, coke ovens, by-product plant and rolling mills.

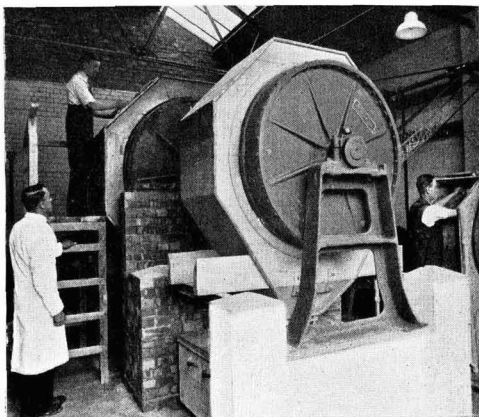
Calcium for Metallurgical Use

FIFTEEN years ago, the price of calcium metal was in the neighbourhood of £4 per lb., but it is now about 6s. for a product which is 98.5 to 99 per cent. pure. The metal is produced by the electrolysis of pure fused calcium chloride, which is maintained at a temperature of 780-800° C. In this process a vertical contact cathode is used, and the metallic calcium continues to be deposited so long as the cathode is moved upwards; at the same time the newly deposited metal is adequately protected from the action of air by a thin film of calcium chloride drawn from the bath.

The noteworthy fall in the price of calcium metal has been due to the rapidly increasing use of the metal in metallurgy. For instance, calcium can be added to lead to the extent of 0.03 or 0.04 per cent. in order to increase tensile strength and resistance to deformation; lead so treated is well suited for the sheathing of electric cables. In another direction, calcium can be used as a deoxidiser for copper, and in this connection it is preferable to silicon as the conductivity of the copper is very little affected whereas the action of silicon is pronounced. For this particular purpose high calcium copper alloys are available, usually in powdered form. A third metallurgical application concerns cast iron, 0.5 per cent. of calcium producing a casting which is denser and more uniform in grain structure than normally. Applied to the deoxidation of steel, special methods have been developed for shooting slugs of calcium into the ladle of molten metal by air pressure. The pressure used is sufficient to send the calcium deep into the molten steel where it disintegrates, does its deoxidising and is converted into lime which rises and is removed with the slag. At the present time calcium slugs can be shot at the rate of 120 per minute when the gun is hand-operated, or 200 to 300 per minute if motor driven, and a 60-ton ladle of steel can be deoxidised in a period of 5 minutes using 2 lb. of calcium per ton of steel.



Static Reverberatory Frit Smelters, capacity 1,700 lb. of frit per 8 hour run.



Grinding Mill for Dry Enamels, operating at a peripheral speed of 300 ft. per minute.

Modern Vitreous Enamelling

A WEALTH of information upon the equipment of a modern enamelling works was given in a paper which Mr. J. T. Gray, of Gray and Sons, Ltd., read before the Southern Section of the Institute of Vitreous Enamellers at their meeting in London, on January 28.

Until quite recently the enameller was left to solve his equipment problems for himself. Among the equipment manufacturers the furnace-makers were the first to realise the necessity for special attention being paid to the development of furnaces and furnace equipment of higher efficiency, but there are now established firms who specialise exclusively in equipment for the various branches of the enamelling trade.

Owing to the rapid development of enamelling in this country and the potential market available, a number of the larger firms has reached the point where the installation of continuous plants is being considered more seriously than hitherto. The complete mechanisation of enamelling plants has been carried out to a very considerable extent in the United States and in other countries, but so far the British enameller does not seem to have been able to make up his mind whether the output of his individual plant warrants such mechanisation.

Rotary and Static Frit Smelters

The rotary frit smelter was introduced to replace the old direct-fired static reverberatory type. The primary claim for this type of smelter is speed of operation—and thermal efficiency. The original intention was that the furnace should rotate continuously during the entire smelting period, but a number of enamellers has discontinued this practice in favour of allowing the smelter to remain stationary for, say, ten minutes, and then revolving the drum one half-turn, thereby bringing the hot upper part of the furnace to the bottom, and repeating this half-turn every ten minutes. It is claimed that with continuous rotation the frit in its semi-molten state trickles down from the upper half of the lining and a considerable proportion of this is blown out of the exhaust owing to the high velocity of the flame. Some enamellers consider that owing to the drastic direct-firing of the rotary smelter there is always a possibility of contamination through carbon formation, but this is a matter of opinion. The efficient capacity of a furnace of this type, 6 ft. long, 27 in. diameter (inside dimensions) has been found to be approximately 500 lb. of frit per charge. The average time for smelting this batch of 500 lb. of frit is three hours and the oil consumption is 96 gallons (or 864 lb.) per ton of frit.

With the static reverberatory smelters, the dimensions of the smelting-hearth being approximately 5 ft. by 5 ft. 6 in., the capacity is approximately 1,700 lb. of frit per charge and the average time for smelting this batch is eight hours. Here the oil consumption is 105 gallons (or 945 lb.) per ton of frit.

Some Aspects of Modern Equipment and Lay-out of Works

With this type of reverberatory furnace the question of contamination is almost entirely eliminated as the combustion chamber is built separate from the smelting chamber. The incandescent gases from the fuel oil are delivered into the smelting chamber by way of a series of ports. With this type of smelter, moreover, the waste gases can conveniently be used for drying the frit.

The grinding time of an average dry enamel in this size of mill is approximately 22 hours—or one grind per day. In dry grinding, porcelain balls are used as a grinding medium; flint pebbles cannot be used for this purpose as they chip and leave a scale in the enamel which cannot be removed. This is such an important matter that some manufacturers go to the length of using a grinding medium made of the same material as the enamel. To do this they extract what may be termed large "rocks" of enamel from the smelter and charge these into the mill with the frit. The best practice is to use a much lower weight of grinding balls in proportion to the frit in dry grinding than in wet grinding. In mills with a peripheral speed of 300 ft. per minute, 800 lb. of porcelain balls are used for grinding 1,120 lb. of frit. Linings of manufactured porcelain blocks are extensively used and give considerable service. In some cases linings of much harder material, such as silex are used. Silex linings are usually from 6 to 8 in. thick when new, and reduce the capacity of the mill accordingly.

Dry Grinding Mills

The speed of these mills is an important matter as there is no water to assist in suspension; therefore the blow of the grinding balls is much heavier than in wet grinding. Once a mill is started on any particular colour (or white) enamel, it is never used for the grinding of any other colour. To clean out a mill for the purpose of changing from one colour to another is so laborious that it is not practical.

In the Coupe dusting booth the tilting and rotary motions are carried out by an assistant who has a clear vision of the job through a glass panel at the side of the booth. An extractor fan is incorporated which allows for a velocity of about 50 ft. per minute at the mouth of the booth. This draught is so balanced as to prevent any enamel dust escaping into the shop, without, however, drawing any appreciable amount of enamel into the exhaust system. The bottom of the booth is fitted with a tray into which enamel falling past the job is collected in a clean and re-usable condition.

The magnetic separator is a comparatively new introduction

to the enamelling industry. The earlier types of machines used were fitted with serrated primary poles and it was found that these serrations had a retarding effect on the flow of the enamel and were difficult to clean. This machine has been specially designed for the treatment of enamel slop. The primary magnetic poles over which the enamel flows form a flat machined surface. It has been found that owing to its sluggish action, it is not necessary to use serrated primary poles when dealing with enamel slop. The primary magnets are formed of hinged castings which become magnets by induction from the primary poles. The magnetic field is concentrated in order to extract any finely sub-divided iron or other magnetic substances from the material being treated.

The magnetic separator was first introduced to the enamelling trade for the treatment of enamel scraping collected from the booths for re-use. Its application has been considerably extended and a number of works now treat a large proportion of their new enamel (especially white) with such a machine. A considerable amount of metallic residue can be extracted from any average enamel and this reduces the possibility of black specks in the finished ware.

Mechanically-Operated Sieves

Many types of mechanically-operated sieves have been tried for the sifting of wet enamels, but it has been found that these separate the water from the solid material. This machine is of the vibrating type and is operated by a $\frac{1}{4}$ h.p. electric motor direct-coupled to geared reciprocator. The hopper is mounted in rubber seatings and a rubber buffer is used as contact between the sieve and the reciprocator, ensuring high resilience. A machine of this type with 18 in. diameter lawn will effectively sieve 960 lb. of enamel ground to a coarseness of 11 units, and weighing 38 oz. per pint, through a 30-mesh lawn, in eleven minutes. A further advantage of this sieve is that it assists in mixing the enamel, and is also extensively used for the sifting of dry enamels.

Pickling room equipment comprises a degreasing plant, acid tank, water tank, soda tank and borax tank, in addition to a conveyor dryer. The baskets of work are conveyed through the various stages of pickling by means of an overhead runway which extends into the grip-coat dipping department.

Standard oil-fired fusing furnaces served by double-acting charging machines. Special attention must be drawn to the method of double-decking the work on specially-designed double-deck nickel-chrome frames, thirty electric fire fronts per load being obtained in a 9 ft. by 4 ft. furnace.

Static dryers are provided with independent oil-fired air heater. A typical installation comprises three drying rooms each 18 ft. long by 6 ft. wide, placed end on to each other. Each of the long sides of these rooms is fitted with a series of slideaway doors and the width of the dryer gives just sufficient clearance to allow for the trays being placed crosswise. Two boys place the skids and trays in position for the sprayers as they are required. The sprayer lifts her work from the booth, turns round, and places it in the dryer in a travel of about 7 ft.

Hot Air for Dryers

The heater is of the single-pass indirect type, and the average oil consumption is two gallons per hour. A 14 in. diameter fan, displacing 4,500 cubic feet of air per minute, absorbing 3 h.p., is used. The hot air is distributed through a ducting placed in a trench running central through the entire length of the three dryers. The top of this trench is covered by means of perforated plates. At equal distances along the dryers a vertical branch pipe is taken from the main ducting. This vertical pipe is capped at the top and is provided with horizontal slots at 6 in. pitch throughout its height, through which the hot air is discharged into the dryer. The object of this is to have horizontal currents of hot air passing between the trays of work. As in all dryers there is a slight temperature variation, and an actual test showed that the outdoor atmospheric temperature was 48° F., the temperature of the first air outlet nearest the air heater was 184° F., and the temperature at the farthest outlet from the heater was 170° F.

A re-circulating system is incorporated, the air from the dryers being exhausted through outlets in the roof and returned to the heater by the overhead ducting. The temperature of this returned air immediately before entering the fan was 85° F., and this installation has provided sufficient accom-

modation for the work of fourteen sprayers producing general cast iron and sheet steel parts.

In the latest type of conveyor dryer double booths are placed at right-angles to the dryer. Along the side there are a number of rectangular openings, through which the sprayers place the work, either on trays or on hanging racks according to the type of ware. The combined racks and trays are suspended from the conveyor track and the design allows for loading the work either flat or suspended.

The Conveyor Dryer

This conveyor dryer accommodates the work of twelve sprayers and the racks travel at bench height, returning along the overhead track to the discharge end where the work is lifted off and is sub-divided on to various trays in the order required for fusing. Waste gases from the fusing furnace are utilised for the heating of the air by means of a multi-tubular double-pass heat-interchanger. The waste gases are supplemented by an auxiliary oil-burner which consumes approximately $2\frac{1}{2}$ gallons of oil per hour. This burner is only required for about the first four hours of each day-spraying shift. A fan running at 1,420 r.p.m., absorbing 3 h.p., is used. The hot air is delivered from the heater to the conveyor dryer by means of overhead lagged ducting, a re-circulating system being employed.

A considerable amount of valuable data and information has been gleaned from this installation. The temperature of the flue gases at the inlet end of the air heater was found to be 725° F., and at the outlet 338° F. The temperature of the air leaving the heater was 356° F., and the temperature of the air discharged into the conveyor dryer was 320° F., showing a drop of 36° F. The temperature in the dryer at the loading height of the conveyor was 120° F. At the top of the dryer in the space occupied by the return track the temperature was 130° F. It was found that the time taken to dry a flat casting weighing 18½ lb. was 25 minutes; castings weighing 12½ lb. took 20 minutes. The speed of the conveyor is 2.5 feet per minute and to complete the cycle of the endless conveyor occupies 50 minutes.

In some modern mill rooms it is the practice to have a two-storey building with the frit stores and mixing carried out overhead, and the mills are charged through chutes in the floor to the mills below. This is quite good practice where mills of large capacities, say, 1,000 lb. and over, are used and where the mill room is large enough to necessitate the employment of three or more men. In small and medium-sized mill rooms, however, milling, say, up to 25,000 lb. of wet enamel per week, where one mill-room man or a man and boy are employed, there is ample time to charge the mills from ground level, and their whole time and attention are confined to one floor only.

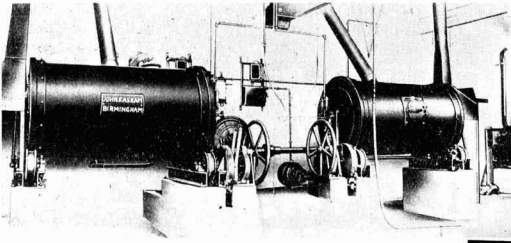
The Annealing Furnace

The annealing furnace should be of the semi-muffle type, fired by means of fuel oil. In this type of furnace the products of combustion are discharged into the working chamber through a series of ports along each side of the working-hearth as it is not necessary for annealing to have a completely enclosed muffle, and as no carborundum or similar expensive muffle is necessary this type of furnace is cheaper in first cost and more economical to run. A typical furnace has a clear internal working space 10 ft. back to front, 5 ft. wide, and 2 ft. 9 in. high above the landing walls; this height is necessary to accommodate the hanging perrets, of which there are four per load and 20 framed castings per perret, giving a total of 80 of this type of casting per annealing load. A double-acting charging machine is used and one man operating this furnace handles 5½ tons of light stove castings per day of 8½ hours.

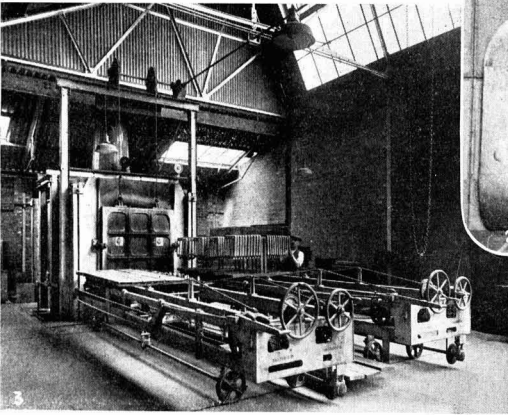
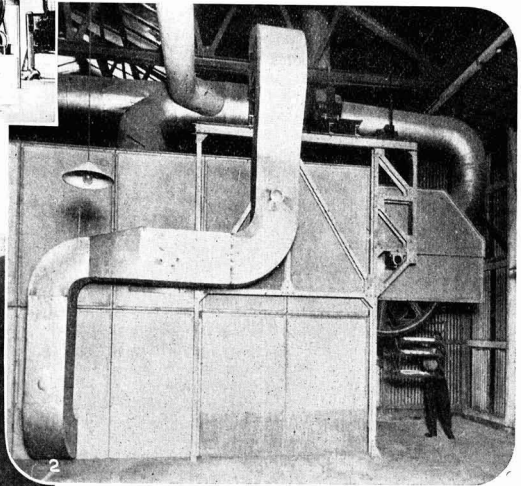
Two rotary tables and a small cabinet comprise the sand-blast equipment. Only one rotary table is in constant use, the second having been installed as a standby and to meet peak demands. Three men per shift are employed, one on the rotary table, one on the cabinet, and the third man assists the other two by feeding them with work and generally processing the castings through the sandblast department. A fourth man is called in when the second rotary table is required. The output from the rotary table is 6 cwt. of light general stove castings per hour. The machine is fitted with four $\frac{3}{8}$ in. diameter nozzles and steel grit No. 16 is used as an abrasive.

The conveying of work to and from the various operators

Modern Equipment at Vitreous Enamelling Works



1. Two Rotary Frit Smelters, 27 $\frac{1}{2}$ in. diameter x 6 ft. long, capacity 500 lb. of frit per smelter per three-hour run.



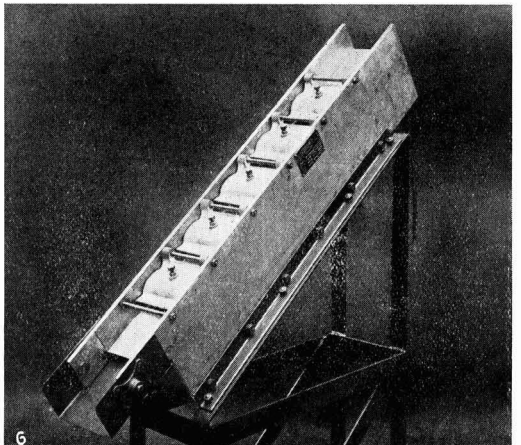
2. Conveyor Dryer (discharge end).

3. Annealing Furnace with double-acting Charging Machine, capacity 5 $\frac{1}{2}$ tons of light castings per 8 $\frac{1}{2}$ hours.

4. Electrically-operated Sifting Machine with $\frac{1}{4}$ h.p. motor directly coupled to geared reciprocator.

5. Coupe Dusting Booths for dry process enamelling on small and medium size ware.

6. Magnetic Separator for treating Enamel Slop.



is done by the usual jack-lifting truck, skids, and trays, but the system is so arranged that the skids and trays continually circulate backwards and forwards between two stations only. For instance, the castings from the annealing furnace are loaded on to skids and conveyed to the sandblast where they are lifted from the skids and placed on the rotary table where for maximum efficiency it is necessary to mix the castings as, if the rotary table were loaded with framed castings only, these would leave too much of the surface of the table exposed to the action of the abrasive material. As castings are lifted from the rotary table they are placed on fresh skids and separated into their various classes. The skids unloaded at the sandblast are returned by the third man to the annealing furnace. Therefore these skids travel only to and from the annealing furnace and the sandblast, and this method of skid circulation is adopted throughout the plant. As the skids of work are loaded in the sandblast department they are conveyed to the inspection and filling bench.

Each spray booth is supplied with a bulkhead electric light which is fitted just in front of the centre of the turntable, giving a practically shadowless light. The baffling arrangement is worthy of special mention. This comprises a frame of loose corrugated louvres, and tests have proved that these louvres arrest the maximum amount of enamel dust consistent with low resistance to the air flow. At the mouth of the booth the air velocity is 90 ft. per minute, which is 30 ft. per minute higher than the minimum allowed by the authorities. The exhaust from spray booths is an important matter, as excessive non-baffled draughts will carry a considerable amount of comparatively expensive enamel to waste.

The dryers are heated by the waste gases from the furnaces, by means of underground flues. The drying chamber consists merely of partitioned walls with slideaway doors on the long side adjacent to the sprayers and folding doors at each side of the furnace; they are without roofs and are open to the shop. A boy is engaged at each dryer, his duty being to place the skids and trays in position as required by the sprayers. The average temperature of the rooms is approximately 100° F.

The mottling booths are arranged two on each side of the furnace, adjacent to the exit doors from the dryers. The skids of sprayed work are placed at an angle of approximately 45° to the front of the booth on the right-hand side of the mottler while an empty skid is placed at approximately 45° to the front of the booth on the left-hand side of the mottler. Therefore the operator can lift the sprayed castings from the right-hand side, mottle them, and place them on the left-hand side, without leaving her working position. The mottled ware dries in the open shop and immediately a skid load is complete these are placed on line at each side of the charging machine.

The working temperature on the mottled work in the fusing furnaces is 740° C., and in the case of the ground-coat work 800° C. The average oil consumption of these furnaces is 6.2 gallons of fuel oil per hour. For an output of 35 tons per week, one furnace is fusing 24 hours per day and the other 10 hours per day. The total actual fusing hours are approximately 31 per day. Red warning lamps are fitted to the gravity oil tanks and these light simultaneously with the starting-up of the pump, as an overflow warning.

Some Recent Metallurgical Patents

Granulating Slag

BLAST furnace slag is granulated by mechanical disintegration of a stream of slag, the drops so formed being solidified and cooled. The stream may be broken up by revolving steel vanes or by a blast of air, which may carry a spray of water or steam. The drops are further chilled by contact with a stationary or rotating iron hull, on which water may be sprayed. (See Specification No. 417,694, of E. B. Bjorkman.)

Improved Iron and Steel

CAST iron, wrought iron, or steel is improved by adding to the molten metal in the ladle or ingot mould a product containing an OH-group, or water of constitution, or both, and an alkaline or alkaline-earth carbonate so as to secure an energetic stirring of the metal by introducing water at the moment of pouring, an atmosphere of carbon dioxide during pouring, and a very fusible alkaline slag to prevent re-oxidation. Boric acid, or an alkaline borate, and a carbonate may be added to the metal in the ladle or ingot mould. Aluminium may also be added to kill the metal. (See Specification No. 418,656, of Soc. des Acieries de Longwy.)

Removal of Occluded Gases

ALLOYS are obtained free from occluded gases, particularly oxygen, by melting them or their constituents in a non-oxidising atmosphere in the presence of a reducing agent such as carbon. The non-oxidising atmosphere may be obtained by combustion of a hydrocarbon within a closed vessel containing the metals, and the reducing agent may be the carbon so formed or may be separately added. Two or more constituent metals of an alloy may be combined by the process and the product subsequently combined with the remaining metal or metals. The production of alloys of zinc and magnesium is referred to, particularly an alloy for reflectors consisting of about equal proportions of zinc and magnesium. A zinc-magnesium alloy obtained in this way may be added to molten aluminium to form an intermediate alloy which is subsequently added to a main portion of aluminium. Reoxidation of the alloys during subsequent recasting may be avoided by melting and casting them by the Durville process. (See Specification No. 414,094 of A. J. Wakelin, and C. E. Denney.)

Ferro-Chromium

CARBON-FREE ferro-chromium is produced by mixing together chromium nitride and iron free from carbon and melting the mixture. The mixture may be sintered before melting, or the chromium nitride heated to expel most of the nitrogen before being mixed with the iron. The process may be carried out in an inert or reducing atmosphere or wholly or partly *in vacuo*. (See Specification No. 418,560, of Norsk Hydro-Elektrisk Kvaestofaktieselskab.)

Purifying Lead

BISMUTH is removed from lead by adding lithium and calcium to the molten metals and removing the dross which forms: the lead bath may be partially debismuthised by calcium alone, the lithium being added subsequently. The lithium is preferably added in the form of a lithium lead alloy: residual lithium is removed by introducing chlorine under a salt-cover. The lithium may be used in whole or part substitution for the magnesium and barium described in the parent specification. (See Specification No. 416,634, of the American Smelting and Refining Co.)

Removal of Bismuth from Copper

COPPER containing bismuth as an impurity is treated for the removal of the bismuth by adding to the molten copper an alkali metal, or a hydroxide, oxide, or carbonate of an alkali metal, or any mixture of these reagents, in the presence of air, oxygen, or an oxidising agent, and removing any compounds formed, for example, by skimming. The treatment is carried out on a furnace hearth or in a crucible lined with a refractory material such as magnesite which is inert to or only slightly acted upon by strongly alkaline slags or fluxes. The reagent may be added to the surface of the molten copper or may be passed through the molten metal. Air may be blown through the molten copper or an oxidising agent such as cuprous oxide may be added and sodium hydroxide, oxide, or carbonate may then be added, after preheating, and stirred into the metal. The oxidation and treatment with the alkali metal reagent may be repeated one or more times. If metallic sodium is used this may be introduced as vapour by bubbling nitrogen or other inert gas through molten sodium in a vaporiser, the nozzle of which is placed well below the surface of the molten copper. (See Specification No. 416,572, of British Non-Ferrous Metals Research Association, and G. T. Callis.)

Metallurgical Section

March 2, 1935

Work of the Metallurgy Research Board

INVESTIGATIONS into the part which is played by dissolved gases during the solidification of steel have been continued by the Metallurgy Research Board of the Department of Scientific and Industrial Research during the past twelve months. In the course of further efforts to determine the solubility of hydrogen in pure iron, progress has been made in the production of pure alumina crucibles substantially impervious to gases. By means of these crucibles many of the difficulties previously experienced have been removed.

The study of the factors controlling the grain size of cast metal has also been continued, and a report on the macro-structure of aluminium and some alloys shows that the presence of dissolved gas in the metal, the use of mechanical dressings, and mechanical agitation of the mould during solidification, all lead to grain refinement. This report suggests that grain refinement, in every case, is actually due to the mechanical agitation of the metal during solidification. The possibility that a peritectic reaction would cause grain refinement in alloy systems of such composition, that the reaction would occur (if at all) in completely molten metal, has been examined and some evidence in support of this view has been obtained.

A comprehensive summary of the properties and uses of chromium steels has been prepared for publication, reports having been written upon the separate and combined effect of silicon and manganese on 1.8 per cent. chromium steel, and upon the constitution and properties of pure tantalum iron alloys and steels. The properties of a series of low carbon steels, containing 0.5 per cent. chromium and 0.5 to 4.0 per cent. copper, are still being investigated, with particular reference to temper-hardening. The effect of vanadium on a series of carbon, chromium, nickel, and nickel-chromium steels to produce a temper-hardening effect when heat-treated is another subject which has received attention.

Alloys for High and Sub-Zero Temperature

THE exploratory research on non-ferrous alloys for high temperature service, carried out under the direction of the Metallurgy Research Board, is being continued in the laboratories of the British Non-Ferrous Metals Research Association. The investigation on the influence of aluminium, silicon, and manganese additions to cupro-nickel of various compositions has been completed, and work is now in progress on four systems of ternary alloys, namely, aluminium-nickel-chromium, copper-nickel-chromium, copper-nickel-iron, copper-nickel-cobalt. A rapid survey of the first two systems has been completed, and further work is being carried out on those alloys which give promise of useful application. A preliminary study of the effect of small additions of molybdenum, tungsten, vanadium and tan-

talum to 80/20 cupro-nickel has also been made, but as the alloys prepared showed no outstanding properties this part of the work has been discontinued.

It is well known that some of the mechanical properties of steels and other metals vary greatly with the temperature at which they are determined. In this connection less attention has been paid to the effect of low temperature as compared with that of high temperatures. In the case of aircraft, sub-zero temperatures normally prevail, and more study of the properties of materials at these temperatures would seem to be in order. Work of this character is now in progress at the United States Bureau of Standards, plain carbon steels being the phase under investigation. The tensile, hardness and impact properties of a given carbon steel in heat-treated, normalised, and cold-drawn conditions are being compared at temperatures from + 20° C. down to - 80° C. Particular attention is being directed to the effects of inherent austenitic grain size on the low temperature properties, as well as the effect on the properties at room temperature of the minimum temperature to which the steel has previously been cooled, and the length of time the steel has been maintained at that minimum temperature.

Silver in Minute Amounts

FOLLOWING the discovery of the bactericidal properties of silver and more recent interest which has been aroused in this direction, the need has arisen for an accurate analytical method which is capable of determining the amount of silver in very dilute solutions, concentrations being of the order of 0.02 to 0.2 milligram per litre. Adopting Feigl's rhodanine colorimetric test, which is known to be accurate for the quantitative estimation of silver in very low concentrations, it has been found that accuracy in extremely dilute solutions is seriously affected by the adsorption of silver upon the walls of the glass vessels which are used in the analytical procedure. At the United States Bureau of Standards, where this problem has received attention, the extent of the adsorption has been found to be considerably modified by the type of glass used or by previously treating the surface of the glass. It has also been found that adsorption is far less serious when fused quartz is used in place of glass.

Para-dimethylaminobenzylidene-rhodanine, as an organic reagent for silver, is used in the form of a 0.03 per cent. solution in acetone. It is always employed in acid solution; in alkaline solution certain changes take place in the molecule and the reagent will then react with nearly all the heavy metals, whereas in acid solution it gives a positive reaction only with silver, mercury, copper (cuprous state), gold, platinum and palladium, the silver reaction—under certain conditions

—being specific. By means of the red coloration (actually a reddish-brown precipitate) which is produced, it is possible to detect one part of silver in 5,000,000 parts of water, whereas the chloride ion under identical conditions will give a visible reaction only as low as one part of silver in 400,000 parts of water. This particular reagent is indeed capable of indicating the actual extent to which silver chloride itself is soluble in water.

Nickel and Chromium Plating on Steel

LONG time tests which have been carried out at stations providing different types of atmosphere ("Monthly Review, Amer. Electroplat. Soc.," 1934, 21, No. 2, 8) show that the protective value of nickel coatings on steel depends primarily upon the thickness of the plating, a minimum of 0.001 inch being required in severe atmospheres, whereas 0.0005 inch gives protection under mild conditions of exposure. The actual conditions under which the nickel is deposited is said to have very little influence on the degree of protection which is ultimately provided by the plating. An intermediate layer of copper has been found to reduce the protective power of thin coatings of nickel, but in cases where the total thickness of the superimposed plating is 0.001 inch or more the copper layer is not detrimental. In similar exposure tests, extremely thin coatings of chromium, of the order of 0.00001 inch, have been found to decrease the protective value of nickel plating. The commercial thickness of 0.00002 or 0.00003 inch adds little to the protective value of the nickel plating, but increases its tarnish-resisting properties. Still thicker coatings of chromium (0.00005 to 0.0001 inch) give increased resistance to corrosion, especially in an industrial atmosphere. Layers of zinc or cadmium, beneath either nickel or chromium, are found to produce white stains and blisters.

Corrosion of Stainless Steels

INVESTIGATIONS on the corrosion of wrought iron and steel, to determine whether or not these materials corrode with the same velocity in all directions, are still engaging attention. To the corroding action of the weather Richardson ("Trans. Amer. Electrochem. Soc.," 1920, 37, 529) exposed sections of wrought iron cut parallel and transverse to the direction of rolling and found no difference in the corrosion of the two sections as far as the loss in weight and depth of pitting were concerned. Evans ("Journ. Soc. Chem. Ind.," 1928, 47, 62T) exposed scratched specimens of steel to anodic attack in sodium chloride solutions and observed that a deep groove of rounded cross-section appeared along the scratch line, the corrosion penetrating downwards. On wrought iron the groove produced along the scratch line was invariably shallower, and it was clear that in wrought iron corrosion proceeds preferentially along certain planes roughly parallel to the surface, causing the groove to broaden rather than deepen. Other experiments have shown that steel, as well as wrought iron, was subject to preferential corrosion in certain directions by various corroding agents, but to a lesser degree.

It is well known that the corrosion of iron and steel is affected by the natural oxide films that form on the surfaces. Any tendency of these materials to corrode in one direction more readily than in another therefore suggests that the oxide films on the different surfaces may give unequal protection against corrosion. This

point has been tested in a recent investigation carried out partly under a grant from the Faculty Research Committee of the University of Pennsylvania ("Journ. Frank. Inst.," February, 1935), by making a series of time-potential curves for the surfaces. Tests were made on wrought iron, carbon steel, and stainless steel. In the case of stainless steel, the curves were not sufficiently regular to indicate any definite difference between the longitudinal and transverse surfaces. Every few minutes the potential dropped sharply, indicating a sudden break in the protective film and then rose rapidly again indicating an immediate self-repair of the break. This fluctuation persisted even after the specimen had been in the solution for as long as eight hours. The gradual rise in the maxima of the curve indicated a general improvement in the protective film. The changes produced in the curves by annealing the steel specimens indicate that either the grain structure or the crystal orientation in the metal, or a combination of both, exerts a definite influence on the character of the time potential curves. These same conditions are also present in the case of wrought iron, but are not as evident, probably due to the greater slag content.

World Metal Position

WORLD stocks of copper are estimated to have decreased by about 200,000 tons during 1934. Total consumption in the United States was about 435,000 tons, as compared with 390,000 tons in 1933. These figures indicate definite improvement in the copper industry. Comparing 1934 with 1933 there was an increased use of spelter for brass making and die casting, but apparently a decrease in the use of zinc for galvanising. In the United States zinc production was about 365,000 tons as compared with 325,000 tons in 1933; outside the United States production in 1934 was about 915,000 tons, and in 1933 about 780,000 tons. The bright spot in tin has been in the manufacture of tinplate and its use for tin containers, for which there has been an increased demand due to an abnormal slaughter of cattle under conditions of drought. In the United States there are now about sixty large can-making plants in operation. World consumption for the year ending May, 1934, was 55,000 tons in respect of the tinplate industry, consumption for all purposes being about 130,000 tons. Tin plating, and the use of tin powder for synthetic alloys and pressed metal parts, have been the subjects of development. Numerous new applications of lead have demonstrated the adaptability of this metal to a wide variety of services.

The motor car industry continues to be the world's largest consumer of nickel, but cupro-nickel tubing for marine condenser service has accounted for a large additional tonnage. About 450 tons of nickel per year are now consumed in the making of nickel-silver alloys. The electroplating industry consumes about 10 per cent. of the total output of pure nickel, as compared with 5 per cent. in 1926. Aluminium is showing an activity which is about 70 per cent. better than the lowest level of consumption during the past five years. As a useful metal for everyday purposes it is constantly widening its field of application, bottle closures and aluminium foils having shown a heavy increase during 1934. Although no new aluminium alloys seem to have been introduced during 1934, new applications for those introduced during 1933 are reported.

Industrial Aluminium Scrap

Modern Methods for Separating and Refining the Metal

WITH the ever-increasing developments in aircraft and automobile engineering, aluminium and its alloys receive much more general recognition than hitherto. Accordingly the amount of scrap and turnings which is available on the market has also increased and methods are required to handle this waste material and convert it to a form which will find a ready sale.

Preliminary Treatment

Earlier work in the treatment of fine turnings, millings, borings, etc., showed that great efforts had been made to convert the metal into chemical salts, taking advantage of the fine condition of the mass, but the method of converting aluminium scrap to alum and similar salts has more or less been kept secret. Most refiners who acquire mixtures of brass and aluminium borings in odd lots use them up in the manufacture of aluminium or manganese brasses. To-day, however, much larger consignments of scrap are available, and "occasional" uses are therefore insufficient to cope with the amount of material available.

In cases where the mixture consists mostly of aluminium, one proposed method for treatment was to charge the mass into a kettle of molten aluminium prepared from the melting down of sheet and heavy scrap; here the object was to allow the heavier brass to sink to the bottom. If the temperature is well controlled there is little risk of the zinc of the brass alloying to the aluminium, but this point is of great importance. After most of the free aluminium has been ladled out of the kettle, the bottom portion containing the brass is transferred to a small liquation hearth, and the remaining separation done by means of sweating. This system is much more economical than directly placing the mixed borings, etc., on the liquation hearth, as the volatilisation losses are reduced to a minimum.

Direct Separation of Turnings

In view of the increasing amount of mixed turnings which are available, and the difficulty experienced by the engineer in keeping these wastes separate, efforts have been made to introduce a direct form of separation. One of these systems consists in utilising the flotation principle and separating the different turnings by their difference in specific gravity. Ordinary flotation methods are of little value using either water or oil emulsions, but special reagents (of the mercury salt type) have met with a greater measure of success.

In the ordinary manner, mercury will be precipitated in metallic condition when metals such as aluminium, brass, zinc, etc., are introduced to its solutions. It is a well-known fact that certain mercury solutions possess a very high specific gravity, but they are of little value for this work if any possibility arises of part of the mercury being precipitated. Should the aluminium borings be of that class which contain much zinc and copper, the work will be much more involved as they are much heavier. The quality of the brass borings is of little importance as they are always sufficiently heavy to sink to the bottom of the liquor.

A glazed earthenware tank is used for conducting the separation and the mixed turnings are charged and stirred up. This stirring is imperative as there are many instances where the different turnings will cling together and much aluminium would thus be drawn into the heavy material. Brass, iron and any other heavy metals sink to the bottom, but the aluminium floats to the surface and is rapidly skimmed off. Comparatively few details are forthcoming on the working of this process but there are several points which require careful attention. Although the aluminium or aluminium alloys cannot cause the deposition of mercury from the specially prepared flotation solution, it can become slightly coated on the surface if a sufficient amount of time is allowed to elapse, and hence the reason for the rapid skimming of metal from the surface of the liquor. The same remark applies to the rapid removal of the heavier turnings which have accumulated in the bottom of the vessel.

The separated turnings are immediately washed to recover any of the solution which adheres to them, and these washings are returned to the separation vat. Where the turnings have been dirty or greasy they tend to impart this dirt to the

solution. Although this does happen, the separation work can be persevered with so long as the mercury liquor possesses the property of raising the aluminium to the surface. The besetting sin is the decomposition of the mercury salt which permits of minute amounts of mercury being deposited on the turnings. When first tried some years ago the separation was supplemented by a systematic recovery process, to ensure that all mercury was reclaimed. Other solutions have since been used for the same purpose but they are more expensive.

Separation of Heavy Scrap

Advantage is taken of the light nature of aluminium and its alloys to separate it from associated scrap metals whilst in the molten condition. For this work it is necessary to construct a cylindrical type of melting kettle made of wrought iron plates. The whole rests on a hollow brick structure and is accurately heated by gas ring burners. Heavy scrap and sections cut by the "guillotine" from baled or bundled masses are charged into this kettle.

Too many different forms of scrap exist for one definite system to suit for all of them. One method consists of melting the mixed scrap metal and ladling out the upper portions as far as possible, as these consist mostly of aluminium; the remainder of the contents, however, still contain much aluminium. Scrap zinc is therefore added to form an alloy with the aluminium, after which the kettle is allowed to cool. A brittle alloy is formed on the surface which differs materially from most of the metals usually met with in the scrap; this alloy is then used up in small lots for the preparation of duralumin and similar alloys. Where aluminium scrap is associated with lead and lead alloys this system is usually very satisfactory. The surface of the molten mass is generally protected from the oxidising influence of the air by a layer of oil or cheap grease. Special fluxes and de-oxidisers are seldom employed to any extent for this work.

Where the scrap contains crude aluminium alloys, fluxes are added to reduce impurities to a minimum. If a sufficiently high temperature is permitted in any operations, aluminium will alloy with almost any impurity, hence the reason for employing gas-fired kettles. It has been frequently stated that oil and grease should not cover the surface of molten aluminium since carbon may be unduly absorbed, but in actual practice with refining kettles this has not been fully borne out; in fact, no alteration in the carbon content has been recorded. The weight of grease or oil seldom amounted to more than 1 per cent. of the metal contents and, on computing the carbon present, it will be realised how difficult it is for an appreciable absorption to take place. The manner in which the metal solidifies on the surface of the ingot moulds is a good indication of the quality of the alloy.

Copper in Architecture

Further Possibilities

SPEAKING at the Manchester Municipal School of Art on January 30, Mr. Basil Marriott, architectural adviser to the Copper Development Association, described the various architectural fields in which copper in its different forms can be utilised with advantage, pointing out that the metal was being used to-day for building, electrical engineering, ship-building, and many other industrial purposes. He did not foreshadow any great future for copper roof-tiling, as it seemed to him illogical to cut up a metal sheet into small units, thereby increasing the labour of laying and the number of joints which were potential weak spots. For other roofing work there was being developed a system of spraying the copper to give in a short time the green or grey-green colour coat which was to be seen on many old copper-roofed buildings and which took about seventy years to form naturally. Mr. Marriott mentioned that the propellers on the new liner, "Queen Mary," were of copper alloy, used for the purpose of resisting saline corrosion. The advantages of copper for interior building work were emphasised, as in domestic water pipes, where there was seldom found water sufficiently soft to pick up enough copper to be dangerous to health.

Aluminium in the Chemical Industry

A General Survey of its Usefulness

THE application of aluminium in the chemical industry is developing gradually. As a structural material in this industry its chief advantage lies in its resistance to corrosion by certain chemicals and the character of the corrosion products formed. In a recent paper presented before a meeting of the American Institute of Chemical Engineers at Pittsburgh, November, 1934 ("Ind. Eng. Chem.," 26, 1231), F. C. Frary states that while the metal itself is very active chemically, it is always (except when amalgamated) covered with a thin adherent, naturally formed coating of its oxide. This is inert chemically and insoluble in some reagents—particularly most organic liquids, distilled water, and many organic acids. For certain purposes it is advantageous to produce a thicker oxide coat by anodic treatment in suitable solutions and improve the impermeability of the oxide coating by "scaling" treatments, or impregnate the coating with corrosion-inhibiting substances. In other cases—for example, where brine is the corroding agent—special alloys are found to be much more resistant than pure aluminium, and sometimes it is possible to add corrosion inhibitors, such as a dichromate, to the brine without interfering with the process. In most cases, however, the corrosion resistance of aluminium in acid or neutral solutions increases rapidly as the purity of the metal increases. Broadly speaking, magnesium, manganese, chromium and possibly antimony are the only alloying elements commonly added to aluminium which do not reduce its corrosion resistance to most chemicals.

One of the important advantages of aluminium lies in the fact that its salts are colourless, and slight corrosion therefore does not discolour or stain the materials with which it is in contact, or others with which such materials may later be used. For this reason, aluminium stills, tanks, tank cars and drums are standard equipment in the synthetic acetic acid industry, and aluminium equipment is becoming increasingly important in the cellulose acetate and the organic solvent industries. In this connection the author gives the results of laboratory tests and shows graphically the very slow rate of attack of aluminium at room temperature by acetic acid at all concentrations except the most dilute. At the other end of the curve the rate of attack rises rapidly if even small amounts of acetic anhydride are present. Higher temperatures also increase the rate of attack by the dilute acid.

Freedom from discoloration effects is also an important reason for the use of aluminium in the naval stores industry and in varnish making. The stearic acid industry is interested in the same property and also in the fact that a cake of stearic acid solidified in a properly designed aluminium pan does not adhere to it.

The fact that the corrosion products, in the amounts formed, are non-toxic not only to man and animals, but also to yeasts and other substances used in the fermentation industry, is important—for example, in the dairy industry, the production of citric acid from sucrose and that of gluconic acid from glucose. Aluminium seems to have no specific destructive effect on vitamins even at elevated temperatures. Moreover, as it forms only one series of salts, aluminium causes no catalytic oxidation effects such as may occur in air in the presence of iron or copper salts. Such catalytic oxidation, in the presence of traces of certain metals, has been shown to be the cause of the development of off flavours in dairy products and may perhaps produce a similar effect in other foods. The fact that aluminium is the only common metal which, in its commercial form, does not appreciably catalyse the decomposition of hydrogen peroxide, accounts for its increasing use in the manufacture and shipment of this chemical. Its inertness toward sulphur, hydrogen sulphide and organic sulphides is also often useful—for example, in the distillation and handling of so-called sour crude oils which are high in sulphur.

Extensive tests have shown that aluminium is inert towards anhydrous sulphur dioxide and ammonia (liquid or gas), and its use is approved in refrigeration units employing these materials. Its good thermal conductivity is of importance in the fins, trays, etc., of refrigerators, and its high reflectivity and low emissivity have made aluminium foil important as a light-weight, non-combustible and vermin-

proof heat insulator for both refrigerated and steam-heated equipment. The high thermal conductivity is valuable in equipment when uniform heat distribution and avoidance of local overheating are important.

Experience in shipping synthetic nitric acid in aluminium containers has shown aluminium to be suitable for acid of 80 per cent. concentration or better. The rate of attack by this strong acid is very slow. Small amounts of hydrochloric or sulphuric acids greatly increase the attack, but larger amounts of sulphuric acid reduce it. Inertness to acid fumes, high moisture-proofing power and long life in sunlight have made aluminium paint popular in many chemical plants for protection of both wood and metal, and to improve lighting conditions. Even dilute chlorine fumes, as in a cell room, seem not to injure it seriously, but it will not stand a spray of caustic solutions.

An interesting physical property was revealed in the mechanical tests of aluminium drums for shipping nitric acid, hydrogen peroxide, etc., where dropping full drums from a considerable height failed to burst them, even when they landed on a rail or I-beam. The low modulus of elasticity and the high ductility of the grade of aluminium employed enabled the drum to absorb the shock and stress of the impact by extensive general deformation rather than by local failure, such as would have occurred in a steel drum.

Nickel-Chromium Alloys

Applications for Construction of Chemical Plant

VARIOUS nickel-chromium alloys and their uses in chemical plant construction are reviewed by Dr. R. Hanel in an address published in the "Chemische Fabrik," January 9. Notable stability at high temperatures was stated to be a distinguishing feature of the 80-20 nickel-chromium product, which rendered it exceptionally suitable as a material for electrical resistances. Maximum corrosion-resistance is imparted by a proportion of iron and the alloy modified by the latter metal has given better service in the milk industry than pure nickel itself. Other characteristics of the iron-containing alloys are the high mechanical strength and the ease of welding, which have popularised their use for steam-heated plant in the food industries. In addition, their striking resistance to corrosion by calcium chloride and common salt solutions permits their use in certain types of refrigerating plant.

Chrome-nickel alloys themselves are unattacked by phosphoric acid even without incorporation of other metals. Alloying with small proportions of aluminium and silicon renders chrome-nickel alloys suitable for steam distillation of petroleum and fuels containing anti-knock liquids such as lead tetraethyl. Phosphoric acid does not attack nickel-chromium alloys, but molybdenum is necessary to improve the resistance to acetic acid. An alloy containing 58 per cent. nickel, 15 per cent. chromium, 14 per cent. iron, 5 per cent. tungsten, 3 per cent. molybdenum, 3 per cent. cobalt and 2 per cent. manganese undergoes no perceptible loss in weight after contact with hot or cold 10 per cent. acetic acid. A small percentage of molybdenum also imparts high stability towards nitric acid, hydrochloric acid and aqua regia. A steel containing 18 per cent. nickel and 8 per cent. chromium in addition to copper and molybdenum has recently been introduced as a hydrochloric acid-resistant metal and is also completely stable towards hypochlorite solutions containing free chlorine.

Electric Furnaces in Heat Treatment

THE use of electric furnaces in industrial heat treatment is dealt with in the January issue of "Metallurgia." The various forms of furnace are described, together with particulars of the arrangement of the nickel-chromium heating elements employed. The advantages and costs of electrical heating are discussed and some account is given of modern methods of temperature control and air circulation.

Some Recent Metallurgical Patents

Thallium

ELECTRODEPOSITED thallium is removed from the cathode in flakes and kept under water to prevent oxidation. It is afterwards pressed and melted in graphite crucibles under a cover of oxalic acid and cast into bars. (See Specification No. 419,508, of American Smelting and Refining Co.)

Beryllium Coatings

BERYLLIUM and its alloys are fused in contact with a molten flux containing a compound of an alkali metal and a compound of another metal which is not an alkaline earth, *e.g.*, a double fluoride of an alkali metal and beryllium. A beryllium alloy may be obtained by fusing beryllium in contact with a double fluoride of an alkali metal and the metal to be alloyed with the beryllium, or a mixture containing the fluorides of the alkali metal and the alloying metal, for example, cryolite. (See Specification No. 415,542, of the Beryllium Corporation.)

Heat Resisting Iron

IN a process of treating iron and steel to improve their heat-resisting and/or physical qualities, the iron, etc., is embedded in a mixture of aluminium and/or magnesium, an inorganic carbide, sal ammoniac or its equivalent such as zinc or manganese chloride and a chromium chloride and heated to 650° to 1,150° C. The carbides used are carborundum or calcium, strontium or barium carbides. In an example, the mixture comprises 50 parts of finely-divided aluminium, 40 of carborundum, 7 of anhydrous chromic chloride, and 3 of sal ammoniac. (See Specification No. 411,982, of A. Folliet and N. Sainderichin.)

Cleaning Metals

IRON and steel are freed from rust or pickled by treatment with waste sulphuric acid from benzol or petroleum refineries, the acid having been first purified, by diluting the water to 35°-40° Be. and heating for 30 to 60 minutes at 90° C. either by direct heating or by introducing steam in such proportions and under such conditions that the temperature does not rise above 90° C., and then diluted. The purification removes the resinous polymerisation products, but the purified acid retains a sufficient amount of sulphonated hydrocarbons to inhibit its action on the metal. (See Specification No. 418,994, of A. A. Thornton.)

Steel Alloys

ARTICLES which must, in use, withstand the attack of gases that attack and remove carbon, such as apparatus or parts thereof used in the destructive hydrogenation of oil or coal or in the synthesis of ammonia, are made from non-austenitic steel alloys in which all the carbon is caused to combine with titanium, the titanium content being at least four times the carbon content. Such alloys may also contain one or more of the elements silicon, manganese, chromium, molybdenum and vanadium. (See Specification No. 419,009, of F. Krupp A.-G.)

Copper Oxide Cut-Outs

COPPER oxide cut-outs are made by heating copper at a temperature just below its melting point, preferably about 1,000° C., to form a layer of red copper oxide, and the conditions of cooling are then controlled to give the required breakdown value. The heated metal may be cooled gradually to room temperature, in which case the breakdown value varies inversely with the rate of cooling. Alternatively the heat treatment to form the layer of oxide may be followed by an anneal at a lower temperature, *e.g.*, from 150° to 600° C., the metal being then either cooled slowly to room temperature or quenched. Examples are given in which copper is first heated at 1,010° C. and then annealed at a lower temperature in one case at 150° C. followed by slow cooling and in another at 480° C. followed by quenching, the latter giving a lower breakdown value. (See Specification No. 419,439, of British Thomson-Houston Co., Ltd.)

Rustproofing Iron and Steel

A RUSTPROOFING solution for treating iron or steel is formed by dissolving iron sulphide and sodium carbonate in a concentrated aqueous solution of phosphoric acid. In an example 140 grams of pulverised iron sulphide mixed with 40 grams sodium carbonate are dissolved in 1 litre of orthophosphoric acid containing 400 c.c. of acid of a concentration of 83 per cent., the solution is filtered, and diluted to form a rustproofing bath, which is used at a temperature of about 100° C. (See Specification No. 419,487, of E. A. Walters.)

Lead Alloys

ALLOYS, particularly alloys of lead, zinc, cadmium, aluminium, or tin, with an alkaline earth metal, are made by alternately and repeatedly exposing pea-size particles of an alkaline earth metal carbide to the action of a slag and of a molten metal. The slag may comprise one or more alkali or alkaline earth metal fluorides or chlorides and the bath may be agitated so as to create a vortex by means of an impeller driven at 100 to 300 revolution per minute, the temperature of the bath being about 1,300° to 1,400° F. The formation of a lead alloy containing about 3.5 per cent. of calcium is described. (See Specification No. 412,316, of A. H. Stevens.)

Degasefying Metals

METALS are degasefied by melting them in a vessel in which the atmosphere is rendered non-oxidising and carbon is deposited in the vessel in advance of the melting of the metals, the atmosphere being maintained whilst the metals are in the molten condition so as to combine with oxygen released from the melt. The atmosphere and the deposition of the carbon may be formed contemporaneously by the combustion within an air-tight vessel containing the metal of a liquid or other hydrocarbon. The metals treated comprise iron, aluminium, copper, zinc, manganese and lead. (See Specification No. 419,560, of A. J. Wakefield and C. E. Denney.)

Rubberised Metal Surfaces

ARTICLES made of ferrous metals are first coated with a metal or alloy electropositive to copper, *e.g.*, zinc, lead, tin, aluminium, cadmium or lead-zinc alloys, then coated with copper or a copper alloy such as a brass or bronze by chemical deposition, and then coated with rubber by vulcanising a rubber coating in contact with the copper surface. The coating of metal electropositive to copper may be applied by any suitable method such as hot dipping electroplating, spraying, or cementation, the metal is then cleaned, *e.g.*, in hot sodium carbonate solution, and then dipped in the copper-coating bath. (See Specification No. 415,025, of the Goodyear Tire and Rubber Co.)

Adherent Metal Coatings

To obtain adherent metal coatings either electrolytically or by the fusion melting process on chromium or chromium-containing alloys, the surface of the chromium or chromium-containing alloy is exposed to agents having a strongly acid action during the application of the coating. When the coating is applied electrolytically a strongly acid bath with a pH value less than 2.5 is used. A thin deposit may be formed with such a bath and a further coating of the same or a different metal may then be applied using a weakly acid or alkaline plating bath. Nickel, tin, zinc, and cadmium are specifically referred to as metals which can be applied as coatings on chromium-containing alloys such as rustless steels or on chromium surfaces such as chromium-plated articles. A bath for plating with nickel consists of nickel sulphate, sodium sulphate, boric acid, and ammonium chloride, the bath being brought to the required acidity by the addition of sulphuric acid. When coating by the fusion melting process, the acid action is obtained by the use of strongly acid fluxes such as concentrated hydrochloric acid. (See Specification No. 415,207, of Wurttembergische Metallwaren-Fabrik.)

Fundamental Problems Connected with Tinplate

A Study of Corrosion by Fruit and Vegetable Acids

THE canning industry of Great Britain has made great progress during the last few years, and researches in every branch of industry that contributes to it have solved many of its former difficulties. That no effort is being spared to foster this confidence is shown by a survey of this work, which is published in the "Bulletin of the International Tin Research and Development Council," February, 1935.

A systematic study of the corrosion of tinplate by fruit acids and a survey of the behaviour of metals likely to be required for equipment and plant in canning factories has been carried out at the Low Temperature Research Station, Cambridge, and is reported upon by Mr. T. N. Morris. One of the chief causes of losses and deterioration in the canning of fruits is said to be due to the action of the fruit acids on the tinplate container. The results of this action are (a) discolouration of fruit pigments, tannins, etc., by tin and iron; (b) "doming" or bulging of the ends of cans through the liberation of hydrogen (hydrogen swells); and (c) perforation of the walls of the container.

Discolouration is to some extent mitigated by lacquering the interior of the cans, but a perfect lacquered surface has not yet been attained and it is found that lacquering as at present carried out on a practical scale may tend in some cases to aggravate the formation of hydrogen swells and perforations. In other respects, also, the problem of corrosion is not straightforward. For instance, the rate of formation of hydrogen swells and perforations is not proportional to the acidity of the fruit.

Causes of Corrosion

A systematic investigation of the corrosion of tinplate under conditions comparable with those obtaining in a can was therefore called for, and it was felt that the starting point would consist in studying the effect of a typical fruit acid like citric acid in dilute solution on (a) the steel base of tinplate, (b) tin, (c) the tin-iron couple, and (d) tinplate itself. These investigations also involved studying the effect of pH , oxygen and the products of corrosion on the further corrosion of these materials, *i.e.*, of tin salts on the corrosion of iron, and of iron salts on the corrosion of tin and iron in the presence and absence of air. Other studies included the effect of introducing into the system sugars, various colloids, sulphur compounds, such as might be derived from fungicidal sprays.

The influence of pH on the corrosion of steel and tin in the presence and absence of air at ordinary temperatures has been determined and it has been shown, particularly with certain types of steel, that oxygen actually stimulates the evolution of hydrogen as the pH increases from 4 to 5.5. Changes in the pH have also been shown to affect the relative positions of corroded and non-corroded areas on steel specimens. Tin corrodes in fruit acids only in the presence of air, but is attacked both in the absence and presence of air when coupled with steel.

Data regarding the action of various accelerators and inhibitors of the acid corrosion of steel have been obtained over a pH range. A few mg. per litre of sulphur either as hydrogen sulphide or sulphur dioxide will double the rate of acid attack on steel at high acidity (pH 2.4), but actually protect the steel above about pH 4.0. Colloidal and other inhibitors of hydrogen production exert their maximum effect at high acidity and are less effective at low acidity.

Diffusion of Hydrogen through Tinplate

Previous knowledge regarding the behaviour of the tin-iron couple has been confirmed and extended by work at the Low Temperature Research Station. In general, it has been shown that factors which decrease the corrosion of one of the members of the couple increase that of the other. Coupling with tin or the mere presence of tin in the same solution enormously reduces the corrosion of iron. Tin salts in solution act as typical inhibitors of corrosion, a fact which is largely responsible for the relative immunity which tinplate enjoys. Further causes of this relative immunity lie in the fact that there is a reversal of potential between the steel and tin soon after immersion, the tin becoming slightly

anodic to the steel; also the small areas of exposed steel are the only avenues for evolution of hydrogen in tinplate.

Recently the importance of a study of the diffusion of hydrogen through steel and tinplate has come to light and results under this heading are shortly to be published. It has been found that hydrogen passes through tinplate, probably on account of the porosity of the tin coating, and it is obvious that the rate at which this occurs will affect the incidence of hydrogen swells. The work in this connection affords experimental evidence that accelerators and inhibitors affect the rate of deposition of hydrogen on the metal rather than the rate of conversion of atomic to molecular hydrogen, as has been supposed.

One of the most important observations which has been made here in regard to tinplate is the variability in the rate of corrosion of different samples of steel in dilute citric acid. Some samples have corroded 300 to 400 per cent. faster than others and the difference in behaviour is still apparent when the samples are coupled with tin. It is early yet to make any statement as to the causes of this, but it is obvious that the subject is likely to be of great practical importance in the fruit canning industry.

The work on the effect of pH on the corrosion of tinplate has now found practical application. The addition of a small quantity of citric acid to certain fruits of low acidity, such as prunes, sweet cherries and greengages, which normally give much trouble, brings about substantial reduction in the rate of formation of hydrogen swells and perforations. There is also evidence which is not yet complete that certain fruits which respond unfavourably towards the addition of acid will respond favourably to an adjustment of the pH in the other direction, brought about by adding a small quantity of sodium citrate. Advantage has also been taken of the presence of substances in raw beet sugar which inhibit the production of hydrogen to effect a substantial reduction in the rate of formation of hydrogen swells.

Correspondence

Magnetic Separators

SIR,—With reference to the report of Mr. J. T. Gray's paper on "Modern Vitreous Enamelling" which appeared in the Metallurgical Section of THE CHEMICAL AGE of February 2, there are several comments we would like to make regarding Mr. Gray's statement on magnetic separators. We are the makers of the first and practically all the magnetic separators which have been supplied for vitreous enamel, and we look upon the serrated edges incorporated in our machines as a most essential feature. Mr. Gray states these serrations have a retarding effect on the flow and that owing to the sluggish action these are unnecessary. With the serrated edges any magnetic material has many more chances of being caught than if it had passed over one edge per magnetic unit only. The interval between the cleaning down which is required, when serrated edges are used, is far longer than when a plain machine surface only is used, and the slight extra trouble is compensated for by the fewer times the machine has to be cleaned down.

It can easily be shown by iron filings on a permanent magnet that the iron will tend to collect at the edges of a magnet, and, consequently, if there are more edges iron particles are more liable to be caught. The statement that the flow of material is adjusted by regulating the magnetic field is a mis-statement, as if the hinged bar is lowered by means of the set screws it is obvious that the regulation of flow is carried mechanically and the strength of the magnetic field has nothing at all to do with the quantity passed. Also the statement that the primary magnets are formed of hinged castings should obviously read "secondary magnets," as the primary magnets are mounted below the trough and magnetise the upper bars by induction in exactly the same way as is done in our machines.—Yours faithfully,

THE RAPID MAGNETTING MACHINE CO., LTD.

Magnet Works,
Lombard Street, Birmingham.

Metallurgical Section

April, 6, 1935

Increasing the Strength of Tin

SOME properties of tin containing small amounts of aluminium, manganese or bismuth were reported by Professor D. Hanson and Mr. E. J. Sandford, both of the University of Birmingham, in a paper read before the Institute of Metals, at their meeting in March. Aluminium, it was pointed out, has a large effect on the strength of tin; 0.5 per cent. increases the strength of pure tin from 1 to 5 tons per square inch, while the elongation decreases from about 80 to 30 per cent., but further additions, up to 1.0 per cent., produce no appreciable effect. These improved properties are not permanent when the alloys are stored under normal conditions, owing to a deterioration of the material which commences at the surface and spreads slowly inwards. Actually a brittle "skin" is formed, which cracks when the alloy is bent or otherwise strained; the "core," however, remains ductile for long periods.

The effect of manganese on the strength of tin is only slight, and is practically independent of heat treatment. Manganese is probably soluble in solid tin to a very small degree at most temperatures. The addition of 0.10 to 0.15 per cent. greatly refines the crystal size of the tin at all temperatures; the effect of 0.2 per cent. is much less, and with manganese contents exceeding 0.3 per cent. a fine grain is again produced. Slight variations in tensile strength have been correlated to corresponding variations in crystal size. Bismuth, however, greatly increases the tensile strength of tin, from 1.0 ton per square inch in the pure metal to 4.5 tons per square inch, with a bismuth content of 4 or 5 per cent. Heat treatment has little effect on the strength, but alloys heat treated near the eutectic temperature have low elongations. Bismuth also has a profound refining effect on the grain size of tin, producing much finer grain structures than any other alloying element yet investigated.

Nature of Tinplate Coatings

NEW evidence upon the nature of the bond between the steel and the tin coating on tinplate was given in a paper which Mr. W. E. Hoare read before the Swansea Technical College Metallurgical Society, in December last, and now published by the International Tin Research and Development Council (Technical Publication, Series A, No. 14). The removal of unalloyed tin from the tinplate by means of a selective reagent, has been found to leave a thin layer of an iron-tin compound firmly attached to the steel, and the characteristics of this layer have been closely studied. Analysis of a pure sample gave indication of an alloy containing 81 per cent. of tin, which approximated very closely to that required by the formula FeSn_2 . At a temperature of 496°C ., this compound decomposes with the formation of tin and a new phase, FeSn , which is distinguished by its lower resistance to the attack of

etching reagents. Normally the thickness of the layer, as determined by microscopical methods, is only 0.00002 inch.

Experiments indicate that at temperatures as low as 150°C ., the initial formation of a film of FeSn_2 at the iron-tin interface is relatively rapid, and that this initial film permits only a very slow diffusion of the reacting elements. A specimen of charcoal tinplate showed no distinct increase in the amount of this compound after annealing for 250 hours at 150°C ., but at 180°C . there was a small increase in the layer which amounted to an additional thickness of 0.000006 inch. The tinning process has been analysed into a series of reactions from which it is deduced that imperfections in the coating will be either true pores (extending through both the tin and alloy layers to the steel) or potential pores (where only the compound layer is exposed through the stripping of the tin in the later stages of the tinning process). "Grease lines," and mottle defects were discussed by Mr. Hoare, and it was shown how the defect known as "scruffy" may result from the interaction of iron and molten tin under working conditions.

Effect of Titanium on Iron and Steel

ALTHOUGH claims have been made to the effect that an increase in the strength of cast-iron up to 50 per cent. has been obtained by the addition of titanium, it is significant that few attempts have been made to introduce titanium into cast-irons for this purpose in England, states a recent Bureau Report (No. 130) of the British Cast Iron Research Association, where Mr. E. Morgan gives a review of published information concerning the effect of titanium on iron and steel. It is pointed out that results of investigations in general have been vague and no very clear conception appears to exist regarding the influence of titanium on cast-iron. The fact that titanium has a strong affinity for oxygen and nitrogen has caused it to be employed to a large extent in American iron and steel foundries for the removal of oxygen and nitrogen, which are dissolved in the molten metal, and strong claims have been made for its use in the production of sound castings.

Some remarkable claims following the use of titanium have been made by Treuheit ("Stahl und Eisen," 30, 1192), who states that there are improvements in the machining qualities, an increase in the hardness of the chill, increase in general mechanical properties and an increased soundness of the castings, 0.05 per cent. titanium being effective. Stoughton ("Bulletin of the American Institute of Mining Engineers," 1912, 1245) also found that steel and cast-iron are improved by additions of titanium. He came to the conclusion that, with the correct addition of titanium, it is possible to increase the strength of cast-iron by 30 to 50 per cent.,

but he attributes the improvements not so much to the direct influence of titanium as to its cleansing action in removing such impurities as oxygen, oxides, nitrogen, occluded slag and sulphur.

In view of the difficulties associated with the addition of titanium to the melt, it is interesting to note that Comstock ("Transactions of the American Foundrymen's Association," October, 1933) has developed an alloy which is claimed to be readily soluble in cast-iron. This alloy contains 15-20 per cent. titanium and 15-20 per cent. silicon, the remainder being chiefly iron. It is low in carbon and aluminium and is said to dissolve readily in hand-ladles, although the recommended method of making the addition is by dropping it in the stream of metal as it leaves the cupola. The best results are obtained by using, in conjunction with the alloy, small amounts of chromium in order to counteract of graphitising effect. In this way it is claimed that the beneficial results of a fine graphite pearlitic structure are obtained. Results obtained with the electric furnace iron are said to be more regular than those obtained with cupola metal. The titanium is stated to be present in the cast-iron in the form of carbide or cyanonitride.

Ferrous Alloys in the Soviet Union

THE alloy iron and steel industry of the Soviet Union is showing signs of a rapid development. Under the second Five Year Plan the production of alloy steels is anticipated to reach $3\frac{1}{2}$ million tons. Alloy irons are regarded as equally important, for the Zaporozhstal plant is now making extensions for the production of ferro-chrome alloys, with an annual output of 10,000 tons commencing in 1936. Simultaneously, the production of ferro-wolfram alloys will be taken up, to the extent of 1,500 tons per year, and at the Zestaphoni plant some attention is being directed to the production of ferro-molybdenum alloys. These few instances, considered quite apart from others, are still more remarkable when we remember that in the days before the revolution Russia had no ferrous alloy industry, although there were enormous mineral resources awaiting development. Nearly 60 per cent. of the world's known deposits of manganese ore are located in the Soviet Union, and these deposits form the source of raw material for the Zestaphoni and Zeporozhye plants whose total annual production of ferrous alloys now exceeds 230,000 tons. Ferro-silicon is produced at the Zeporozhye plant to the extent of 30,000 tons per year.

Temper Brittleness in Nickel Steels

BY means of a survey of the literature, and a comprehensive series of experiments, W. Bischof ("Archiv für das Eisenhüttenwesen," 1935, 8, 293) has made an evaluation of the validity of the two theories of the cause of temper brittleness, *viz.*, the assumption of precipitation processes, or of the modifications in certain special carbides, as the cause of the brittleness. The experiments, which were made on a series of carbon, nickel, chromium, manganese and nickel-chromium steels of representative types, comprised an examination of the relative value of physical and mechanical methods for determination of brittleness, a detailed investigation of the influence of time and temperature of single and repeated tempering treatments and of rate of cooling, and a study of effect of

variation in temperature of quenching prior to tempering. The capacity of the steels for precipitation hardening was studied and the results were examined in the light of the susceptibility of the respective materials to the development of temper brittleness. The results obtained lead to the conclusion that temper brittleness is attributable to the action of certain special carbides of chromium and manganese. On rapid cooling the high-chromium or manganese-carbide is held in solution to a low temperature, at which it precipitates chromium or manganese and is transformed into the lower-chromium or manganese-carbide. The brittle condition ensues if the rate of decomposition of the carbides is greater than the rate of absorption of the precipitated chromium or manganese into the ground mass. Inhibiting elements, such as molybdenum, and modifications in method of production are stated to act by modifying these processes.

Aluminium Films as Mirrors

IT is now possible to prepare mirrors by coating glass with aluminium in the form of a film which is obtained by a vacuum evaporation technique. These mirrors have several properties which ordinary silvered mirrors do not possess. According to Dr. J. Strong, whose work has made possible the coating with aluminium of glass surfaces up to 36 inches diameter, the development of aluminised mirrors is likely to become important. In a paper published by the Astronomical Society of the Pacific, he points out that the aluminised mirror will never tarnish if it is kept dry. The reflectivity of aluminium for visible light is almost as high as that of silver, but for ultra-violet light it is far better than that of silver; in addition, aluminium films do not scatter light.

Two methods may be used for coating a glass surface with aluminium. The older method of cathode disintegration or "sputtering" requires a moderate vacuum of the order of 0.01 mm., a cathode of the same size as the glass surface being placed opposite to the glass, at a potential of 10,000 volts. Under these conditions an opaque film of aluminium is obtained in the course of 50 or 60 minutes. For the evaporation process a vacuum of 10^{-4} mm. of mercury is necessary, the pure aluminium metal being heated by small tungsten coils which are arranged in front of the glass surface. As each atom of aluminium evaporates it leaves the tungsten coil and travels by an uninterrupted straight path until it strikes glass surface or the inner walls of the vacuum chamber, where it condenses to form a film. As such a film is one ten thousandth of a millimetre thick, very little heat is released on the glass as a result of the condensation. The films have exactly the same degree of polish as that of the underlying glass surface. Preliminary determinations of the reflectivity show that green and yellow is reflected to the extent of 89 per cent., blue 87 per cent. and violet 86 per cent.

Steel for Bakelite Moulding Dies

NICKEL molybdenum steel of low carbon content and special depth-hardening capacity has been developed for dies used in moulding bakelite. The dies are annealed at 1,450°-1,500° F. and carburised at 1,600°-1,650° F. for a period dependent on the depth of case required. After cooling in the carburising box the dies are hardened by oil quenching from about 1,500° F. and tempered at 300°-400° F.

Platinum, Gold and Silver

Some Direct Industrial Uses

DIRECT industrial uses for platinum, gold and silver were discussed by Mr. Edmund Downs, M.Sc., F.I.C., in a paper read before the Midland Metallurgical Societies at Birmingham on February 28.

The Refining of Platinum

Platinum is recovered from alluvial sand by hydraulic concentration and is delivered as "crude metal" for the refining process. This consists in dissolving the metal in aqua regia and precipitating the platinum with ammonium chloride. The ammonium platonic chloride thus formed is then calcined to metal in the form of sponge and finally melted or compressed and forged at a high temperature. This refining process may be repeated several times to get the purity required. Other refining processes are, of course, used, but they need not be enlarged upon here. The extraction of platinum from the Canadian ores is a different matter and here the platinum metals are finally found in the anode slimes from the electrolysis of nickel in the case of the electrolytic refining of nickel and in the residues left after the volatilisation process in the case of the Mond process. These rich residues are then treated for the recovery of platinum by well-known refinery methods.

The South African ores are concentrated hydraulically, giving a rich product of platinum metals as sulphides which is sent to the refinery for further treatment. The product of the refinery is in the first place platinum sponge as mentioned above. This sponge is a finely-divided powder, and by careful pressing and forging can be compressed into an ingot which for all purposes is equal to if not superior to the melted metal from the point of view of subsequent mechanical treatment, e.g., rolling and drawing into wire. Where a harder platinum is required, as, for example, by alloying with iridium, melting of the metal is essential and may be done either by the old method, using a lime furnace heated by an oxy-hydrogen or oxy-acetylene flame, or by the more recent method of electrical heating, using a high-frequency induction furnace.

Platinum as a Catalyst

The most interesting chemical property of platinum is its catalytic activity in certain reactions. In all its various metallic forms, whether as coarse sponge or colloidal platinum, the activity is present and, generally speaking, the finer the state of division of the metal the greater its catalytic powers. An explanation of this is the formation of an oxide on the surface of the metal or adsorbed or occluded oxygen rendering the oxygen exceedingly active, although this explanation can only hold in oxidising reactions whereas platinum is also able to act as a catalyser in certain reducing reactions. This property can be partially or completely inhibited by certain "poisons," the most powerful of which are found to be reducing agents, as, for example, sulphuretted hydrogen and arsenious compounds which, no doubt, interfere with the formation of the suggested active oxygen layer.

It is only natural that the special properties of platinum in its action as a catalytic agent should find ample scope in the chemical industry. To-day, large quantities of the metal are used in the production of synthetic nitric acid and sulphuric acid. In the former process, ammonia is oxidised to nitric oxide and then to nitric acid, and the catalyst is used in the form of pure platinum gauze made of wire 0.06 mm. diameter and containing about 80 meshes to the inch. A finer gauze containing 3,600 meshes per sq. cm. is also used for catalytic purposes. American practice appears to favour an alloy of platinum + 10 per cent. rhodium or other special alloys, which are understood to give a greater conversion efficiency and to have a longer life, but the use of alloys in place of pure platinum is by no means general practice.

In the manufacture of sulphuric acid, platinum has long been used and for a long time held a complete monopoly. Within the last 15 years, however, a serious competitor has arisen in "vanadium" catalyst, but the extravagant claims originally made for this have not been entirely borne out in practice and platinum is still in great demand as a catalyst

for the oxidation of sulphur dioxide. The original form of the metal used for this purpose was platinumised asbestos prepared by igniting asbestos soaked in platonic chloride, thus forming the active material of platinum sponge. A later development in the preparation of the catalyst is the substitution of silica gel for asbestos as the carrier, and this has greatly increased the efficiency and useful life of the catalyst. This discovery represents a very notable advance in the cheapening of the cost of the oxidation of SO₂ in the sulphuric acid industry, and has undoubtedly enabled platinum to meet and hold its new competitor. An important consideration in the use of platinum is, of course, the high scrap value of the spent catalyst.

Platinum Plating

Platinum plating has to some extent been superseded by rhodium plating. Platinum plating, however, is still in demand for special requirements and is considered to be superior to rhodium for those parts which are subjected to high temperatures, e.g., in contacts where arcing or sparking occurs, and for the plating of medical and surgical instruments.

The platinum plating solution generally used in this country consists of a solution of sodium hexahydroxyplatinate, Na₂Pt(OH)₆, which is made slightly alkaline by the addition of caustic soda. Conducting salts such as sodium sulphate and sodium oxalate are also added. The working temperature of the bath is between 65-80° C. at a cathode current density of approximately 7½ amperes per sq. ft. and very high electrode current efficiencies of almost 100 per cent. are obtained. The average thickness of the platinum deposit is 25 millionths of an inch (0.000025), which is a bright hard plate and requires practically no subsequent polishing. For building up an excessive thickness of platinum plate a lower current density of 3 amperes per sq. ft. is advisable, but current densities higher than 12 amperes per sq. ft. may result in "burnt" deposits. An insoluble anode is used and may be either of platinum, nickel- or platinum-plated copper. Platinum is, of course, too expensive for general use. For all usual purposes the platinum content of the bath is kept at 1 per cent., and at this composition the throwing power and general working efficiency of the bath are excellent.

Cathode Dispersion for Precious Metals

Cathode sputtering or cathode dispersion is a recent development in gilding. The projection of metals of high melting point in the gaseous form from cathode surfaces in high vacuum is a phenomenon that has been known for some time, but it is only in recent years that certain applications of this process have been developed so as to be of commercial value and use to industry and the arts. For instance, if pieces of glass are placed in a chamber which can be evacuated and within which are provided electrodes of gold, then on passing an electric current of high voltage through the electrodes the gold will be dispersed and projected upon the glass with the formation of a mirror of that metal, the film of which is less than 1 millionth part of an inch in thickness.

The same result can be achieved with silver or platinum, and mirrors so obtained have the advantage over those produced by chemical means, in that there are no chemicals absorbed or contained in the surfaces. As the process is one in which there is very little or no heat in the metallic gaseous stream it is possible to coat fabric or other organic material with a layer of gold or other noble metal. In this way, gold and silver cloth can be produced having all the properties and suppleness of fabric with the metallic sheen and beauty of cloth surfaces made with gold or silver wire. Moreover, the quantity of gold is very much less per unit surface and is equally brilliant.

Liquid Gold for Pottery Decoration

An everyday and not unimportant use of gold is for pottery decoration, the gold being applied to the pottery in the form of "liquid gold." Liquid gold is really a solution of a complex organic gold compound in certain essential oils. The first stage in the preparation of liquid gold is the pro-

duction of what is called gold lustre. The final product, as used in the ceramic industry, is obtained from this gold lustre by addition of other materials to modify the colour and assist the adherent properties; certain resinous organic diluents are also added to give it the necessary viscosity. When applied to the pottery ware, which is fired usually in an electric furnace, the gold is left as a natural bright colour. Matte surfaces are obtained by the use of solutions in which metallic gold is held in suspension and is applied to the pottery in the ordinary way. The resulting surface, after firing is scoured with fine silver sand or agate to produce the final effect. Various shade effects may be obtained, such as red, green or yellow, by the addition of greater or smaller quantities of silver.

Another form of application of gold to pottery and used chiefly for heavier and more expensive decoration is by the use of "potters' " gold. This gold is a specially-prepared dark brown amorphous substance which is then amalgamated with mercury, certain fluxes added and ground to a fine powder. This is applied with a mixture of resin and turpentine as a medium and afterwards the article is fired and usually scoured. The amount of gold on pottery ware is small, but, generally speaking, the thickness of the film of burnished gold is greater than that of ordinary liquid gold, while potters' gold gives the thickest films of all. A final class of liquids where gold is used is in the so-called "lustre" colours, where varying amounts of gold are added to produce certain tints after firing; for example, red, pink, blue and also the coppery effect.

The consumption of gold by the pottery industry in this country for decorative purposes amounts to at least 20,000 ozs. per annum.

Silver bullion, as received by the refinery, may vary in purity from 50 to 92 per cent. silver and may contain either gold or the platinum metals, or both. The choice of the method of refining is determined by this initial purity and composition and the character of the base metals which are present. Three methods of refining are available: (1) Metallurgical, where the bullion is cupelled with lead on a large cupellation furnace. (2) Chemical, where the silver is dissolved in hot strong sulphuric acid along with other soluble metals present, and the silver subsequently separated by precipitation with copper or iron. (3) Electrolytic, where the impure bullion is made anode in an electrolytic cell and pure metallic silver is deposited on the cathode.

Adsorption of Oxygen by Silver

A very interesting and unique property of silver is its ability to adsorb large quantities of oxygen when in the molten state. Pure molten silver just above its melting point will adsorb 20 times its own volume of this gas which is practically all liberated during the subsequent solidification of the metal resulting in a "split" which covers the whole of the exposed surface of the cast bar. The effect of this on the silver is to cause sponginess and brittleness and renders the silver completely useless for most industrial purposes. During the melting of fine silver, therefore, it is essential to thoroughly deoxidise the molten mass, and, fortunately, this can be carried out comparatively simply by adding charcoal in sufficient quantity to completely cover the surface of the silver and allowing to stand for 5 minutes. Removal of the last traces of oxygen can only be carried out by a metallic deoxidiser, e.g., copper phosphide or magnesium.

Non-Tarnishable Silver

During recent years a considerable amount of work has been carried out on the sterling alloys of silver with a view to producing a non-tarnishable product which can still receive the hall-mark. The base metals added to produce the effect have been chiefly nickel, cadmium, zinc, antimony and manganese, and very extensive tests and trials have been carried out. Results, however, on the whole, have been disappointing and a sterling silver alloy completely resistant to tarnishing is not yet available. The most successful of the alloys to date is an alloy containing 7.2 per cent. manganese, with 0.3 per cent. aluminium, and this is almost completely non-tarnishable, but for reasons of policy the attempt to put this on a commercial basis did not materialise. At present, therefore, the permanent bright effect so largely sought after by the users of sterling silver ware can only be obtained by electro-plating the object with a metal such as platinum or rhodium.

An important series of silver alloys which have found considerable use in industry are silver solders, which are used for all purposes where highly reliable joints are essential. The composition of these solders varies considerably and may contain as low as 10 per cent. silver, or as high as 80 per cent. As solders, they are free-flowing and have the highly desirable properties of high malleability and ductility. They also have a high tensile strength with a comparatively low melting point between 700 and 750° C. Zinc and copper are the chief base metals used for alloying purposes, but other solders contain, in addition, varying amounts of tin and cadmium. A new class of solders which have recently become available are the manganese-silver solders containing 60 per cent. silver, 30 per cent. copper and 10 per cent. manganese, or slight variations from this, and are specially suitable for all classes of work upon stainless steels and monel metal. Another class of silver solders which are an improved substitute for the ordinary soft solders contain 5.20 per cent. silver with tin as the base metal, and have the very low melting point between 300-400° C.

An unusual silver brazing alloy which should be mentioned is one sold under the name of "Silfos"—patented in America a few years ago. It differs from all other silver solders in that it contains 5 per cent. phosphorus in addition to silver and copper and has a melting point of only 710° C. It is very free-flowing, penetrates quickly and alloys with adjacent metal, making strong, sound, ductile joints. These joints show an average tensile strength of 33,000 lb. per sq. inch with an elongation of 17.2 per cent. in 2 inches.

Silver for Chemical Plant

Within recent years the use of silver in chemical plant has shown considerable development, especially in the food trades, where it is essential that the materials should be prepared under the utmost cleanliness and free from any possible taint resulting from metallic corrosion during the various stages of preparation. The properties of silver make it an ideal metal for such purposes as, speaking generally, organic acids, and fruit juices have no effect whatever on the metal. Undoubtedly the original cost of the silver plant is high, but it must be remembered that the scrap value of the plant is usually at least 70 per cent. of the original cost and, hence, such plant should be regarded rather as a lock-up of capital than an actual expenditure.

The silver used for all chemical plant is electrolytically-refined metal of at least 9997 fineness and free from base metal impurities which are undesirable where autogenous welding forms part of the fabrication of the silver utensil. Fine silver can, of course, be made into tubes up to 2 in. diameter, wire down to 0.0005 in. and sheet down to transparent thickness. A notable example of the application to silver plant is found in the acetic acid industry, where the very corrosive action of acetic acid at the moment of condensation is liable to cause considerable corrosion of the condenser coils. These coils were formerly made of copper, but have now been replaced to a large extent by silver coils which completely withstand the corrosive action of the acid, and owing to their higher thermal conductivity they can be made much smaller than the original coils of copper.

To encourage the consumption of silver and its alloys in industry a research associateship has recently been established at the United States Bureau of Standards by silver producers and those immediately interested in its development as an engineering material. Their progress reports have already reviewed the possible range of usefulness of silver and emphasise the large and promising field that awaits the metal in the food manufacturing and kindred industries in the fabrication of plant where linings of silver may be made use of. This lining would be either loosely fitting into the vessel or an electrodeposited lining, or a lining known as "Duplox" or rolled silver. Of the three types of lining the rolled silver sheet is superior, being non-porous, and plant of this material can be fabricated into any shape or size required provided a suitable base metal backing is used.

The Bureau of Standards is also investigating the effect of small quantities of silver upon other metals, e.g., tin and lead. In the case of a tin-silver alloy containing 3.5 per cent. silver, they find that the tensile strength of the alloy is in excess of 5,000 lb. per sq. inch, whereas pure tin gives a value of only 2,000 lb. per sq. inch. Pipes of the same material specified as $\frac{3}{8}$ in. and 5 oz. per ft. were also tested for bursting pressure and showed a value of 2,550 lb. per sq. inch, whereas the pressure for a pure tin pipe was 1,700 lb.

per sq. inch. In the case of the lead alloys, their results show, although the investigation is by no means completed, that alloys containing not less than 5 per cent. silver are definitely more resistant to the corrosive action of sulphuric acid than pure lead.

Silver is now finding application in the addition of the metal to pewter to the extent of 8.5 per cent. and also in relatively small quantities as an alloy with cadmium and copper for bearing metal in the automotive industries.

An interesting effect of very small quantities of silver on the annealing temperature of copper has also been investigated. It has been found that copper containing 0.05 per cent. silver begins to soften at 350° C. and is complete at about 450° C., while the approximate range of annealing of pure electrolytic copper is 200-300° C. This finds an interesting application in the use of argentiferous copper wires for electrical transmission. With ordinary silver-free copper wire it is found that it is completely softened over a period of time at temperatures as low as 100-150° C., but the addition of 0.05 per cent. Ag. has the effect of raising this softening temperature beyond that to which the wire is likely to attain as a conductor of current. This small quantity of silver added has no effect upon the mechanical properties of the copper or upon its conductivity.

Silver Plating

The use of silver in the plating bath accounts for quite a large annual consumption of the metal. Within the last few years considerable improvement has been made in the silver anode of the bath, and the greater purity of the metal now used—usually 9997 quality—together with the special heat treatment of the anode sheet have reduced anodic troubles, such as pitting, and the formation of black anode slime to a minimum. As a result, the solution of the silver anodes proceeds perfectly uniformly and can be kept in the plating bath until the original sheet is merely a thin gauze representing a scrap figure as low as 3 per cent.

An interesting biological property of silver discovered within the last fifty years, and one which is now being taken

advantage of, is its effect upon bacterial life. Certain metals, particularly silver and copper, are found to possess what is called oligo-dynamic action, which simply means that minute traces of these metals in solution in water are able to kill any existing bacteria in the water, and, further, that the water is rendered sterile to further contamination by bacteria. Silver possesses this property in a marked degree, and of the metals known is by far the most bactericidal.

Electro-Catadyne Properties

The quantity of silver in solution is very minute and one part in 1000 millions (a quantity which is undetectable by ordinary analysis) is apparently sufficient to exhibit this oligo-dynamic action, which is considered to be due to ionisation resulting from a film of active oxygen—adsorbed or otherwise—on the surface of the metal, the silver ions which are formed being capable of adsorptive union with the protein of bacteria, thus causing dehydration and death.

A direct and interesting application of the electro-catadyne method in this country is the treatment of the water of public swimming baths. Water thus treated has none of the disadvantages of chlorine-treated water. Plants are in operation at the Derby pool, Wallasey, and at the Roehampton baths, where water is kept in perfect condition with low bacteriological counts in spite of the very heavy bathing loads during the past summer. For carrying out the sterilisation, an electrolytic cell is fitted into a by-pass pipe connected with the main circulating system, so that a portion only of the circulating water receives the silver ions, which are sufficient for the sterilisation of the whole volume. The electrodes are of fine silver and the amount of silver passing into solution is regulated by the current input. There are also catadyne and electro-catadyne plants in use in parts of Europe for the sterilisation of drinking water, vinegar brewery waters, beer, mineral and table waters, dairy products and for food preservation in general. The degree of activation required varies according to the particular sterilisation, but from published accounts varies between 25 milligrams to 500 milligrams per metric ton of water.

Modern Stainless Steels

Their Properties, Characteristics and Uses

THE two types of stainless steel in most general use are the chromium steel (with about 13 per cent. of chromium) and the 18-8 nickel-chromium steel (containing 18 per cent. of chromium and 8 per cent. of nickel). The nickel and chromium contents are varied with advantage for special purposes, said Mr. S. A. Main, B.Sc. (Hons.), F.Inst.P., in a paper read before the Royal Society of Arts on March 13. The addition of other elements, such as molybdenum or silicon, usefully improves the hardness of the cutlery steel.

In the chemical industries and the manufacture and canning of foods, 18-8 nickel-chromium steel satisfies a large range of uses, involving many kinds of active agents. Sulphuric and hydrochloric acid are among those against the attack of which the standard type of steel is not entirely effective. By modifications in composition, or the adoption of suitable expedients, its use is made possible in many processes involving the use of these and other acids. The manufacture of nitric acid, celluloid, artificial silk, wool, rubber, explosives, leather, imitation leather, paper, paint and perfumery are among the many chemical processes in which acid-resisting steels are employed, while the canning and bottling of foods and the handling and conveyance of milk also call for large quantities.

Chemical processes involving reactions at high temperatures and pressures demand further special properties in the material of the vessels and fittings. These are being well met by steels of a heat-resisting type, rather beyond the scope of the present lecture. Where suitable as regards their resistance to corrosion, the plain chromium steels have advantages over the nickel-chromium steels for purposes where stresses have to be sustained, owing to their better elastic properties; their tenacity can also be better graduated to suit requirements.

Steam turbines of a total capacity of some six million horse-

power are now equipped in whole or in part with blading of a nickel-chromium steel specially developed for the purpose.

The manufacture of stainless steels and their preparation into articles or components for use requires a highly-developed technique, and in the steelworks it has been found desirable to segregate the production of the nickel-chromium types of steel, using specially-designed plant. Cleanliness of the steel is important to the final properties, and close control with fettling of surfaces must be exercised in rolling and forging operations to avoid serious waste. The mirror finish required for special purposes has necessitated the development of polishing processes, since the areas to be prepared are much larger than any which had to be dealt with before the coming of stainless steels. With the development of a special welding technique excellent welds are now readily made by either the oxy-acetylene or the metallic arc processes. The problem of weld decay in the 18-8 steel, due to its small carbon content, has been completely remedied by suitable addition to the steel of special elements such as titanium.

Stainless steels, unlike precious metals such as gold and platinum, owe their non-rusting property to the impervious character of an extremely thin surface film produced by contact with the air. The similar film on ordinary iron and steel is of a porous texture, and non-protective. The reality of these films has been demonstrated by Dr. Ulick R. Evans, of Cambridge University, who has isolated and examined them. Similar temper colours on stainless and on ordinary steels require about double the temperature in °C. in the former type for their formation.

The total American production of non-corroding and heat-resisting steels in the peak year 1930 was 60,000 tons, a figure which could probably be doubled to represent world production: of this, more than half, or 55 to 60 per cent., is of the 18-8 nickel-chromium type.

Some Recent Metallurgical Patents

Hardening-Baths

To the hardening-baths described in the parent specification is added gum arabic, glucose or similar materials such as solutions of gelatine, albumen, dextrin starches, plant gums, agar-agar, tragacanth or alkali cellulose. (See Specification No. 419,196, of R. Feix and E. Scheinberger.)

Ductile Steel Alloys

DUCTILE steel alloys contain about 2 to 30 per cent. of chromium, up to 0.5 per cent. of carbon, and more than about four times as much niobium as carbon. The preferable niobium content is between eight times the carbon content and eight times the carbon content plus 2 per cent. The alloys preferably contain not more than about 1 per cent. of manganese, 1 per cent. of silicon, and 1 per cent. of impurities. Steel alloys each containing chromium and one of the metals uranium, molybdenum, and tungsten instead of niobium are referred to by way of comparison. (See Specification No. 419,680, of Electro Metallurgical Co.)

Treating Auriferous Pyrites

In working up auriferous and cupriferous arsenical pyrites or such pyrites in admixture with sulphur pyrites, a part of the ore is roasted and smelted to matte which is blasted in a converter, whilst the remainder of the ore, after roasting, is charged direct into the converter to be blasted together with the matte. By this procedure, loss of gold in the converter slag is minimised. Roasting of the ore to be passed direct to the converter is so controlled that all arsenic is roasted out whilst leaving the bulk of the sulphur, and that any iron present remains in the divalent state; such ore should, when possible, have a higher gold and a lower copper content than that part of the ore which is smelted to matte. (See Specification No. 420,577, of A. R. Lindblad.)

Magnetic Alloys

To obtain constancy of permeability in the range of small field strengths in a nickel-iron alloy containing 30-90 per cent. of nickel and at least one added metallic constituent of low solubility, whose extent of solid solubility in the nickel-iron complex increases with rising temperatures, the alloy is heated to a temperature, usually 800-1,100° C., sufficient to produce a solution of the added constituent or constituents in the complex and then cooled slowly to produce a precipitation of the added constituent or constituents. Examples of the latter materials are silver, beryllium, antimony, magnesium and calcium. The alloy may also contain manganese up to 12 per cent., chromium up to 15, molybdenum up to 12, tungsten up to 10, copper up to 15, aluminium up to 5, silicon up to 5, vanadium up to 5, and cobalt up to 15. (See Specification No. 420,406, of Telegraph Construction and Maintenance Co., Ltd.)

Hard Alloys containing Carbides

In a method of producing hard alloys containing a carbide of a refractory metal such as tungsten, and a more fusible metal or alloy such as cobalt, the metal or alloy is added wholly, or at least to the extent of 35 per cent., in colloidal form to the carbide, and the mixture is pressed and sintered in known manner. The metal or alloy may be added in the form of a colloidal solution; for example, the hydro- or organo-sol, the solvent being evaporated after mixing with the carbide. The mixture after further mixing is pressed, and sintered *in vacuo* once or twice. Alternatively, the metal may be separated from the colloidal solution and introduced as a dry powder to the carbide. In the case of articles of a complicated shape, the mixture is dried only to the consistency of dough and then pressed, rolled or cast. The metal or alloy may also be introduced as a colloidal solution of its oxide or hydroxide, or a freshly-precipitated, highly-dispersed, semi-colloidal hydroxide or hydrated oxide, the mixture being subsequently reduced by hydrogen. (See Specification No. 420,544, of G. Dillon.)

Cementation

Melt baths for the cementation of iron, steel or alloys thereof are prepared by fusing together alkaline earth carbides and

inert salts such as common salt, potassium chloride or mixtures of the same in the presence of alkaline-reacting agents such as caustic soda, sodium carbonate or sodium oxide. The temperature of the baths used for the cementation varies between 700 and 1,050° C. In an example, the bath consists of 10 kgm. of potassium chloride, 10 of sodium carbonate and 1.1 of calcium carbide. (See Specification No. 421,014, of Deutsche Gold- und Silber-Scheideanstalt Vorm. Roessler.)

Rustproofing Ferrous Metals

An anti-corrosive coating is formed on ferrous metal by immersing the metal first in a bath containing phosphoric acid and then in a bath of oil containing graphite in colloidal suspension. The metal may be treated in a bath containing $\frac{1}{2}$ -1 per cent. phosphoric acid, washed to remove all traces of acid, and then immersed in a colloidal suspension of graphite in oil, preferably linseed oil, the suspension containing 1 fluid ounce of graphite per gallon of oil. The graphite fills the pores in the metal and in conjunction with the phosphate coating protects the ferrous metal from corrosion. (See Specification No. 420,461, of J. H. Tucker and Co., Ltd., and J. N. R. Hannam.)

Treating Metallic Surfaces

ADHERENT coloured coatings are formed on articles made of zinc or coated with zinc by dipping the articles in a bath consisting of an aqueous solution of a salt of a heavy metal other than iron to which a small amount, *i.e.*, 0.001-2.5 per cent., of a molybdate, *e.g.*, ammonium molybdate, has been added. The heavy metal salt is preferably nickel sulphate, the amount of sulphate used being up to 5 per cent. An ammonium salt, *e.g.*, 0.2-1.0 per cent. of ammonium chloride, may be added to the bath. The bath is regenerated by the addition of tartar, which fixes the oxide formed in the bath, the tartar being preferably added together with small quantities of the heavy metal salt and molybdate. (See Specification No. 419,469, of H. Tichauer.)

Hardening Iron and Steel

IRON or steel articles are hardened by heating them to red heat (850° to 950° C.) in a carbon-dioxide containing atmosphere and then quenching in a bath containing one or more resins or resin soaps and one or more carbon-containing substances dissolved or suspended in one or more oils or fats. The bath may also contain one or more nitrogen-containing substances and one or more metal compounds such as the metal salts of resin acids, metal formates or carbonyls. The articles may then be heated and quenched in any known manner. In an example the bath contains 12 parts of colophony dissolved in 100 parts of linseed oil to which is added 3 parts of nickel formate. Instead of or in addition to the formate 7.5 parts of urea may be added. (See Specification No. 416,316, of I. Budowski and H. Bardt.)

Tungsten Carbide Alloys

ALLOYS containing carbides, borides, silicides, or tellurides of tungsten, tantalum, or molybdenum, particularly tungsten carbide and one or more of the metals iron, nickel, and cobalt, are made by mixing the powdered components, heating the compacted mixture to incipient fusion or reaction temperature, removing the highly heated mass from the furnace, and pressing or centrifugally casting it during the ensuing rapid cooling. (See Specification No. 416,408, of J. H. L. de Bats.)

Chromium Alloys

ALLOYS of chromium with one or more of the elements phosphorus, aluminium, manganese, titanium, tungsten, vanadium, molybdenum, cobalt, or nickel, and which may also contain iron, are obtained by reducing chromium-bearing substances such as chromium ores or chromium oxide, say, in an electric furnace, in admixture with carbon or coal and one or more reducible compounds such as phosphates, clay, bauxite, manganese ores, rutile, tungsten, vanadium, or molybdenum ores, or cobalt or nickel ores. Silica or lime-bearing substances may be added during the production of the alloys. (See Specification No. 416,624, of H. D. Elkington.)

Metallurgical Section

May 4, 1935

Spectrographic Analysis of Aluminium

THE programme of standardisation for spectrographic methods of analysis—which consists in photographing the spectrum of the light emitted by vaporised metal, either by spark or arc, and determining certain lines which are characteristic of each element present—has been carried a stage further by a paper on the spectrographic analysis of aluminium, which Mr. D. M. Smith presented at the spring meeting of the Institute of Metals, March 6-7. In this work the intensity of the lines, under predetermined standard conditions, is a measure of the amount of any particular element which is present, but the methods adopted for accurately determining the intensities vary somewhat for different metals. Mr. Smith's paper dealt with the standardisation of a rapid spectrographic method for the quantitative estimation of copper, iron, manganese, titanium and silicon in the amounts which are ordinarily found in commercial grades of aluminium. In general, the spark method was found to give the more reproducible spectra, but the arc was useful for qualitative analysis and for the detection of traces of elements. A notable saving in time is effected by the use of these spectrographic methods of analysis, for one skilled and one semi-skilled worker can handle about thirty photographs per hour.

The Steel Deoxidation Problem

THE main problem in the production of steel is still that of proper deoxidation, or more so, the intelligent use of ferro-alloys for deoxidation. According to an article on the progress of alloy steels and ferro-alloys in 1934, which Mr. J. C. Vignos contributes to the January issue of "Blast Furnace and Steel Plant," the question of controlled deoxidation becomes very complex when the amount and composition of the oxides occurring in the bath, as the result of working the heats at different temperatures under varying slag compositions, is taken into consideration. He points out that considerable effort has been made to eliminate these oxides and their compounds by dissociation, deoxidation and final removal of the products of deoxidation. The dissociation of oxides and their compounds in the slag and metals, however, is greatly influenced by temperature and the nature of the deoxidising agents. The latter must necessarily be in excess, and the oxides which are formed during deoxidation must be stable in the system which is formed, whilst the removal of oxide compounds depends upon their melting point and fluidity in the system at different temperatures.

For complete deoxidation, the commonly used deoxidation agents—ferro-manganese, ferro-silicon, and silico-manganese—require additions of aluminium, but the alumina which is formed has a high fusion point, and as it lacks fluidity it is not removed from

the metal. The quantity of aluminium which is necessary for final deoxidation has been receiving serious consideration by nearly all producers of alloy steels in the United States during 1934, and it is now hoped that the amount necessary can be greatly reduced by a better understanding of the use of ferro-manganese and ferro-silicon under controlled conditions. With a much closer working relationship between the ferro-alloy producers and the steel producers which has recently been evident, greatly improved deoxidising agents are to be anticipated during the next few years. Iron-manganese silicates can be greatly influenced in their physical properties by the conditions and systems in which they are formed. Those which are formed in a high manganese oxide system appear to have greater fluidity in comparison with those formed in a highly ferrous oxide system, and consequently the former have a much better chance of removal from the metal.

Hardening of Carbon Tool Steel

WORK on the hardening characteristics of 1 per cent. carbon tool steels, which is in progress at the United States Bureau of Standards, has demonstrated that the critical quenching rate of a steel of this type may depend not only upon the grain size characteristics of austenite (the high-temperature constituent of steel), but also upon the initial structure existing in the steel before it is heated for quenching and hardening. Identical samples of a steel, which was not a so-called "controlled grain size" steel, were heat-treated to produce micro-structures which were widely different—a coarsely grained lamellar pearlite in one case, and a completely sorbitic structure in the other case. The pearlitic specimen when quenched in brine from 773° C. was more brittle, and it hardened to a greater depth and had a coarser grained fracture than the companion sorbitic specimen after being quenched from 815° C. It therefore appears possible to change a steel from a "deep hardening" to a "shallow hardening" steel, or *vice-versa*, not only by suitably changing the temperature attained just prior to quenching, but also by changing the initial micro-structure of the steel.

Yellow Stains on Tinplate

A DETAILED study of the yellow stain which sometimes forms on tinplate during storage has recently been carried out by Messrs. C. E. Beynon and C. J. Leadbeater at University College, Swansea, under the supervision of Professor C. A. Edwards, for the Research Committee of the South Wales Tinplate Association. This yellow stain is due to a type of surface oxidation which is electrolytic in character and intimately related to the conditions under which sheets are stored. The essential condition for its formation is that there should be comparatively free access

of air to one part of the sheet and restricted access only at some other. The trouble occurs where access of air is restricted, that is, at the middle of the sheets rather than the edges, and at the bottom of a heavy stack of sheets more than at the top of the stack where the sheets are not pressed into such close contact. Lithographing difficulties, it is reported, are not due to "yellow stain" alone, for degreasing, which does not remove the stain, enables sheets to be printed without trouble. A cathodic reduction treatment, however, has been devised to rapidly remove both the grease and the stain from sheets, which will then print normally. It is suggested that removal of grease from tinplate by the use of trichlorethylene vapour as a degreasing medium might be more efficient than the usual mechanical method now in use, although it is not yet known whether this would tend to prevent the development of "yellow stain." In view of its direct value to the tinplate industry, a summary of this research has been issued as one of the technical publications of the International Tin Research and Development Council.

Restricted Copper Production

THE principal producers of copper, excluding those of the United States, have recently been in conference in New York for the purpose of considering the problems of the industry in connection with the production of metal from sources outside the United States and for its sale in foreign markets. Participating in the conference were representatives of foreign companies having an aggregate current production of about 750,000 tons of copper per year, or more than 75 per cent. of the total foreign primary production of the metal, excluding Russia and Japan. As a result of the conference, a curtailment amounting to 240,000 tons per year from current production will be made effective by June 1, and the agreement will be in force until July, 1938. An organisation has also been created to compile complete statistical information to the end that, whilst an adequate supply of copper will be provided at all times, the accumulation of excess stocks will be avoided. There is to be no pooling of sales or fixing of prices, but an effort will be made to ensure stable markets and avoid wide fluctuations in price. In accomplishing this, uniform trade practices—so far as they govern sales, deliveries and terms of payment—will be adopted.

Copper Production in Canada

As a leading producer of copper, Canada holds a unique and somewhat strategic position among producing countries. Practically the whole of her production, which accounts for close to 15 per cent. of the annual world output, is in the form of a by-product of other base metals and of precious metals operations, principally nickel, gold, lead and zinc; consequently production costs are low, and also control of output cannot be exercised without curtailment of production of the associated metals. These factors, combined with the announcement on the eve of the conference that a peak output record of 184,000 tons was established in 1934, thrust the Canadian position into bold relief before the conference representatives. According to the Department of Mines at Ottawa, the copper-nickel mines of Ontario were the chief source of Canada's copper output in 1934. Two companies, International Nickel and Falconbridge Nickel, have been operating at record rates in order to meet the requirements for nickel in the

industrial markets of the world, and are, as a consequence, producing copper as a by-product metal, at a rate of over 90,000 tons per year, or about 57 per cent. of the 1934 Canadian output.

In Ontario, the International Nickel Company of Canada, the world's leading nickel producer, reports that net earnings in 1934 were in excess of any other year with the exception of 1929. This company has a controlling interest in the Ontario Refining Co., the largest copper refinery in the British Empire; blister copper produced by International Nickel is refined at this plant. Part of the company's nickel-copper matte output is shipped to the United States, and part to England, for the production of monel metal.

Effect of Copper on Cast Iron

A Review of Existing Information

A REVIEW of existing information on the effect of copper in grey and malleable cast iron is published in the April issue of the "Bulletin of the British Cast Iron Research Association."

It appears probable that, in small quantities, copper has little effect on the density of cast iron, but that in larger amounts the density is somewhat raised. Little information is available as to the effect of copper on the shrinkage of castings. With increasing copper content, the depth of chill is said to increase.

There is a preponderance of opinion in favour of copper as a graphitising agent. An investigation at present in progress in the B.C.I.R.A. laboratories indicates that the effect of copper in quantities up to between 2 per cent. and 5 per cent. is to graphitise the iron; above this percentage the copper tends to harden the iron. The exact percentage of copper at which the change occurs depends largely on the composition of the iron base. Much of the apparent confusion in the literature of the subject is due to the fact that many of the workers in this field have investigated the effect of copper up to only 2 per cent. or 3 per cent. The effect of copper on the form, size and distribution of graphite is uncertain; there is, however, some evidence that copper has a slightly refining action on the graphite.

There can be no doubt that additions of copper to Ni-resist decrease the amount of nickel necessary to form austenite and this indicates an effect of copper on the pearlite point.

Solid Solubility of Copper in Cast Iron

Little work has been done on the true solid solubility of copper in cast iron. From the examination of the physical properties of an iron of approximate composition, total carbon 3.00 per cent., silicon 2.25 per cent., manganese 0.72 per cent., it has been decided that the solid solubility was between 0.5 per cent. and 1.0 per cent. copper. Determinations of the solubility of copper in cast iron have been made by many workers. These workers, however, have made no attempt to attain equilibrium conditions by annealing or true liquid solubility conditions by quenching. Their values depend on the melting temperature and on the rate of cooling. Moreover, most of these determinations have been made on only one, or at the most on only a few base irons. The results given vary between 5 per cent. and 9 per cent. copper.

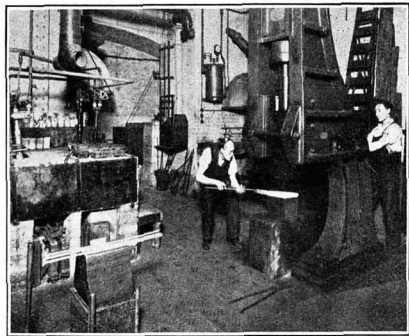
There is little doubt that the direct effect of additions of copper to cast iron is to increase the hardness of the matrix. This effect is, of course, modified by the influence of the copper on the combined carbon content. There is also little doubt that additions of copper to cast iron improve both the tensile and transverse strengths, while the deflection is somewhat reduced.

Even small quantities of copper greatly improved the resistance of cast iron to corrosion by acid mine water. The resistance of grey iron to molten caustic alkalies is improved by the addition of copper. An improved resistance to atmospheric and artificial salt spray corrosion in irons containing 0.3 to 0.4 per cent. of copper has been reported.

The presence of 1 per cent. to 1.5 per cent. of copper raises the yield point of the resulting malleable iron by about four tons per square inch.



Old Silver Rolls as formerly used by Johnson Matthey and Co., Ltd., at Hatton Garden.



Forging for a 400-ounce Platinum Ingot under a pneumatic hammer at Hatton Garden.

The Precious Metal-Refining Industry

IN 1910, Johnson Matthey and Co., Ltd., had already been established in Hatton Garden, on the outskirts of the City of London, for over a hundred years, a century of growth in scope, turnover and importance, but yet the changes which have taken place since make that growth seem small and slow. The company has always been associated with the precious metals and engaged in their preparation for monetary or industrial uses, and in the course of this practice it has built up a position of great prestige in all parts of the world. Its stamp upon bullion is taken as an absolute guarantee by dealers, bankers and governments everywhere and its standing in the world of finance is rated very high. Its connection with chemical industry is one of long standing, but one that has become closer and stronger in recent years when modern research has led to the discovery of more numerous uses for the precious metals. For a century, platinum has been a valuable servant to both the chemist and the chemical engineer, but the employment of gold is more recent and that of silver more recent still, while even the rarer metals of the platinum group are now pressed into service.

Platinum Supplies in War-Time

The changes which have taken place during the past 25 years in this business are as varied and on as large a scale as can have happened anywhere else. In 1910, platinum was the company's principal business. Apart from scrap and a few oddments, the only source of raw material was the Russian alluvial deposits, and people talked of how near these were to exhaustion and speculated on the future of platinum after this had happened. All the mineral was alluvial metal, of which one was told that it had never been found *in situ* and that, if it ever was, it would be so disseminated as to be unprofitable in the absence of an entirely new equivalent of the cyanide process. But one answer to such questions was already beginning to emerge, for just about the time of King George's accession the presence of platinum in minute quantity in the nickel ores of Canada began to give rise to by-products sufficiently rich in it to be of interest to the market. At first this was merely a trickle and was handled by the existing refiners, but as the uses of nickel multiplied and the output of ore increased, the platinum became important enough to be handled by the producers and has by now grown into one of the world's principal sources.

The cutting off of the Russian supplies from Johnson Matthey and Co. was effected not by exhaustion but by the war and the subsequent revolution. The insistent demand arising from a vast manufacture of sulphuric acid for munition purposes was met from stock and from various relatively small alluvial deposits of which the most important was in Colombia. Supplies in all belligerent countries were strictly controlled by the Governments, and in Great Britain this company was appointed sole agents and distributors. At peace control was removed, but the disposal of Government stocks, together with the Colombian output, proved insuffi-

Progress of Johnson Matthey and Co. Ltd., 1910-1935

cient to satisfy a brisk demand. In consequence, the price rose to a high limit of 770s. per ounce at the end of 1919, and the situation was not eased until 1924 when Russian supplies again became available in already refined form. This was the beginning of a very rapid change, partly owing to the large expansion of the output from the nickel fields, and partly to the discovery in South Africa of a field of platinumiferous ore of apparently illimitable possibilities in quantity, but widely disseminated and therefore costly to win. Contemporaneous with this increase in supply came a falling off in demand, principally a result of the period of peak prices which had driven users to substitutes. A steady fall in price compelled the producers to agreement and quotas, with a consequent stabilisation at a much lower level at which demand has been reasonably restored.

In all these changes the company played a prominent part, and at present its position is that of refiner to the South African producing interests. The change-over from the refining of the clean Russian alluvial metal of 1910 to that of the highly complex and relatively poor sulphide ores of to-day has been a very complete one; the methods of recovery are entirely different and a vast amount of very intricate research went to their building up. The success which has been attained is a striking instance of the extreme elasticity which conditions demand of any company interested in the precious metals, conditions which are often dictated by politics and the capricious actions of governments and not by predictable natural phenomena or by a strict working of supply and demand.

Present-Day Demand for Platinum

On the side of demand, platinum has also experienced great changes since 1910. In those days, apart from laboratory ware, the principal consumer was the sulphuric acid industry, which took large quantities for use as a catalyst. There was a considerable demand in dentistry and a few minor uses in jewellery and in electrical and automobile engineering. To-day the demand for laboratory ware has been multiplied by the spread of scientific methods and research into all the by-ways of industry. Jewellery has become a major consumer and automobile engineering a considerable one for magneto contacts. The sulphuric acid industry is no longer a large user. The period of high prices turned it to cheaper substitutes or encouraged it to make one ounce of platinum do what fifty ounces did in 1910, but to some extent its place has been taken by the synthetic nitrates industry, which uses platinum to catalyse the oxidation of its synthetic ammonia to ammonium nitrate.

In 1910, as now, the company were official refiners and assayers to the Bank of England, a position that in those

days implied much more actual work than it does to-day. The bank then handled the entire output of the Rand mines, which came to England in the form of unrefined bullion bars in weekly shipments. These were divided among three official refiners and the product was subsequently marketed by the bank which itself took any surplus remaining over outside requirements. The quantities to be refined were increasing from year to year, and up to 1910 had been handled by slow and old-fashioned chemical methods. Johnson Matthey and Co. were the first refiners to depart from these and to instal an up-to-date electrolytic refinery which gave a product of higher quality in less time. The installation of this process was just commencing in the year in question, and by 1913 it was completed in a plant capable of handling a ton in two days—a large capacity for those times. This worked at high pressure throughout the war and post-war periods until 1922, when the Rand interests decided to set up their own refinery at the mines and to send only refined gold to London.

Gold Refining in London

Refining in London was on a small scale for several years after this, until the abandonment of the gold standard for sterling in 1931 brought about a rise in the price of the metal large enough to increase considerably the scope of mining operations and to tempt hoarders to realise their holdings. Gold movements increased in size and rapidly to previously unheard-of dimensions under the haphazard momentum of political changes, of which the greatest and most eventful was the coming of the "new deal" in the United States in 1933. All the old methods of refining gold were inadequate to the new demands, and even if the company had not scrapped its electrolytic plant in 1922 it would have proved neither large nor elastic enough to cope with the new world hunger. The only process capable of doing this was the one in which chlorine is passed into the molten metal and scavenges out all the base metal from it. A plant was laid down in 1932 capable of handling two tons a day and the capacity of this has been severely taxed on several occasions. Gold has poured in from every side. A great scratching-up of mineral resources has occurred all over the world; the vast hoard of ages in the vaults of India has been released in search of a sterling profit; and even the general public, stimulated by a horde of peripatetic collectors, is turning out its old gold in the form of anything from sovereigns to old teeth.

New Applications for Gold

Two industrial applications of gold must necessarily be referred to in any review of the Jubilee period. In 1910, practically all the British Empire supplies of "rolled gold" for cheap jewellery and of "liquid gold" for the decoration of china came from abroad. The interruption caused by the war made it necessary for manufacture to be commenced here, and Johnson Matthey and Co. undertook the very large amount of intricate research which was necessary to perfect the production of two difficult commodities. As a result, they have been for some years past in the position to supply the whole of the Empire market and even to compete successfully abroad.

Little space is left to deal with silver, in connection with which the company's expansion has been most spectacular. In 1910 the only refining process available was a chemical one with a maximum output of about three tons a week. Supplies came mostly from scrap and from lead and zinc refineries, but even then experiments were in progress on a more modern electrolytic process. This gradually came into action and by the end of the war was ready, with suitable expansion, to deal with the flood of demonetised coinage that flowed, and is still flowing, from all over the world to London for treatment. The chemical method is now no longer used and the output of a much enlarged electrolytic plant and of modernised fire processes is in the neighbourhood of 80 tons a week of pure silver.

The consumption of silver in 1910 was confined almost entirely to monetary purposes, silversmith's work and photography. To deal with the last of these first, the demand has been enormously increased by the coming of the cinema and by the position which Great Britain has taken as a centre for film production. At the same time, the ordinary photographic market has widened through the availability of cheaper cameras and of all-weather films. The company now turns out weekly about two tons of silver nitrate of

very high purity. Silversmiths continue to flourish, which proves that the unwillingness of the public to clean a tarnishable product is an overrated statement. Since 1910, much research has gone to the quest for a better working alloy and a less tarnishable one. The latter problem has not yet been satisfactorily solved, but considerable hope attaches to a proposal to achieve the desired end by covering the finished article with a very thin coating of non-corrodible rhodium. The public appears to be definitely interested in this proposition.

"Matthelytic Silver"

A new application for silver fostered by the company has been to industrial plant for the chemical and food industries. The low level to which the price fell in 1931 drew attention to its desirable properties as a material of construction and the business which commenced then is steadily increasing. The particular silver used for plant is 99.99 per cent. pure and is described as "Matthelytic silver."

Since 1910 the organisation of Johnson Matthey and Co. has undergone a considerable expansion, a large branch factory having been opened in London at Shepherd's Bush, factory and office premises in Birmingham, and a branch office in Glasgow. In addition, by the acquirement of the Sneyd Colour Works, in Burslem, they have entered very considerably into the manufacture of ceramic colours, which business is closely allied to their production of "liquid gold" and other preparations for use on pottery and glass. These latter works have recently been considerably extended and modern equipment installed. They have acquired the bullion businesses of E. W. Oakes and Co., Ltd., and Wm. Turner and Co., both of Sheffield, and they have also developed their connections abroad. Apart from branches in New York and Toronto, they are represented in Vienna, Paris, Warsaw, Riga, Oslo, Madrid, Stockholm, Copenhagen and other Continental centres. Their employees in the British Isles alone total over 1,200, and their premises occupy over eight acres of floor space.

Recent Metallurgical Patents

Deoxidising Steel

In the deoxidation of steel by a process involving the intermixing of the molten metal and a slag, the latter is a fluid acid siliceous slag containing 3-25 per cent. of one or more alkali or alkaline earth compounds. The compounds used comprise caustic soda, caustic potash, cryolite, baryta, or barium salts, magnesia or magnesium salts and, if desired, lime. In an example, a slag contains 70 per cent. of silica, 25 per cent. of sodium oxide and 5 per cent. of lime. (See Specification No. 423,731, of Soc. D'electro-Chimie, D'electro-Metallurgie, et des Acieries Electriques D'Ugine.)

Chromium Steel

In a process of manufacturing chromium steel, *e.g.*, comprising 0.03 per cent. of carbon and 12-20 per cent. of chromium, chromium ore and a reducing agent are charged into a furnace, which is preferably fuel-fired but may be electric; the resulting slag is removed and scrap steel is added to the reduced metal. The reducing agent is preferably exothermic and may be ferro-silicon or aluminium. The manufacture of a steel comprising 0.1 per cent. of carbon and 16-18 per cent. of chromium is described. (See Specification No. 421,856, of K. M. Simpson.)

Annealing Nickel Plates

Electrolytically-produced nickel plates are prepared for use as anodes in plating baths by annealing them in a salt melt containing substances capable of dissolving oxide, etc., adhering to the surface of the plates. The melt may comprise sodium or potassium chloride, or both, and a scavenging substance, such as borax or other boron compounds, such as potassium tetraborate, boric acid or boron trioxide plus sodium metaborate in quantities up to 25 per cent. by weight. The plates are removed from the melt when in a red-hot condition, and are then quenched. In an example, the melt comprises 50 per cent. by weight of sodium chloride, 35 of potassium chloride and 15 of boric acid. (See Specification No. 423,370, of Falconbridge Nikkelverk)

Metallurgical Section

June 1, 1935

Metals in the Oil Industry

A SERIES of papers on the general topic of metals used in the oil industry were presented at a recent New York meeting of the American Institute of Mining and Metallurgical Engineers. In the United States the oil and gas industry absorbs about 8 per cent. of the total steel production, and of this quantity a large proportion is buried in the ground as pipelines or as oil-well casings, the remainder being used in the construction of plant at refineries or otherwise subjected to corrosive oils or hot gases. A lengthy report of some of these papers was published in the April issue of "Metal Progress." The results of tests carried out on 200 commercial metals and alloys under 25 different test conditions in refinery service were given in a paper by Messrs. J. E. Pollock, E. Camp and W. R. Hicks, of the Humble Oil and Refining Co., Baytown, Texas. In these tests the American Petroleum Institute test procedure was employed. High chromium-nickel alloys were found to be particularly resistant to all services when the chromium content was 25 per cent. or more; low carbon 18 per cent. chromium 8 per cent. nickel steel was almost as resistant. All of the high chromium irons (12 to 25 per cent. chromium) appeared to be definitely of less resistance than the low carbon 18 per cent. chromium 8 per cent. nickel steels. The 5 per cent. chromium steels gave a much lower resistance to liquid corrosion but proved to be better than plain steel, especially for crude oil storage.

At these oil refineries corrosion troubles are widely experienced in heat exchangers working in conjunction with fractionating stills. The corroding media are water containing various chlorides, and oil containing some sulphur compounds, hydrochloric acid, sulphurous acid and hydrogen sulphide being in evidence. The pitting of the tubes from the water side appears to be due to galvanic action set up by non-homogeneities in the metal. De-zincification of brass tubes may be due to this action or to general solution in very alkaline water. Spray ponds, for cooling the water prior to its re-use, always saturate the water with oxygen and thereby increase the corrosion of iron and steel, especially with a rise in temperature. According to Mr. H. L. Bedell, of the White Eagle Refining Co., Augusta, Kansas, many metals have been proposed and tried in condenser service and his observations on a large installation show that the major position of permanence is attained by copper-nickel and copper-nickel-aluminium; thereafter follows copper and copper with a small amount of arsenic or silicon (which is especially good at temperatures below 300° F.), admiralty metal or copper-zinc-tin, 4 to 6 per cent. chromium steels, and plain carbon steel.

Metals suitable for oil refinery pumps were discussed in a paper by Mr. A. E. Harnsberger, of the Pure Oil

Co., Chicago, who recommended that the number of hard and corrosion resisting alloys be kept at a minimum so that foundrymen could increase the tonnage of each analysis and so reduce the costs. General service pumps, operating at air temperatures, should be made of iron alloys rather than bronze; hard liners and wearing rings are frequently of Ni-resist (a cast-iron containing 14 per cent. nickel, 6 per cent. copper and 2 per cent. chromium). The liquid ends on hot oil pumps give much trouble because gritty coke is deposited from tractions up to 900° F., whilst corrosive material is especially active at high temperatures and high-speed turbid flow may cause erosion and cavitation. Here, in general, good practice calls for a close grained cast-iron at 400° F., heat-treated carbon steel castings at 800° F., and heat-treated alloy steel forgings for extreme degrees of service at 900° F. In high speed centrifugal pumps for hot oil the coefficient of expansion of all parts of the pump must be matched.

A Modified Form of Monel Metal

A MODIFIED form of Monel metal is produced by the addition of a small amount of aluminium to the usual copper-nickel alloy ordinarily known as Monel metal. The new alloy may be strengthened and hardened by heat treatment, whilst still retaining the excellent corrosion resistance characteristic of Monel. The untreated alloy has a hardness around 140 to 150 Brinell; after heat treatment the hardness is raised to 300 Brinell or even higher. In consequence, the new alloy affords strength ordinarily found in heat-treated alloy steels and not offered by other corrosion resistant alloys which are now available at moderate price levels.

Technical data on "K Monel," as the new alloy is known in the United States, has been published by the International Nickel Co., from their New York Office. In its hardest grade the alloy has a proportional limit in excess of 100,000 lb. per square inch, a tensile strength in excess of 160,000 lb. per square inch, with elongation (in 2 inches) over 15 per cent.; tempered to lower hardness, the ductility is greater and the strength is less. Material which has been heat-treated to produce maximum hardness may be treated to about 1,050° F., followed by quenching or slow cooling, without appreciably affecting the original properties. Maximum hardening by heat-treatment is accompanied by slow cooling from 1,075° to 1,100° F. The hardening is a time-temperature effect and the hardness increases with increased time of holding at temperature up to 6 or 8 hours. Maximum hardness, due to heat-treatment alone, is in the neighbourhood of 300 Brinell, when starting with soft metal, but if the hardness of soft metal is first raised by cold working, the hardness resulting from subsequent heat treatment will be super-

imposed and may reach 350 or 400 Brinell. It has been observed, however, that the product which has been hardened by cold working plus heat treatment, will drop its hardness to 300 Brinell if exposed to heat-treating temperatures (about 1,100° F.) for long periods of time—in other words, the additional hardness due to cold working will be eliminated.

The principal uses of the new alloy, so far developed, have been in cases where either corrosion or weight saving have been the determining factor, as in the case of pump rods. Another successful application has been found in thin-walled cylinders subjected to high hydraulic pressure in apparatus which is exposed to mildly corrosive conditions, but which must function perfectly at any time or even after long periods of idleness. The new alloy makes a better ball, for use as a check valve, than does Monel metal itself, because it is harder and will grind more accurately and take a higher finish.

A Novel Measurement of Corrosion

EXTREMELY thin layers of metal are now employed for the purpose of measuring the extent to which corrosion may take place. Layers of the metal, about 8×10^{-6} cm. thick, are sublimed in high vacuum upon glass plates, and the thickness before and after being subjected to corrosion is measured by determining the coefficient of the light transmissibility of the metal-coated glass. Owing to the high absorption coefficient of metals it is possible with optical precision apparatus to measure a change of thickness to the extent of one atomic diameter. Tests reported in "Industrial and Engineering Chemistry," Analytical Edition, January 15, 1935, were carried out with apparatus by which a difference of five atomic diameter could be measured. The preparation of test plates is described with special reference to iron, copper, and zinc, and some reference is made to the examination of alloys. The work of the author, Mr. W. R. van Wijk, was originally undertaken to investigate the reproducibility of corrosion by gas oils in Diesel engine practice.

A New Electric Induction Furnace

THE March issue of "Aluminium" gives details of an electric furnace newly introduced for light metal melting—the Russ induction furnace. This furnace has no crucible and no heating elements or any kind of closures requiring renewal, and no alteration in heating rate or efficiency can take place from the cutting out of heating elements. The only part of the furnace that requires renewal is the lining; this is made of a special composition and is said to be capable of enduring as many as one thousand melts, whereas many of the best crucibles last for only fifty melts.

The chief advantage of the induction furnace, as a type, lays in the fact that the metal is heated uniformly from within itself, instead of being heated through the walls of the metal-holding receptacle; in consequence, the containing walls can be efficiently insulated and heat losses are reduced to a minimum. With a current consumption of 300 kWh per ton of aluminium there is a heat efficiency of about 86 per cent. In the Russ furnace the primary coil of the transformer is built into the base of the furnace and by induction it heats the liquid residue of metal at the bottom of the crucible-shaped container. Fresh material to be melted is fed in from

above and taken up and dissolved by the already molten metal, the temperature of which is maintained by the induced current.

The advantages offered by the Russ induction furnace are fourfold. In the first place a perfect and particularly gas-free melt is obtained, with thorough mixing of the different components of alloys. Secondly, there is high melting efficiency with short time of melting, and consequently a low metal loss. In the third place there is low current consumption as a direct result of the short melting time and the low heat losses. Fourthly, a good load factor enables the furnace to be connected to any source of electric supply.

Heat Treatable Nickel Alloys

THE information bureau maintained by the Mond Nickel Company continues the good work of disseminating data upon nickel and nickel alloys, one of their most recent brochures being concerned with new heat-treatable non-ferrous alloys in which nickel is one of the components. The response to heat treatment of alloys with compositions approximating to those of the well-known brasses, nickel-silvers, bronzes and nickel-copper alloys is obtained through the medium of compounds of nickel with aluminium, silicon or beryllium, these compounds being soluble in the base alloy at temperatures of about 800° C. and upwards, whilst being retained in super-saturated solid solution by rapid cooling. The supersaturated solid solution, however, is unstable and gradually decomposes if reheated at temperatures in the range of 400° to 650° C. The alloys described in this brochure represent a very recent development, and although they have not been used to any great extent, the industrial trials have been promising. The 30 per cent. nickel-copper alloy contains 1.5 per cent. of aluminium and attains a maximum stress of 58 tons per square inch, with a Brinell hardness of 210 on full heat treatment. By increasing the aluminium content to 2.5 per cent., the Brinell hardness may be increased to 220. Nickel-silvers, and nickel brasses and bronzes, also contain about 1.5 per cent. of aluminium.

Porosity in Steel Castings

THE preparation of steel to avoid porosity in castings was discussed in a paper which Mr. C. E. Sims presented at the 1934 Convention of the American Foundrymen's Association, now published in the "A.F.A. Transactions" for March, 1935. The author gives three main sources for porosity—condition of the metal, condition of the mould material, and construction of the mould. The gases which occur in steel are stated to be carbon monoxide and carbon dioxide (present only as reaction products), and hydrogen and nitrogen (which are soluble as hydride and nitride respectively). It is stated that the porosity problem resolves itself to reducing dissolved gases as much as possible, and producing the conditions favourable for retaining (in solid solution) these gases that cannot be eliminated. The conditions which favour the first step, or low gas content, are a long and vigorous boil, thorough and late oxidation, low residual silicon and manganese, moderate temperatures, and no increase in temperature after oxidation. Conditions favouring the retention of gases in solid solution are thorough de-oxidation and minimum exposure after deoxidation.

Welding in the Chemical Engineering Industry

Experience at Works of Imperial Chemical Industries, Ltd.

WELDED construction is used to a great and ever-increasing extent in the chemical industry, according to Mr. N. P. Inglis and Mr. W. Andrews, of Imperial Chemical Industries, Ltd., in a paper read at a Symposium on the Welding of Iron and Steel, organised by the Iron and Steel Institute, in London, May 2 and 3. There is probably no industry in which so many different varieties of shapes and designs are encountered, and, when such conditions occur, welding, where possible, is the most convenient and cheapest method of construction. There is, however, little in the nature of mass production methods which can be applied to the manufacture of chemical plant, each individual section of a plant demanding sizes and shapes peculiar to itself. Furthermore, improvements are continually being made, and, as the consequent alterations to plant become necessary, it is found that these alterations are often most conveniently and quickly made if welding is used. At the same time, it is probable that no other industry presents so many different combinations of conditions, and it is, of course, not enough to study the effect of these conditions on the original metal only, but it is most essential to study their effect on the metal after it has received all the various operations and treatments necessary to form it into the shape required.

Tanks and Gas-Holders

Although no striking developments with regard to the actual welding of structures for buildings can be reported, so far as the chemical industry is concerned, there has recently been a considerable increase in the use of welding for such structures as tanks and gas-holders. Thus, a large gas-holder, in which the tank is welded and the lift riveted, was constructed 68 ft. 6 in. in diameter and 30 ft. 6 in. deep and with plate thicknesses of $\frac{1}{2}$ to $\frac{3}{4}$ in. A similar but smaller all-welded gas-holder has a capacity of 500 cu. m., a diameter of 33 ft. 7 in. and a depth of 20 ft. The holder is constructed of $\frac{3}{16}$ -in. plate, and the plates are lap welded, using electric arc welding. A number of oil tanks of all-welded construction, the tanks being 39 ft. in diameter and 30 ft. high, with a capacity of 1,000 cu. m., have also been built.

In some cases, welded construction has been used in conjunction with the more usual riveted construction, and an excellent example of this is an oxide purification system in which the supporting structure itself is largely of riveted construction, but the boxes are entirely welded. Each box is 35 ft. square and 23 ft. deep, and has $\frac{3}{4}$ -in. sides with a $\frac{1}{2}$ -in. bottom, and the whole installation consists of twenty-four such boxes. This particular work was carried through to a rigid specification. The sizes of all welds were specified and gauges were used to check these welds. Every welder employed on the work had to pass an admission test, which consisted of making butt welds for test in tension and bending, and fillet welds for a shear test. No welder was allowed to proceed with the work unless he fully satisfied these tests and, in addition, careful supervision was given throughout. It is interesting to note that practically no defects were found on the subsequent pressure test.

Welded Pressure Vessels

The next type of application under the heading of general works requirements is found in the use which has been made of welding in order to replace parts which previously would have been cast or riveted. A typical example of this application is found in the welded steam jackets required for auto-claves. The shape of these particular jobs, with branch connections, etc., lend themselves particularly to welded construction, whereas some years ago castings, with their attendant uncertainties and limitations as far as design was concerned, would have had to be employed. As an example of a typical case where welding has largely replaced riveting, a large distributing hopper may be cited; this was also welded.

The tendency in the chemical industry towards the use of increasing pressures for certain chemical reactions has naturally brought forward many problems with regard to the methods of construction required for the production of pipes, containers, and their accompanying joints. It can be said, at the outset, that for large vessels, involving the higher

pressures which are encountered to-day in the chemical industry (up to 4,000 lb. per sq. in.), welding design and technique is not, up to the present, regarded as a safe and reliable method of construction. The application of welded construction to these vessels is not considered as being altogether outside the bounds of possibility in the future, but, for the present, it is preferred to go slowly and gain knowledge and experience with vessels operating at somewhat lower pressures. It is not a matter of regarding welding as intrinsically unreliable so much as a desire to move cautiously and logically. Advances are, however, being made with vessels required for what might be termed intermediate pressures. Thus, an all-welded air receiver operating under a working pressure of 100 lb. per sq. in. has been constructed.

Containers for Liquefiable Gas

Four or five years ago, the Welded Containers Committee of the Department of Scientific and Industrial Research made an investigation of the position with regard to welded vessels for liquefiable gases. As a result they recommended that forge welding only should be considered for such purposes. However, the advance in technique which has been made since the period when they first examined the question has led to a re-opening of the matter, and committees of the British Standards Institution have now prepared draft specifications covering both forge and fusion welding of containers for liquefiable gases. These specifications are now awaiting the approval of the D.S.I.R.

The application of welding to vessels which have to operate under really high pressures is further complicated by the fact that such vessels are most suitably and economically constructed in alloy steel, particularly in cases where elevated temperature is also involved. In general, the fusion welding of alloy steels brings with it two main difficulties. Alloy steel weld-metal "as deposited" has a coarse ingot structure which cannot be refined by heat treatment; hot-working would be necessary in order to refine the deposited weld-metal. The effect of the welding heat on the structure and properties of the adjacent metal has to be corrected, and hence the absolute necessity for heat treatment when alloy steels are welded.

The second difficulty is the lesser of the two, since, if the vessels were made as forgings in alloy steel, heat treatment would, of course, be necessary, and, therefore, if the first problem were solved, the position would be quite hopeful. With regard to the first difficulty, it may very well be that one possible line of attack would be the use of a deposited weld-metal of entirely different chemical composition to that of the plate, but which would have good properties in the "as deposited" condition. Not a great deal of work has been done along these lines as yet, but preliminary experiments indicate that the most promising metal of this type would be one of the chromium-nickel austenitic steels. However, if such a weld-metal were used, the difference in coefficients of expansion between the weld-metal and the base-metal would have to receive special attention and, in certain cases, contact corrosion effects would also have to be studied.

Sealing Screwed Joints

Before leaving the application of welding to high-pressure vessels, one further use of welding in such work should be referred to, namely, the use of welding for sealing screwed joints against gas leakage. This particular method of construction has been quite extensively used for parts subjected to intermediate pressures. The screwed connection gives the necessary strength to the joint and a light sealing weld is used to prevent gas leakage. Chromium-nickel austenitic steel weld-metal is most usually adopted to provide this sealing weld. An interesting point has arisen in connection with the use of this type of construction for parts which are subjected to hydrogen. It has been found that the thermal disturbance of structure in the region of the sealing weld may result in hydrogen attack of that region, even though the original metal may be absolutely resistant.

The chemical industry is one of the biggest, if not the biggest, user of corrosion-resistant steel, and can certainly

claim to have played some part in its development, on account of the fact that this particular industry utilised the material in the very early days of its development and, naturally, encountered the troubles and difficulties which the pioneer always meets. The first big difficulty encountered in the welding of this steel was the now well-known phenomenon of weld decay, that is, the intercrystalline corrosion of the material at a short distance from the weld, due to the carbide precipitation effect which occurs when this class of steel is heated to, and cooled from, 500°-900° C. This phenomenon was unquestionably the biggest obstacle to the development of the welding of this class of steel, since the only way to prevent this trouble occurring, after welding, was to heat-treat the whole of the welded article. Obviously, this was not always possible, and, even when it was possible, the risks of distortion during heat treatment frequently turned the scale against welded construction. It is not surprising, therefore, that practically all workers in this field devoted themselves to methods of eliminating this particular disadvantage.

A comparatively recent development has been the introduction of small quantities of both tungsten and titanium into the steel, and exhaustive experiments have shown that the addition of these elements in the correct proportions has very greatly minimised the risks of disintegration after heating in the range 500°-900° C. As a result of this invention, the field of welded construction in this class of steel has been greatly extended.

Dangerous Heating Range

The introduction of the titanium into this class of steel has brought with it certain disadvantages which have had to be overcome. In the first place, the presence of the titanium considerably modifies the microstructure of the steel, since, instead of the purely austenitic structure of the original composition, there is now a duplex structure consisting of austenite and ferrite. It has been found that after heating in the above-mentioned "dangerous heating range" carbide precipitation *does* occur, even in the titanium-bearing steel, but that it occurs in the ferrite itself, rather than at the grain boundaries, which was so much more disastrous. However, the precipitation of the carbide in the ferrite areas does lead to increased corrosion in those regions in which this precipitation has occurred. Whilst this increased corrosion is not such a serious difficulty as was the disintegration previously encountered, it is a distinct disadvantage when dealing with the more corrosive liquors.

The introduction of the titanium also necessitated investigation into the welding materials, since, if welding rods of the same composition as the plate are used, the subsequently deposited weld-metal will be deficient in titanium, and will be liable to weld decay if reheated in the dangerous heating range. Compensation for this loss of titanium has to be made by increasing the titanium content of the welding wire, and also by other means.

Correct Flame Conditions

As the chromium-nickel austenitic steels are expensive, much construction is carried out with comparatively thin sheet and plate, and, therefore, oxy-acetylene welding has been extensively used. The correct flame conditions for oxy-acetylene welding were soon found, and it was shown that even a slightly carburising flame would result in absorption of carbon, with greatly impaired corrosion-resistant properties in such higher carbon regions. Special instructions must therefore always be given to welders with regard to maintaining a neutral flame and, generally speaking, this is not difficult. Occasionally, however, flame conditions alter a little and, unfortunately, these give areas in the weld-metal of somewhat higher carbon than is desirable.

The difficulties encountered in the welding of this steel have naturally been stressed, but, at the same time, a very large amount of welded equipment in this class of steel has been successfully used for a period of several years. Even prior to the introduction of the disintegration-proof chromium nickel austenitic steel, welded construction was successfully used, chiefly for the type of work which could be heat-treated after welding. Thus, in one case a large number of tubes have been made by rolling from sheet and then welding the longitudinal seam. These tubes are 10- and 12-gauge thickness, 3½ in. diameter, and 4 ft. long, and were all heat-treated after welding. They have been successfully used in place of the much more expensive solid-drawn tubes.

Hot-Dipped Tin Coatings

Factors Involved in Formation

THE formation of tin coatings by hot-dipping involves a number of factors which have not been completely elucidated. The problem is being studied by the International Tin Research and Development Council, and forms the subject of Technical Publication, Series A, No. 17 ("Factors Influencing the Formation and Structure of Hot-Dipped Tin Coatings," by E. J. Daniels, M.Sc.). This paper was presented to the recent symposium on the structure of metallic coatings organised by the Faraday Society.

After reviewing previous work, the author considers the mechanism of the wetting of a solid metal by a liquid metal, and shows that, in general, wetting depends on the formation of an intermetallic compound or a solid solution. This leads in turn to a discussion of the intermediate alloy layer which is formed between the basis metal and the tin coating. In a section dealing with fluxes, the characteristics of several new fluxes are described, and an explanation of their action is suggested. Some interesting results are described showing how the manner of solidification of the tin coating depends on various factors. This is of importance since it governs the surface of the coating, which may be smooth, rippled or spangled according to circumstances. Besides the temperature of tinning, and the method of cooling, alloying has a marked effect, and particularly smooth coatings have been obtained by adding small percentages of certain metals to the tinning bath.

Zinc Manufacturers' Scheme

Three Companies to Unite

COOPER BROTHERS AND CO. have prepared a scheme for the amalgamation of the Zinc Manufacturing Co., the N.C. Metal Co., and the Metallic Ore Reduction Co., all of which are interested in the "Coley" process for the concentration of low-grade ores and the production of zinc and tin oxides. It is proposed to liquidate the companies and form a new one with a capital of £356,000 (divided into 126,274 five per cent. redeemable non-cumulative preference £1 shares and 459,452 ordinary 10s. shares), which will take over their undertakings as from January 1, 1935, and will acquire from H. Edwin Coley, Ltd., that company's rights to receive royalties, etc., from the N.C. Metal Co. The purchase prices will be paid in shares of the new company. Arrangements have been made under which all amounts due to creditors of the Zinc Manufacturing Co., the N.C. Metal Co., and the Metallic Ore Reduction Co., at December 31, 1934, will be satisfied by the issue of five per cent. preference shares of a nominal value equal to the claims, which total £126,274. Thus, all the preference capital of the new company will be issued to creditors of the amalgamating companies.

If the scheme is approved, the liquidator of the Zinc Manufacturing Co. will receive 82,918 preference shares and 119,814 ordinary shares. Three-fourths of the ordinary shares will be distributed to the "A" shareholders in the ratio of one share in the new company to every twenty shares in the old company, and the balance will be distributed to the "B" shareholders. The liquidator of the N.C. Metal Co. will receive 41,328 preference shares and 150,000 ordinary shares. In addition, he will receive a further 51,853 ordinary shares through the holding in the Zinc Manufacturing Co. and the Metallic Ore Reduction Co. He will therefore receive in all 201,853 ordinary shares, which will enable him to make a distribution of approximately four shares in the new company for every five shares in the old company. In the case of Metallic Ore Reduction Co. the liquidator will receive 2,028 preference shares and 102,096 ordinary shares, while H. Edwin Coley, Ltd., will be allotted 87,542 ordinary shares in consideration for agreeing to the surrender of all its rights in connection with the "Coley" process as applied to zinc and tin. A provisional agreement has been reached with Stewarts and Lloyds, Ltd., whereby they undertake to act as managers of the new company and to advance such sums as may be required for preliminary expenses and the working capital necessary to carry on the company's business from January 1, 1935, to June 30, 1936. These advances will be secured by a first charge on the assets of the company, and will carry interest at 4½ per cent.

Meetings of shareholders in the three companies have been convened for June 17 to consider the scheme.

Recent Progress in Non-Ferrous Metal Research

The Penetration of Steel by Soft Solder

THE penetration of steel by soft solder and other molten metals at temperatures up to 400° C. was the subject of a paper which Dr. L. J. G. van Ewijk read before the Institute of Metals, March 6-7. Investigation of the failure of a nickel-chromium steel axle-tube of an aeroplane showed that the material had been weakened by intercrystalline cracks due to a soft-soldering operation. Experiments were made with test-pieces of a number of steels by stressing the specimen during exposure to molten metals and alloys at temperatures up to 400° C. Cracking occurred in several of the steels, and microscopic examination showed characteristic intercrystalline penetration by the molten metal. The steels varied in their behaviour, certain specimens being particularly sensitive. Tests were made to determine the effects of temperature of the molten metals and treatment of the steel.

Keystone of Nickel-Chromium Steels

The tests which were carried out show clearly that nickel-chromium steels may be liable to rupture when put under stress and brought into contact with molten solder, lead, tin, zinc or cadmium. For carbon steel, however, no such liability could be observed. Variation in temperature of the molten metal does not appreciably affect the action. As regards the influence of heat-treatment of the steel, the few tests which were made suggest that tempering within the range of temperature commonly used has little effect on the sensitiveness of the steel to penetration and rupture. By tempering the particular steel used at 700° C., however (*i.e.*, in the neighbourhood of the critical range), the liability to rupture under the test was greatly reduced. The attack of nickel-chromium steel by molten metals shows a close resemblance to the attack of manganese-bronze and brass as described by previous investigators. The cracks are characteristically intercrystalline, and in many cases show the penetration of the applied metal; frequently, however, no trace of penetration is visible. It may be that in these cases the penetrated layer is too fine to be detected microscopically.

The constitution of the alloys of cadmium and silver from 30 to 60 per cent. by weight of silver, reinvestigated by the methods of thermal and micrographic analysis were reported in a paper by Mr. P. J. Durrant, Ph.D. The liquidus was found to consist of four smooth curves intersected by peritectic horizontals at 592°, 640° and 736° C. No changes occur below the solidus in phases ϵ and γ , but the β undergoes two transformations. The upper transformation $\beta \leftrightarrow \beta'$ occurs at 470° C. when γ is present, at 440° C. when α is present, and at some intermediate temperature dependent on the composition when β alone is present; the lower transformation $\beta' \leftrightarrow \beta''$ occurs at 230° C., 240° C., or at some intermediate temperature under the same respective conditions. Both of these transformations are associated with marked changes in the range of solid solubility, and with the existence of eutectoid points at which the solid solution decomposes into a characteristic duplex structure of the Widmanstätten type.

Cadmium-Tin Alloys

The constitution and properties of cadmium-tin alloys were discussed in a paper presented by Professor D. Hanson, D.Sc., and Mr. W. T. Pell-Walpole, B.Sc. The research described in this paper is a further contribution to the study of the effects of added elements on tin, and was undertaken with the aid of a grant from the International Tin Research and Development Council. Constitutions were determined by means of cooling curves and microstructures. A eutectic is formed at 176° C. and 33 per cent. of cadmium, but while there is a solid solubility at either end of the system, the exact positions of the sloping solidus lines have not yet been determined. Above 131° C. tin holds between 5 per cent. and 6 per cent. of cadmium in solution, but at 131° C. two conjugate solid solutions are formed, which at 127° C. have the compositions 1.25 per cent. and 5 per cent. of cadmium. At this temperature, the one richer in cadmium decomposes to form a eutectoid. This transition occurs in all compositions from 1.25 per cent. to 99.5 per cent. of cadmium. In

alloys containing 40 per cent. to 90 per cent. of cadmium, a slight transition connected with a change of solubility of tin in cadmium, occurs at 170° C.

The tensile strength and hardness of alloys containing up to 10 per cent. of cadmium were measured after various heat-treatments. A permanent value of 5 tons/in.² can be obtained after suitable heat-treatments with addition of 5 per cent. of cadmium. Cadmium has a very marked refining effect on the grain-size of tin. After a reduction of 80 per cent. by rolling, the grain-size is reduced from 1,600 grains/cm.² in the case of pure tin, to 26,000 grains/cm.² when 1 per cent. of cadmium is present.

Unsoundness in Aluminium Castings

In a further paper on unsoundness in aluminium sand castings, Professor D. Hanson, D.Sc., and Mr. I. G. Slater, M.Sc., Ph.D., dealt with solidification in sand moulds under pressures. By allowing gassy aluminium-alloy melts to solidify in sand moulds under an extraneous pressure of air or nitrogen, the authors found that pinholes are reduced in size and ingots of high density may be obtained. With most aluminium alloys a pressure of 50 lb./in.² is sufficient to remove all visual traces of pinholes from a 2 in. x 2 in. diameter sand-cast block. At higher pressures, ingots having densities approaching the optimum are obtained. The applied pressure appears to affect the gas cavities by compressing them to finer dimensions. The mechanical properties of the alloys are much improved by solidification under pressure, whilst shrinkage is confined to a single cavity.

This paper described further stages of an investigation carried out for the British Non-Ferrous Metals Research Association on unsoundness in castings and ingots of aluminium and its alloys. The immediate practical considerations which arise may be summarised as (a) the production of aluminium alloy castings, which may be produced from melts of indifferent quality as regards gas content, whereby the castings are free from pinholes, and (b) the production of castings which are free from isolated shrinkage cavities.

Ordinary photographic records of arc and spark spectra of graded series of standard alloys of aluminium with copper, iron, manganese, silicon and titanium were reported in a paper by Mr. D. M. Smith, A.R.C.S., B.Sc., D.I.C., from the point of view of the establishment of a satisfactory routine method of analysis. The spark gives a steadier and more reproducible source of light and, since adequate sensitivity of detection of the impurities usually occurring in aluminium is obtained, analytical tables have been compiled for use with the spark method. For routine testing of samples, an auxiliary alloy of aluminium with 1 per cent. nickel is used for the auxiliary spectrum method, but further accuracy of determination would be obtained by direct comparison with suitably selected standard samples. The arc method is more sensitive for the detection of traces of such impurities as lead and gallium.

United States Molybdenum Industry

Advance Statistics for 1934

THE production of molybdenum in the United States in 1934 was far the greatest annual output yet made, the increase over the previous record year (1933) amounting to about 65 per cent. The mine production of ore in 1934 amounted to 1,339,000 short tons which yielded 9,119 short tons of concentrates carrying 9,362,000 lb. of metallic molybdenum. The output consisted of 1,312,400 short tons of molybdenite-bearing ore which yielded 8,723 short tons of concentrates averaging 88.98 per cent. (15,523,000 lb.) of molybdenum sulphide (MoS₂) containing 9,313,800 lb. of metallic molybdenum; and 26,600 short tons of wulfenite-bearing ore which yielded 396 short tons of concentrates averaging 9.13 per cent. (72,300 lb.) of molybdenum trioxide (MoO₃) containing 48,200 lb. of metallic molybdenum. Concentrates shipped from mines in 1934 contained 9,377,000 lb. of metallic molybdenum with an estimated value of \$6,502,000.

Some Recent Metallurgical Patents

Treating Copper Ores

In order to remove arsenic and antimony in the smelting of ores and the like containing complex copper compounds, the ores, etc., are mixed with oxygen compounds of iron, e.g., roasted pyrites, hammer scale, etc., whereby a copper matte is produced containing iron sulphide, and the arsenic and antimony are liberated as oxides mixed with some sulphides. Fluxes such as slags rich in copper may be added to the charge to be smelted. Precious metals present in the ore are obtained from the subsequent electrolytic or other sludges. (See Specification No. 422,369, of H. Cmyral.)

Removal of Crystalline Inclusions

Thermally reduced high-silicon aluminium-silicon alloys, of the kind used as hardeners for addition to aluminium for the production of alloys suitable for pistons and other articles, are treated for the removal of crystalline inclusions or hard spots by passing gases or vapours, such as nitrogen or steam, through the melt, or by generating or liberating gases or vapours within the melt, for example, by the introduction of salts, such as volatile fluorides or chlorides. In some cases, the hardeners may be first treated for the removal of readily oxidisable constituents, whereafter the cast product may be remelted and treated as above when required for use. (See Specification No. 422,688, of Metallges, A.-G.)

Sintered Alloys

A hard carbide material is obtained by sintering together so as to produce a product consisting substantially of compound carbide, a compressed powdered mixture composed substantially solely of (a) a preformed hard carbide of boron, titanium, silicon, zirconium, cerium, thorium or two or more of these carbides, and (b) one or more of the metals vanadium, niobium, tantalum, molybdenum and tungsten, in substantially stoichiometrical proportions. The pressed mixture may be sintered by heat in one or more working cycles, if desired, with intermediate mechanical treatment. According to an example, the carbide $Ti_3C_2W_2C$ is obtained by sintering a compressed mixture of 25 parts of titanium carbide (TiC) with 75 parts of tungsten at a temperature of about $1,600^\circ C$. (See Specification No. 422,961, of Siemens and Halske A.-G.)

Refining Light Metals and Alloys

Light metals, particularly aluminium, magnesium and their alloys are refined by incorporating in the molten metal, if not already present therein, a reducing substance which is at least partially volatile at the temperature of the molten mass and adding an oxidising agent which yields its oxygen to the added reducing agent, the reducing agent, in turn, transferring the oxygen to the impurities to be eliminated. Suitable oxidising agents are alkali chlorates, perchlorates, oxychlorides, chromates, bromates, iodates, perborates, permanganates, cyanates, nitrates, nitrites and manganese dioxide, copper oxide, etc., and suitable reducing substances are the alkali metals, zinc, cadmium, sulphur and sulphur dioxide. The treatment takes place under a flux such as the alkalis or their halogen salts. (See Specification No. 421,994, of Compagnie Generale D'electro-Metallurgie.)

Deoxidising Copper

Molten copper is deoxidised by treatment in an induction furnace with a mass of molten and very fluid slag having a high extracting power towards copper oxide, a violent agitation of the metal which is, in part, transferred to the slag being produced by the electric field, and the surface of the metal being protected from oxidation throughout the operation by a covering of the slag. The slags used may comprise one or more of the following materials: silica, titanium dioxide, alumina, lime, magnesia, alkali and alkaline earth compounds, and iron and other metal oxides not reducible by copper. The slags may be melted in a water-jacketed furnace, and exhausted slags may be regenerated for reuse by reduction, for example, with carbon. In some cases the slag may be removed and the operation continued with a fresh slag. (See Specification No. 423,607, of Soc. D'electro-Chimie, D'electro-Metallurgie, et des Aceries Electriques D'Ugine.)

Refining Pig Iron

Vanadium is removed from pig iron by adding a strongly basic and very liquid slag to the molten pig iron before or during oxidation of the vanadium, and removing the slag as soon as the vanadium is completely oxidised. The basicity of the slag may be determined by the presence of sodium or potassium compounds, ferrous oxide, or manganous oxide. When the molten iron is run directly into the slag, preliminary oxidation of the vanadium may be promoted by increasing the distance through which the iron drops, by supplying air enriched with oxygen or steam to the iron, or by adding to the iron substances adapted to yield oxygen, such as red iron ore, or slags containing ferrous oxide. Prior to removal of vanadium, the pig iron may first be freed from silicon by the use of a slag rich in silicic acid; in this case, oxidation of the vanadium during following treatment with the basic slag may be promoted by addition to the slag of metallic oxides such as red iron ore. After removal of vanadium, refining of the pig iron may be completed. (See Specification No. 422,592, of N. J. Wark.)

Stainless Steel Alloys

Stainless iron or steel alloys are made by intimately mixing finely-divided metallic iron with finely-divided chromium powder in an amount adapted to impart the desired stainless quality and the desired amount of carbon powder, the metal powders having clean metallic surfaces, moulding the mixture under pressure and subjecting the compressed powders to a non-oxidising heat treatment at a temperature substantially below their melting points, e.g., above $900^\circ C$., but below $1,200^\circ C$., to bring them to their bonding point to form a substantially homogeneous product. If an alloy also containing nickel is desired, the necessary amount of nickel powder is added to the mixture before moulding. The powders should pass through at least a 200-mesh screen, and the moulding should be carried out at a pressure of not less than 20,000 lb. per sq. in., so that a product of predetermined density and porosity is obtained. A liquid binding agent, e.g., water or nitrocellulose, may be incorporated with the mixture of powders and the mixture extruded to form the desired article, e.g., tubes or wires, instead of being moulded. (See Specification No. 424,282, of H. Fairweather.)

Basic Slag

An Investigation of Oxidising Power

An investigation into the oxidising power of basic slags was reported to the Iron and Steel Institute at its meeting in May. The joint authors, J. White, R. Graham and R. Hay, of the Royal Technical College, Glasgow, pointed out that in the binary system Fe_2O_3-CaO , there was evidence of the existence of two compounds only—monocalcium ferrite and dicalcium ferrite. At the Fe_2O_3 end of the system the diagram is really of a pseudo-binary nature, due to the dissociation of the excess Fe_2O_3 at high temperatures. The melting point of Fe_2O_3 was determined as $1,595^\circ C$., but this figure is low, due to the presence of ferrous iron resulting from the dissociation of the ferric oxide. The dissociation pressure of Fe_2O_3 was investigated: it was found to be appreciable at $1,100^\circ C$., and to increase rapidly with the temperature, reaching a pressure of the order of 5×10^2 atm. at its melting point. Evidence was also obtained which indicates that Fe_2O_3 is partially soluble in Fe_2O_3 , and that Fe_2O_3 is partially soluble in Fe_2O_3 .

In recent years much attention has been given to the functions of the slag in the refining operations in the open-hearth process of steel production. Much of the data and also the theoretical treatment of the subject are recorded in the report of the Symposium on the Physical Chemistry of Steel-Making Processes held by the Faraday Society in June, 1925. McCance ("Journ. West Scot. Iron and Steel Inst.," 1933-34, 41, 1) has recently reviewed the work in this field and has shown that whilst the behaviour of the slag/metal relationships in the acid process can be accounted for in a reasonably satisfactory manner on theoretical grounds, the same cannot be said for the basic process.

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