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CHEMICAL SOCIETY'S ROOMS, BURLINGTON HOUSE,
Monday, 13th February, 1881.

PROFESSOR F. A. ABEL, C.B., F.R.S., IN THE CHAIR.

WASTE PRODUCTS AND UNDEVELOPED PROCESSES.

BY O. T. KINGZETT, F.C.S., F.I.C.

From the history of chemical industry, it is apparent that many previously waste products have been utilised, and a number of originally crude processes have been developed, by the application of chemical knowledge which had been gained long before. Progress, therefore, by no means depends entirely upon

the prosecutions of new investigations. While chemical research often leads to improvements in the arts and manufactures, and even creates, from time to time, absolutely new industries, great advances may also be effected by the intelligent application of knowledge which has already been placed upon record—that is to say, we have to utilise chemical information as well as waste products and other substances. Now, in our respective vocations, we—the members of the Society of Chemical Industry—practically confine our attention to a more or less limited number of subjects, and the natural consequence is that our minds become specialised. We are intimately acquainted with the details of those industrial operations that concern us most; but here the line is drawn, and we do not, and indeed cannot, extend to other matters the same amount of thought and attention. It often happens, then, that the subject matter of an everyday experience in one branch of industry becomes the starting-point of an important improvement in another department. We are struck with the truth of this fact when outsiders effect advances in our own particular manufactures by the mere application of chemical information available to all, but not applied by ourselves. Specialism is necessarily concentrated, so to say, by the growth of chemical industry, for, as each branch extends its operations, and covers wider ground, the demand on individual time proportionately increases, and there is, consequently, less to spare for other matters. The same kind of difficulty is experienced by the purely scientific chemist, who, finding it is utterly impossible to keep abreast with the progress made in all departments of his science, may pay a general attention all round, but devotes the bulk of his time and energy to one or more particular divisions. The circumstances of daily life, as well as the limit imposed upon individual capacity, alike necessitate us to be specialists; but we may find some consolation for this fact in the saying, which is none the less true for being trite, that "A jack of all trades is master of none."

These matters, however, are not merely useful as bases for reflection: they are concerned, and intimately concerned too, with the general progress of chemical industry; for while, as we have seen, there exists a more or less adequate provision for the development of certain branches within definite limits, there is a want of interchange of thought and knowledge, which, while it exists, is a barrier to general progress. The alkali manufacturer may know little or nothing about the operations of a colour-works, and soap and candle makers may be practically unacquainted with the processes involved in oil-boiling and varnish-making, and so on. The special information and experiences gained in each department of chemical technology are not, in short, generally available, but are more or less confined to those persons who are

directly interested; and when we consider that every manufacture admits of improvements being introduced, or is attended with the production of waste products, it is at once apparent that there exists an impediment in the way of advancement.

This Society having for its great object the promotion of applied chemistry in the widest sense, it occurred to me that we might with considerable advantage pursue an example set by another association, and endeavour thereby to make each other better acquainted with the nature and properties of waste products, and with defects or failures in various chemical processes. The example I refer to is that set by the Pharmaceutical Conference which publishes annually a list of substances and subjects which particularly call for investigation and study at the hands of its members. To this list all are invited to add, and, when revised from year to year, it serves a most useful purpose, for it immediately reveals what is wanted. So, too, I am confident, if such a list as related to chemical arts and manufactures could be prepared and periodically revised, it would serve an equally useful purpose, and appreciably promote the objects of this Society. To be more specific, we require the compilation of a list of what are known as "waste products," giving notes regarding their sources, general properties, and composition, and directing attention to the constituent or constituents of greatest value. There might also be added a *résumé* of attempts which may have been hitherto made at utilisation. Undeveloped processes should be similarly dealt with, and in all cases the information should be concise and precise.

In preparing the notes which follow the preceding introductory observations, my chief regret has been that I have little or nothing of an original character to communicate to the Society upon this occasion.

Having devoted a good deal of time during the last few years to certain processes of chemical industry, I have more than once been surprised at my ignorance of a large number of matters constituting the subject of very ordinary knowledge to persons more intimately associated with the operations in question, and I doubt not that a similar experience has been that of most of the gentlemen who are present this evening.

My sole object is to induce a good discussion, in which representatives of various industries may join, and thus secure publicity to special knowledge about the waste products and undeveloped processes, not only of the few departments of chemical technology which I may have occasion to touch upon, but also and more particularly with regard to their own manufactures. Cordial co-operation in this respect on the part of the members at large will furnish a very respectable category of products and processes requiring the further attention of industrial chemists.

FATS, CANDLES, SOAP, AND GLYCERINE.

In his address to the first general meeting our President called attention to the waste of glycerine in the soap trade, and pointed out that, in view of the growing demand for this substance, for the manufacture of explosives, etc., its then price was £120 per ton. Already at that time soapmakers had begun to turn their attention to the more complete recovery of the glycerine contained in the spent lees, and since then the subject has been still further pursued. These lees contain water, glycerine, common salt, sulphate of sodium, a small quantity of caustic soda and sodium carbonate, and small amounts of albuminous, resinous, and soapy matters. To illustrate their general composition when concentrated to a certain degree (which is easily attained in practice), I may state the composition of a sample recently

examined by me. It showed a specific gravity of 1.236, the gallon being made up as follows:—

Water.....	7.531b.
Glycerine.....	2.011b.
Salts.....	2.781b.
	12.323b.

I am also able to give my analysis of the salts as deposited from the lees upon concentration—

NaCl.....	= 75.12
Na ₂ SO ₄	= 8.61
Insoluble inorganic matter.....	= 0.22
(Glycerine and organic matter).....	= 1.55
Water.....	= 7.50
Alkali (calculated entirely as carbonate of sodium).....	= 2.61
	100.61

the excess over 100 being caused by calculating all the alkali present as Na₂CO₃, the fact being that some of it was present in the caustic condition.

From a study of the various patents that have been granted during the past year in connection with the recovery of glycerine, I have been confirmed in the opinion that it is very much easier to obtain a patent than to make a discovery. Let us glance at some specifications already published.

M. Constant Victor Clotus (specification No. 681 of 1891) neutralises soap lees with hydrochloric acid, and evaporates the settled liquor till it registers 32° B. Heated air is then blown through to remove the rest of the water, the salts deposited during both stages being fished out and treated in a turbine. The final product may be finished by drying *in vacuo*. The crude glycerine thus obtained is said to contain but little salt, but the exact amount is not stated. It may be distilled in order to purify it. So far I fail to detect anything of an original character in this proceeding. Instead, however, of neutralising the soap lees with hydrochloric acid the patentee may use carbonic anhydride, so that when evaporation has been carried to 25° B, after further exposure to carbonic anhydride, bicarbonate of sodium (being only slightly soluble in a glycerine solution of salt) is precipitated upon cooling. Another mode of freeing his crude glycerine from salt consists in treating it with excess of hydrochloric acid of 22° B, or in the form of gas. The solubility of the salt is said to be thus diminished, and in consequence, more of it can be removed. The excess of hydrochloric acid is subsequently got rid of by a current of air or by an excess of plumbic oxide.

Messrs. Benno, Jaffé, and Darmstadter (specification No. 1562 of 1881) employ sulphate instead of chloride of sodium for salting out the soap. They then neutralise the spent lees with sulphuric acid, filter, evaporate, and thus get only sulphate of sodium separated. They say the sulphate is removed more easily than the chloride, and hence the value of this method seems to turn on whether the increased ease of removing the salts more than atones for the increased cost of material for salting out, because the only comparable difficulty in removing the chloride is one of cost.

Mr. George Payne (specification No. 2816 of 1881) neutralises the lees with an acid, allows any precipitate to settle, and then adds a 10 per cent. (by weight) solution of tannin or tannic acid, until albuminous matter is no longer precipitated. The filtered liquor is concentrated by heated air or superheated steam, or direct by fire. He thus gets, he says, a crude solution of glycerine containing about 10 per cent. salts, which may be more easily refined than any other crude glycerine. In connection with this patent I regard it as pertinent to ask whether the excess of tannin introduced is not an objectionable as the matter which is thereby removed?

Messrs. C. Thomas and A. Domeier (specifica-

tion No. 2462 of 1881) concentrate the lees and add an excess of acid until there is present about 1 to 1½ per cent. of acid. This is to decompose any soap, bind the resinous matters, and to so act on other matters that, when neutralised by alkali later on, they are precipitated. After this neutralisation and filtration the lees are further concentrated, and the crude glycerine is extracted with about 33 per cent. of coal-tar oil or petroleum, or bisulphide of carbon, or amylic alcohol, or ether, or other menstruum in which the glycerine is insoluble, in order to remove any soluble matters which may be disagreeable to the smell or taste. After extraction, the glycerine is subjected to hot air or steam, in order to get rid of traces of the solvent employed, and may then be used for commercial purposes or further purified by distillation. They also describe an apparatus designed for the concentration of thin lees, in which the liquor slowly descends a tower fitted with alternately-inclined shelves, and in which it encounters a current of hot air, much in the same manner as Mr. Leuthor proposed to make bleaching powder, viz., by causing lime to encounter an ascending current of chlorine gas in its descent down a tower fitted with a continuous spiral shelf.

J. Weineck (specification No. 1289 of 1881) avoids the use of both chloride and sulphate of sodium in soap-making as follows: He exposes fats in a cylindrical wrought-iron vessel, fitted with a stirring gear, and provided with a jacket which is filled with hot water. At 45°C. the tallow (when that fat is used) melts, and then 20 per cent. of a 2 per cent. solution of soap at the same temperature is added to the fats, stirring meanwhile. When the mass is perfectly emulsified caustic ley of the same temperature is added. When well mixed the temperature is raised to about 90°C. and the stirrer kept at work until saponification is completed. After some hours the spent ley is let off and registers from 5° to 10° B. Operating thus, he claims to utilise some chemical heat evolved in the action of the ley upon the emulsified fats, and by saponifying the fats in this globular state he says he saves fuel, time, labour, cost on plant, and, above all, obtains lees free from any large amount of salts. But even in this process, assuming it works otherwise satisfactorily, it would appear that the alkaline ley must be neutralised with an acid before concentration, otherwise the glycerine would suffer decomposition. Perhaps in such a case, however, carbonic anhydride could be profitably employed.

The most curious specification is that (No. 2176 of 1881) of P. J. Baptiste Depouilly and Léon Droux, of Paris. These gentlemen neutralise the spent lees with any acid, filter, evaporate, remove the deposited salts, and heat the mother-liquor in contact with oleic acid or other fatty acids at a temperature of 170 to 175° C. In this way they reproduce fats which are washed and subsequently decomposed by means of lime, or by superheated steam with or without the aid of sulphuric acid. When lime is employed, the soap thus produced is afterwards decomposed by the agency of an acid. Or, instead of using free fatty acids the patentees employ neutral fats and oils in their process, thus giving rise to the formation of diacid and monoacid glycerides. In brief, the whole of their proposals are based upon the well-known classical investigation of Bertholot, but it is not easy to see in what precise manner they can be economically carried out in commercial practice.

Reviewing these various specifications, we see that the different processes described therein are designed to effect the following objects:—

1. To remove or destroy albuminous and resinous matters, together with any residual soap contained in spent soap-lees.

2. To facilitate the removal of the salt, either by employing means to diminish the solubility of chloride of sodium, in cases where that substance is used, or to substitute for it another which may be more readily and profitably removed.

3. To economise the cost of concentrating the purified lees to that point at which the glycerine may be at once employed for certain purposes in its then crude condition, or still further purified by distillation.

I very much question whether the alkali utilised by the carbonic anhydride process would pay for the cost of the gas necessarily to be employed, except, perhaps, in conjunction with Weineck's process, and I equally doubt whether the cost and trouble of increasing the insolubility of chloride of sodium in glycerine liquors, by the employment of hydrochloric acid, would even be balanced by the effect produced. Speaking generally, therefore, and after giving a considerable amount of practical attention to this subject, the soapmaker who wishes to recover the glycerine from spent lees cannot do better, at present, it would appear to me, than proceed to evaporate the water from the neutralised liquor in the most economical manner available, with the dual object of getting rid, by deposition and crystallisation, of as much salts as possible, and of preparing the crude glycerine for distillation, and surely he can do all this without the use or infringement of any patented process—indeed, it is being done on a large scale. But there is another way of dealing with the production of glycerine already known and practised, and which will, I feel sure, be much more widely adopted in the course of time. At present, the soapmaker saponifies neutral fat and oils with caustic ley, and then, at an expensive rate, seeks to recover the glycerine left in the lees; but, theoretically speaking, he would be better advised to decompose the fats and oils, in the first place, in the manner that is practised by the candle-maker, viz., by the agency of superheated steam, with or without the assistance of sulphuric acid or lime, using the fatty acids for saponification with alkali, and obtaining comparatively pure glycerine in this direct manner. The practical objection to this procedure is that the existing plant of soapmakers is not adapted to the process, and, moreover, they cannot produce such good-coloured soaps from the fatty acids as result from the direct saponification of fats. But this is largely a sentimental objection, the soap being really equal in quality, and so far as the objection is sound, I am confident that at the right time it will be overcome.

ALBUMEN.

I now propose to glance at another and growing branch of chemical industry related to calico printing, and that is the preparation of soluble and congluable albumen. Blood albumen, prepared from serum, and egg albumen, prepared from the whites of eggs, are at present the most familiar commercial albumens in the market, but the supply of both these materials is limited. Egg albumen has the greater value, by reason of its greater freedom from colouring matters; indeed, until recently, the darker qualities of blood albumen could not be utilised except for certain crude purposes. My investigation of the atmospheric oxidation of the terpenes placed in my hands the means of bleaching blood albumen, and, at the same time, of preserving it from putrefaction, thus avoiding the necessity of evaporating serum to obtain the scales of commerce. (See specification No. 2630 of 1876.) This process consists in the aerial oxidation of certain hydrocarbons in the presence of the albuminous solution to be bleached, at a temperature below the congluable point. Thus, if turpentine be employed, peroxide of

hydrogen is formed on the one hand, and this bleaches the albuminous principles, while certain other substances are simultaneously produced in small but sufficient amount, and passing into solution they preserve the mass from putrefactive decomposition. (See *Pharm. Journ.*, Sept. 29, 1877.) During the past four years this process has been carried on, actively producing good commercial solutions containing from 2lb. to 4lb. of albumen per gallon, but, unfortunately for the greater development of the process, we have been dependent upon the supply of serum and dark-coloured scales as exclusive sources of the albumen to be prepared. This led me to make many experiments with the view of utilising flesh, casein, gluten and allied substances, by dissolving them with the aid of certain ferments (such as are afforded in the lining of pigs' stomachs), or by means of alkalies, seeking then to hit upon some salt or salts which, by being dissolved in the bleached solutions, would cause the coagulation of the albumen when subjected to the heat that is experienced in the practical operations involved in printing with albumen. My success was not great, although I did "sail close to the wind," if experience should confirm the statements made by another inquirer in a recent specification (No 1686 of 1881). Emil Ritter von Portheim has patented the following process: 100 parts insoluble blood albumen, fibrin, raw meat, residue obtained in the manufacture of Liebig's extract, casein, gluten, or protein of ground nuts, are minced or ground up and washed with water, and then dissolved in 200 to 250 parts of water in which there has been previously dissolved 4 parts by weight of caustic soda or potash, at a temperature of 90° to 100° C. To the solution thus prepared he adds 4 per cent. of a solution containing 40 per cent. of "glycerine-sulphate of calcium," or "glycerine-phosphate of calcium" (I presume that glycerio-sulphate and glycerio-phosphate of calcium are meant), or 4 per cent. of a mixture of calcic chloride and an alkaline salt of citric, tartaric, or metaphosphoric acid. The mixtures are "scaled" in the usual way, and the patentee claims for the solutions the coagulability upon which the successful employment of albuminous solutions depends. Unfortunately, the extent to which coagulation occurs is not stated, and I can only express the hope that it exceeds in a great degree anything which I obtained by operating in much the same manner. I trust soon to be able to commercially test this process, and if it works successfully it will be of much importance, because it will open up new and plentiful sources of albuminous material, admitting of being bleached and preserved in the liquid state by my own process, and finally supplied at low rates to calico printers.

AMMONIA.

Dr. Hubert Grouven has taken out a patent (specification No. 2423 of 1881) for "Improvements in the treatment of organic substances for the production of ammonia, and apparatus therefor." The process employed is said to be applicable in the laboratory as a method of quantitative analysis besides being serviceable for commercially obtaining carbonate of ammonium. It consists in exposing organic matters to the action of superheated steam, and conduction of the gaseous products of decomposition over what is called "Grouven-contact-substance" (an argillaceous earth containing 50 per cent. of lime in the form of silicate of lime). Pumice-stone, asbestos, sandstone, grey lime, etc., are not so efficacious as "Grouven-contact-substance" in securing the production of carbonate of ammonium. According to the patentee, every organic substance burnt in glowing steam—say at a temperature of 400° to 700° C.—

yields approximately 45 to 55 per cent. of its nitrogen in the form of carbonate of ammonium, the other portion being evolved in the form of alkaloidal and other vapours which produce tar upon condensation. No free nitrogen is formed, as is so largely the case where air is used instead of steam. If the mixed vapours obtained as described be conducted over strongly-heated porous substances, such as asbestos, there is a further yield of carbonate of ammonium obtained by the decomposition of the alkaloidal vapours to which reference has been made. But if "Grouven-contact-substance" be employed, then all the alkaloidal matters are changed, so that the whole of the nitrogen is ultimately obtained in the desired form of carbonate of ammonium, the final products, previous to condensation, being hydrogen, carbonic oxide, carbonic anhydride, and ammoniacal gas. For instance, the gas obtained from pent contains 64 per cent. of hydrogen, 12 per cent. carbonic oxide, and 24 per cent. of carbonic anhydride. (I presume this composition is arrived at after separation of the ammoniac carbonate). The oxygen contained in the two last-named gases is derived from the water, which suffers decomposition in the process. The contact substance is said to admit of regeneration by exposing it for some time to a current of air at a high temperature. Now that ammonia has such a high importance in relation to the commercial production of carbonate of sodium, this process of obtaining carbonate of ammonium from horn, leather, glue, wool, and animal and vegetable refuse generally, on a large scale, is worthy of the best attention.

TAN, OR SPENT BARK.

Tan, or spent bark, has been recommended in conjunction with coal-dust as a good fuel, and I know that, as a matter of fact, it is also used alone for this purpose. Mr. Sorberg, in 1861, proposed to utilise spent bark for the production of charcoal, tar, acetic acid, and gas. It has also been proposed from time to time to reduce tan to pulp, or "half-stuff," for papermaking, but the cost of conversion is said to have proved too great, on account of the difficulty encountered in dealing with the knots or hard portions. Messrs. William Guest and Charles Court (specification No. 2672 of 1881) claim to have overcome this difficulty by operating as I shall now briefly describe. The spent bark is placed in a hopper, and by means of a feed roller is passed on to be crushed between two other rollers. In this way the hard knots are reduced to a fibrous state. The crushed tan is then placed in a sort of rotatory steam-tight boiler, fitted up internally with revolving blades, and in this way it is exposed to the action of a saturated solution of caustic soda (about 5lb. of soda being used to each cwt. of spent tan) and steam at a pressure of about 30lb. After two hours the bark fibres are found separated and free from tannic acid. The fibres are next rinsed in water, passed through a second crushing mill, which not only squeezes out the water, but also completes the disintegration of any residual knots and hard pieces, after which the product is said to be fit for profitable conversion into paper. The patentees also state that the alkaline extract of the spent bark, incidentally obtained in their process, is of considerable value to the tanner for the ordinary operations of his business, by virtue of the tannic acid it contains in combination.

CHLORATES.

In the course of his recent valuable communication to this Society, Mr. Weldon referred to a practical difficulty which is experienced in the manufacture of potassic chlorate. The mother-liquor resulting after

the separation by crystallisation of the bulk of potassic chlorate contains, as I understood, with the calcic chloride, yet a small amount of potassic chlorate, and a certain larger quantity of calcic chlorate, and the loss of this amount of chlorates is a matter of considerable importance to manufacturers. It occurs to me to suggest the addition of potassic sulphate to such mother-liquors, with the view of getting the remaining calcic chlorate converted into calcic sulphate, with the corresponding production of an increased amount of potassic chlorate. Whether, however, the calcic chlorate would be engaged in the reaction with potassic sulphate before the larger quantity of calcic chloride became affected, and, if so, to what extent, are questions requiring an experimental answer, even should there be no other objection to such a treatment of the mother-liquors. If the treatment admitted of practical adoption, then the filtered liquid might, within certain limits, be used in making a new batch of chlorate. Or again, now that chlorate of sodium is coming largely into use, why not decompose the chlorate of calcium with sodium sulphate (now produced so cheaply) direct? These suggestions may be valueless—they must have occurred to manufacturers of chlorates—but even in that case a statement to this effect will clear the ground in a certain measure and give valuable information to outside chemists who may be excused for entertaining such ideas.

SPILLED GUNPOWDER.

In course of conversation the other day, Dr. Otto Helmer mentioned a circumstance to me with which I had been hitherto unacquainted, viz., that a very large quantity of gunpowder is annually and irretrievably spoiled, owing to various conditions of its exposure, dampness, I take it, being amongst the causes. He also stated that there is no known method of profitably recovering its ingredients. The value of this commodity naturally leads chemists to think about working out some such process, and without having any knowledge of the matter, derived from practical acquaintance with the subject, I would inquire whether the nitre cannot be extracted with water, and the insoluble residue exposed to a sufficiently high temperature to melt the sulphur out from the charcoal? Or can the mixture of sulphur and charcoal be profitably employed for making carbon disulphide or chloride of sulphur (a substitute now largely used in making "indiarubber substitute")? Or may be, that such a mixture of carbon and sulphur might be utilised for making a crude sulphide of iron by heating with scrap iron or cuttings of tinsplate, afterwards using the product either in the manufacture of sulphuric acid or for the production of ferrous sulphate by moist oxidation. I only hope that our esteemed and learned chairman will excuse my ignorance of attempts that must have been made to recover the ingredients of gunpowder, and with all of which he is doubtless familiar.

ALKALI WASTE.

Quite apart from the consideration of the recovery of the sulphur as a valuable constituent of alkali waste, it is not improbable that a certain considerable quantity of this waste product might be economically used in paving the streets of manufacturing towns. For this purpose I would suggest that the waste should not be used in its raw state, but should be first air-dried, then crushed in rolling mills, and finally melted up with a certain proportion of gas pitch and shale oil, preparatory to laying the asphaltic pavement in the ordinary way. It is well known that large quantities of different varieties of so-called British asphalt are now made in a similar

manner from chalk or chalk and sand, and even the natural formations of asphaltic rock are largely composed of calcic carbonate, as may be seen from the analyses below. These analyses, which I have recently made, refer to the natural rock, the "mastic" made from it, and the final pavement as laid down.

	Stock.	Mastic.	Pavement.
Bitumen	84.03	17.20	20.72
CaCo ₃	84.15	78.21	69.25
Grit (insol. in dilute HCl) ..	1.77	4.55	15.50
	99.95	99.96	99.51
Magnesium Carbonate and undetermined ..)	.73		
	100.00		

The calcic carbonate and sulphides in the waste would take the place of the natural calcic carbonate, and the unburnt coal would take the place of grit, which is always added to the mastic with Trinidad pitch, before using it for making footpaths, etc. I have ascertained by experiment that the use of waste for these purposes can be realised with no more nuisance than is experienced in remelting the mastic in the ordinary operations; and I have a small specimen here made from waste pitch and oil in this manner. Such pavement could also be made from the waste which has been first utilised for the production of "yellow liquors," so that the operation would not interfere in any way with the present mode of recovering sulphur.

RUSTLESS IRON AND STEEL.

A few words regarding the present position of the attempts that have been made to render iron and steel rustless may not be altogether out of place. Following the initial advance made by Professor Barff (with the details of which we are all familiar), Mr. George Bower found that the work of superheated steam could be equally well done by superheated air; and, very shortly afterwards, Mr. A. S. Bower proposed to overcome certain difficulties which had been experienced in the practice of his father, by exposing the iron or steel articles, and producing thereupon the coating of magnetic oxide, in a chamber heated to the proper temperature by the combustion therein of gaseous fuel. The process, as now worked, is, I understand, as follows: The iron goods, whether rusty or not, are, without preliminary treatment of any kind, placed in a suitable chamber sufficiently capacious to hold about one ton weight of contents; and this chamber is heated by the combustion therein of carbonic oxide gas, produced near at hand by several gas furnaces, an excess of air over that requisite for combustion being admitted also into the chamber, after having been heated in its passage through coils of rope placed immediately underneath the operating chamber. A film of magnetic oxide forms upon the immediate surface of the iron articles, and this appears to be surmounted with one of ferric oxide (Fe₂O₃), and it is by the subsequent reduction of this substance by means of carbonic oxide that the coating of magnetic oxide is increased to the requisite extent. In brief, the excess of air present in one stage of the process seems to form ferric oxide, and when the proportion of air present is reduced (as it may be at will) so that carbonic oxide is present, then the ferric oxide becomes reduced to the lower state of oxidation, its oxygen contributing to the production of carbonic anhydride. The time required varies from three to twelve hours, and the magnetic oxide as thus formed exhibits a very pleasing French-grey or leaden tint. Should the colour, however, be unsuitable to the intended use of the iron articles, the more costly metals may be deposited upon them by rubbing the surfaces "with a brush or device having filaments or attenuated or finely-divided bodies composed of or coated with the metal

which it is desired to deposit." By the courtesy of Mr. George Bower, I am enabled to submit some interesting specimens of castings which have been protected by the processes described.

It was originally my intention to say something about the metallurgical processes which have so long engaged the successful attention of Mr. F. Maxwell Lyte, but I have abandoned it, feeling sure he would be present with us this evening, and favour the Society with some observations. Similarly, I have, after consideration, abstained from saying anything about the alum process of Messrs. Duncan and Newland, not only because it is now well known and appreciated to the extent of its great merits, but because, also, its wider adoption seems to depend upon the employment of sulphate of alumina free from iron, and the manufacture of such a product has recently received great improvement at the hands of Mr. J. W. Kynaston.* I believe also Mr. B. E. R. Newlands has given practical attention to this subject, and intends to give a description of his investigation to the Society at an early date. I had also hoped to be able to say something about some attempts in which I have been recently engaged at effecting certain improvements in the oil-boiling and varnish-making trades, thus giving some little of that originality to my paper which it so much lacks, but I am not at liberty to do this at present.

In conclusion, I will ask the members to give me their indulgence in respect of my poor communication, remembering that I make no claim to originality in my paper, the sole object which I have in view being to induce each of them, so far as he may be able, to give specific information regarding waste products and undeveloped processes, so that by the diffusion of such information the subject may claim and receive greater and more universal attention at the hands of industrial and industrious chemists.

THE DISCUSSION.

Dr. MESSALL: I have made some experiments bearing upon the production of ammonia, but I think it is almost useless to look about for new sources so long as we waste such large quantities of this substance, as is yearly done, in coke ovens. That question first demands attention.

Mr. B. G. R. NEWLANDS: Mr. Kingzett began his paper by saying that if manufacturers were to acquaint us with their special wants, and to describe the waste products of their manufactures, we might find some means of assisting them. Indeed, this was the Alpha and Omega of his paper, and, as he says (I will do him justice to admit this), I think it would be a most important thing if scientific men were to give more of their time to considerations of this kind, and allow manufacturers to utilise, free of charge, the information which would be obtained in this way. I think, however, that manufacturing chemists look upon this question very much in the same light as the owner of an estate looks upon his game. He has certain game on his estate which is difficult to find. He knows it is there, but cannot tell exactly where to lay hands upon it, but yet thinks it very undesirable to call in strangers to assist him in the discovery. If I had waste products in my manufactory, I should endeavour to work out their utilisation myself. If we find difficulties, we like to try to overcome them, and reap the harvest of our own sowing.

Mr. DAVID HOWARD: With reference to the illustration just given, I would remark that besides the game which we keep for our own amusement or profit, there is also a large amount of "stray cattle" of which we should be happy to dispose. I do think

it is a very important matter that more attention should be called to this subject. The waste products from one manufacture may be the raw material for another, and there is a great deal more to be effected in this way than has yet been done. This can only be brought about by the diffusion of more knowledge as to what extent the superfluous residue of one process may be utilised in another operation. By all means let us as manufacturers, so far as we can profitably do so in our own interests, use up every waste product, but still beyond that it is quite possible there may be uses for many substances which we cannot utilise. Hence, it is desirable that scientific chemists should be acquainted with such matters. The royal secret in the utilisation of waste is to effect it economically. It is very easy to take up a text-book of chemistry, and make a substance, but a very difficult matter to produce it cheaply. However, I regard this question of waste products as the most important of all subjects which either individually or jointly we can consider.

Mr. CROWDEN: Respecting the question of ammonia which Dr. Messall has referred to, any gas manager, I think, will admit that calculating the quantity of ammonia producible from coal is a very different thing from realising it in practice. It is not possible to obtain more than about a fourth, the other three parts being lost in the air. Regarding Dr. Gronven's process, I was told by a gentleman who went to Belgium, to examine the process, that he made a combustion by this process, and succeeded most perfectly in getting the full proportion of ammonia—that is to say, he got the theoretical quantity of ammonia. The great difficulty, I understand, is to carry it out on a large scale. Such processes are often successful on a small but fail on a large scale. The process, I believe, is still attracting attention. Being very much interested in the subject, and having to use very large quantities of ammonia, I have made a great number of experiments, and I may say that I spent twelve months studying the process, but judging from the results, although I think it might be made successful, there would be a great number of practical difficulties experienced in carrying it out.

Mr. F. MAXWELL LYTE: Mr. Kingzett, in his very interesting paper, has been good enough to allude to a process invented by me for certain metallurgical purposes. We are at present in course of setting up works at Widnes for working this process on a large scale, and I fully intend hereafter making the matter the subject of special communication to this Society—that is, when the process is started, and I can point to its being worked commercially. The process has, however, been already proved on a considerable scale by working with some tons at a time, and with a large plant. I will now only just mention what are its general features. It is known to everybody who has to do with lead ores that they are constantly found contaminated with different impurities, that render them difficult or impossible to be worked by the ordinary smelting processes. Among such minerals are blende, and the various zinc compounds. The means I employ for economically separating the constituents involve no new reactions—they are rather to be looked on as a special application of certain known chemical reactions. Let us take, for example, a lead ore—galena—containing silver, and contaminated with zinc blende. The ore is ground and calcined, whereby all the metals are oxidised, and the sulphur driven off. More or less sulphate remains, however, with the metallic oxides formed, according to the temperature used. The calcined ore is finely pulverised. It is then treated with hydrochloric acid, which dissolves the zinc, and leaves the lead and

* See his paper in *Chemical News*, vol. xlii, pp. 101 and 202.

silver as chlorides mixed with the gangue. It is next treated with strong boiling brine, or a boiling solution of one of the alkalino-earthly chlorides. This takes up the lead and the silver chlorides. The solution is allowed to settle, and is then decanted off and allowed to cool. The saline solution, which takes up while boiling 5 to 6 per cent. of lead chloride and about 1 per 1,000 of silver chloride, deposits, on cooling, four fifths of its lead chloride, but none of its silver chloride, this latter remaining in solution with the remaining one fifth of the lead. The cooled saline solution is again decanted off, and into it are plunged some pigs of spelter. The lead quickly forms around the zinc, as reduced spongy metallic lead, forming the well-known lead tree, that every boy is acquainted with. This spongy lead is shaken or brushed off, and floats in the liquor, and a workman being set to rake it about, it soon collects and sweeps out of the liquor all the silver therein contained. There are thus produced in separate vessels, by operations which consist in effect mostly of mere decantations, zinc chloride and lead chloride, while in the third vessel metallic lead is obtained with all the silver, and this may be got with even 28 or 30 per cent. of silver in it. Other acids may be used for extracting the zinc in this process as well as the hydrochloric acid, but the advantage of employing the latter—which is at present a waste and troublesome product—is manifest. Antimonial lead ores are treated in a somewhat similar manner, only the antimonious chloride formed is volatilised by exposure to a sufficiently high temperature, instead of being decanted off like the solution of zinc chloride. The antimonial ores are frequently very rich in silver, and cannot be treated by smelting, or the silver extracted unless the antimony be first got rid of.

Mr. SPILLER: It is a well-known fact that photographers cannot do without albumen. We already have egg and fish albumen, and although attempts have been made to supersede these by blood albumen, there is still plenty of room for purified albumen. The existence of the salts that are present in serum will be of no disadvantage to us since they do not interfere with the photographic action. If Mr. Kingzett's purified albumen proves serviceable to photographers, it will have the effect of restoring a large quantity of food, in the shape of eggs, to the market.

The CHAIRMAN: The opening and concluding remarks of Mr. Kingzett's paper seem to have provoked more discussion than the other subjects. There is no doubt that every one of the subjects would merit very much more elaborate description than was possible within the limits of Mr. Kingzett's paper, and each one in that case might have led to a very interesting discussion. What was perhaps of special interest was Mr. Kingzett's own process for bleaching albumen. With regard to the general observations, I think most of us must agree generally with that that has fallen from Mr. Howard; but referring especially to what fell from Mr. Nowlands, I must confess that some of his remarks struck me strangely. I am certainly of opinion that so far as the utilisation of waste product is concerned the incentive has arisen from the results of scientific research. The history of coal-tar colours strikingly illustrates this fact. Again, for instance, I do not know how so many efforts should have been made for the recovery of glycerine, if it had not been for the discovery of nitro-glycerine. And so I think I may take the whole list of waste products which have been rendered valuable, and show that scientific men have some large amount of praise due to them for their share in the work. There is no doubt, on the other hand, that the economical question is also

a most important factor in the utilisation of waste materials, and it is to be hoped that by following the suggestions thrown out by Mr. Kingzett, and inquiring more minutely into necessary essentials, we shall greatly advance chemical interests generally.

ERRATUM.

In the February number of this Journal, p. 42, lines 10-51, Mr. Weldon desires to substitute the following corrected reading: "The quantity of heat absorbed during the splitting up of calcium oxychloride into calcium chloride and lime is exactly the same as the quantity of heat evolved during the reaction of chlorine on milk of lime, so that when a milk of calcium oxychloride is treated with chlorine there is no rise of temperature. Two reactions take place simultaneously, and the evolution of heat during the one, and the absorption of heat during the other, exactly balance each other."

MEETING OF THIS SECTION.

April 3rd. "The Technology of the Jute Fibre," by C. F. Cross, B.Sc., F.C.S.
Discussion on Mr. Tyrer's Paper on "Smoke Abatement." (February Number, page 36).

Liverpool Section.

Chairman: E. K. Muspratt, Seaforth Hall, Liverpool.

Committee:

Dr. Campbell Brown.
Holbrook Gaskell, Jun.
J. C. Gamble.
H. Tate, Jun.
Dr. Hurter.
J. H. Crossley.
J. F. Allen.

F. G. Gossage.
S. M. Harrison.
W. Douglas Herman.
J. L. Muspratt.
A. Norman Tate.
Dr. A. R. Garrick.
A. E. Fletcher.

Hon. Sec.: Dr. A. R. Garrick, Eccleston Park, near Prescott.

DYNAMIC THEORY OF THE MANUFACTURE OF SULPHURIC ACID.

BY FERD. HURTER, PH.D.

APPENDIX.

The derivation of the equation, which I have termed the dynamic equation, is too lengthy to appear in this journal.

The reasoning by which I obtained it is based upon the following hypotheses, which have received general assent:—

1. The molecules of a gas are in constant motion.
2. Chemical action does not take place at measurable distances.

Without going into mathematical reasoning, it follows, as a necessary consequence of these two statements, that the rate at which any given reaction can proceed must depend upon two factors. The one of these two factors must be a function of the rapidity with which the molecules about to undergo a reaction can approach each other to the requisite distance at which alone the reaction commences, and which is usually called the radius of the sphere of action. The other factor must be a function of the special properties of the substances undergoing a change. It is clear that when once, by processes of diffusion, a group of molecules has been formed at such distance from each other that these special properties can come into play, that then the function depending upon these properties must have a nearly constant value, and that consequently the rate of the change must depend very much upon the facility with which such groups can be formed in the system in which the change takes place. The rigorous derivation of the equation being too lengthy, I will only point out that it is analogous to the course of arguments pursued by R. Clausius, in his paper "On the Mode of Motion called Heat" (*Phil. Mag.*, Fourth Series, vol. xiv., p. 108, and vol. xvii., p. 81).