

in hydrochloric acid, and the cone is dried and weighed anew. If the ore contains copper, it is deposited with the zinc. The deposit is redissolved in nitric acid, and the copper is precipitated by electrolysis in an acid liquid. Cadmium alone is determined along with the zinc, which is the case also in volumetric determinations. When it is present in the ore in notable proportions it must be removed by means of sulphureted hydrogen. The quantity of potassium cyanide must be exactly limited. If more is used than the weight given the metal will be deposited more slowly, and if the quantity is less the deposit is not adherent. This electrolysis in alkaline liquids occasions an attack of the platinum electrodes, and the formation at the negative pole of a black coating of finely-divided platinum, which is not removed by treatment with acids, but which changes continually the weight of the cone. The author avoids this inconvenience, due to the decomposition of ammonium hydrochlorate and the formation of nascent chlorine, by adding to the liquid to be electrolyzed 5 c. c. of a saturated solution of ammonium acetate. The acetate is decomposed by the current, and no chlorine is formed, so that the electrodes are not attacked. Ammonium nitrate answers the same purpose, but it delays the precipitation of the zinc. The results obtained in the absence of cadmium are absolutely exact.

THE RECOVERY OF SULPHUR FROM ALKALI WASTE (SCHAFFNER AND HELBIG'S PROCESS: A RECORD OF RECENT RESULTS.*

By ALEXANDER M. CHANCE.

INVENTED and applied in France by Leblanc, about the year 1790, and first introduced into England by Mr. Muspratt, in 1823, the manufacture of soda from common salt—generally known as the alkali trade—has gradually extended, until it has become the most important of all the chemical processes in Great Britain. Upon its production depend the manufacture of glass, soap, paper, and of many other articles of everyday use throughout the civilized world, while the quantity of raw materials required, and the labor and capital employed, render the alkali trade one of the leading industries of this country.

But apart from the interest which any such industry necessarily creates in a manufacturing country like England, there are special features incidental to the alkali trade which have, from the very outset, caused much more general attention to be bestowed upon alkali makers than they themselves have desired.

In transforming chloride of sodium (common salt) into carbonate of soda (common soda), by Leblanc's process, two by-products are produced, to deal with which, so as to prevent annoyance to their neighbors, and injury to adjacent property, has not only taxed to the utmost the ingenuity of the manufacturers themselves, but has also led to several special acts of Parliament. These two by-products are, as is well known, hydrochloric acid gas and alkali waste.

Since 1863, the condensation of hydrochloric acid gas has been rendered compulsory, and this acid, once a source of anxiety and loss, has, with the progress of chemical industry, gradually acquired considerable commercial value, and is now, in many districts, an article of primary importance to alkali makers, principally for the manufacture of bleaching powder and of chlorate of potash. In works managed with ordinary care, it is now easily kept under perfect control. The other by-product, namely, alkali waste, forms the subject of our consideration this evening.

By Leblanc's methods, the conversion of salt into soda, whether as carbonate or as caustic, necessitates several chemical operations. The decomposition of salt by sulphuric acid into sulphate, and the conversion of sulphate, by the addition of limestone and coal, into carbonate, involve, as every alkali maker knows, the entire loss of the sulphur and the lime, which thus become the chief constituents of the bulky, insoluble mass known as alkali waste. Of the two materials so lost, by far the more costly is sulphur, the cheapest supply of which comes to us from abroad in the shape of pyrites (principally from Spain); and it has long been felt that means ought to be found to prevent this enormous waste of sulphur.

According to the Board of Trade returns, as kindly supplied to me by Mr. William Smith, of Bristol, the following table shows the imports of brimstone and pyrites into the United Kingdom, during the years 1880 and 1881:

	1880.	1881.
	Tons.	Tons.
Brimstone.....	46,896	40,561
Pyrites	657,867	542,046

We have thus a yearly average of 599,956 tons of pyrites for these two years, or in round numbers, say, 600,000 tons a year, for 1880 and 1881.

Let us now try to ascertain how much of the sulphur in this large quantity of pyrites is lost in alkali waste. According to the returns of the Alkali Association, we find that in 1880, 700,016 tons of salt, and in 1881, 675,099 tons of salt were decomposed, showing an annual average for 1880 and 1881, of 687,557 tons decomposed.

Now, as from the sulphur in one ton of Spanish pyrites about 1½ tons of ordinary salt may be decomposed, we find the quantity of pyrites required to decompose 687,557 tons

to be $\frac{687,557}{1.75} = 392,890$, which figure therefore may

be regarded as indicating the yearly average quantity of pyrites used in 1880 and in 1881, in the United Kingdom, for the decomposition of salt in the alkali trade. But part of the sulphate of soda thus made was sold as sulphate, for glass making and other purposes; and an allowance must be made accordingly. Assuming that the sulphate so disposed of required for its production 42,890 tons (an outside figure) of pyrites, equal to about 84,000 tons of sulphate, we have, in round numbers, 350,000 tons of pyrites actually imported for the manufacture of soda (more than one-half of the entire imports) of which from 80 to 90 per cent. of the sulphur is lost in the alkali waste.

At the present price of sulphur in pyrites, namely, 6d. per ton per unit, of an average strength of 48 per cent., the value ex ship is 24s. per ton, irrespective of the cost of inland carriage.

The minimum money value, therefore, of the sulphur thus lost may safely be computed thus: 350,000 tons at 24s., equal £420,000, of which 85 per cent., or £357,000, represents the loss of the sulphur in alkali waste.

These figures, estimated carefully, show the commercial importance of the question we are now considering. So long, however, as this loss of sulphur was shared by all makers of soda, and so long as no other method of manufacturing soda more cheaply existed, this loss, large as it is, fell rather upon the consumers than upon the producers of soda, and has hitherto been regarded by manufacturers as part of the cost of production.

Recently, however, the method known as the ammonia-soda process has been so successfully established on a large scale in England, that soda ash is being produced by it more, nay, much more, economically than by Leblanc's process, and thus the recovery of the sulphur from alkali waste, as a means of cheapening the cost of production by Leblanc's process, has become of vital importance.

The treatment of alkali waste is also forced upon the attention of manufacturers by the Alkali, etc., Works Regulation Act, passed in 1881, which came into operation on the 1st of January of the present year, by which alkali waste is, for the first time, made a subject of legislation.

Under section 6, it is enacted that "Alkali waste shall not be deposited or discharged without the best practicable means being used for effectually preventing any nuisance arising therefrom," and heavy penalties are attached to the non-observance of this requirement. By ceasing to have any alkali waste to deposit, alkali makers would, obviously, best comply with this provision; while, if they could at the same time profitably recover the sulphur and the limestone now lost, they might be enabled to compete successfully with the ammonia-soda process just named.

The sulphur recovery process of Messrs. Schaffner and Helbig seems to offer a satisfactory solution of this question; but before we pass on to it, we must refer very briefly to other sulphur recovery processes, in order the better to appreciate fully its true value and importance.

So far back as 1837, the late Mr. Gossage took out a patent for decomposing tank waste by hydrochloric acid, or by carbonic acid, and for employing the H₂S thus generated for making sulphuric acid. But although, to quote his own words, "he devoted thirty years of his life and a fortune" to this object, he failed to establish a process by which the sulphur could be profitably recovered. Since that time, many other chemists have also devoted much time and thought and money to this object; but of the numerous methods suggested, and of the many processes patented, only three need here be mentioned, namely, those of Schaffner, of Mond, and of Mactear.

According to Lunge (vol. ii., p. 652), the recovery of sulphur was accomplished nearly simultaneously (in 1861) by Schaffner and by Mond, who worked quite independently, and elaborated processes differing from each other in many details. The principle of each process, however, is the same, namely, the partial oxidation of the sulphur and calcium compounds in the tank waste, and the decomposition of the soluble compounds thus obtained by hydrochloric acid, by which a certain quantity of the sulphur originally contained in the alkali waste is recovered.

At the few works in England, where the recovery of sulphur from alkali waste has been carried out, the process adopted has been Mond's.

By the courtesy of Mr. Mond, I am permitted to publish the following results, which have been kindly furnished to me by the five firms in England who have used his process, designating, for obvious reasons, these firms by numbers and not by name:

Mond's Sulphur Recovery Process.—Results of the five firms using it in England.

Firms.	Total tons of sulphur recovered.	Percentage recovered of total sulphur in vat waste.	Tons of HCl used per ton of sulphur recovered.
1	6,690	30	3½ of 28° Tw.
2	1,500	27 to 30	4 of 25° "
3	3,200	*25 to 30	4 to 4½ of 28° "
4	3,000	..	4 of 30° "
5	3,223	† 17	not registered.

Total quantity of sulphur recovered=17,613 tons. In Germany generally (according to Lunge) Mond's and Schaffner's processes are combined, and Schaffner himself still continues, it appears, to use his process at Aussig with considerable success, which process Mr. Mond affirms to be now practically identical with his own. But these processes, although greatly in advance of all previous methods, fail to solve the alkali waste question, for the following three reasons among others:

1st. At the most, only 30 per cent. of the total sulphur in the waste has been recovered by them in England.

2d. A large quantity of hydrochloric acid is required for every ton of sulphur thus recovered.

3d. The waste, after treatment, still forms a bulky, troublesome deposit, although apparently no longer liable to cause a nuisance.

In striking contrast with these three drawbacks, will appear the advantages of Messrs. Schaffner and Helbig's process, by which at least 90 per cent. of the sulphur may be recovered, while no hydrochloric acid is required—and the residue to be deposited will eventually be barely one-fifth of the original bulk; probably, even much less.

But this paper, purporting, as it does, to treat of the sulphur recovery question in England, as a whole, would be incomplete if reference were omitted to processes by which sulphur can be recovered from the drainage from old waste heaps.

Schaffner's and Mond's processes, as just described—whether separate or combined—deal only with fresh alkali waste, as produced, day by day. The treatment of the drainage from old alkali waste heaps has been ably dealt with by Mr. Mactear, whose process, as described by himself in a paper read before this society in May, 1878, is in operation on a large scale at Messrs. Tennant's Chemical Works, at St. Rollox, Glasgow, of which he is technical partner.

The experience acquired by him in working this process has led to certain modifications in the details, and the method now in use at St. Rollox is that patented in 1878, No. 885, in which a solution of bisulphite of lime is used, prepared from old waste oxidized chiefly to sulphites, and then treated with SO₂.

The chief advantage claimed for this modified process is that weak drainage liquors can be treated by it; and that, with the same plant, double the work can be done as compared with the original method; but a serious disadvantage is that it requires more hydrochloric acid per ton of sulphur recovered.

Mr. Mactear has kindly permitted me to state that already, by this process, over 14,500 tons of sulphur have been recovered at their St. Rollox Works.

Another mode of dealing with the drainage of old waste heaps, and, as it seems to me a much simpler and more economical one, is that patented by M. Pechiney, and now in use at his works at Salindres, in France.

By an identical method, applied during the investigation of this subject by our chemist, Mr. Dryden, in complete ignorance of M. Pechiney's operations, the whole of the drainage of our waste heap is being satisfactorily dealt with at our alkali works at Oldbury, near Birmingham. It consists simply of oxidizing the drainage liquors in iron tanks, by means of a current of air and steam produced by a Kiering's injector, until the oxidation reaches the point when, by adding HCl, neither H₂S nor SO₂ is given off. By then adding HCl the whole of the sulphur is precipitated as impure sulphur, which is dealt with in the ordinary way, and a clear solution of chloride of calcium is run off. Fuller information concerning this simple and effective method of dealing with the drainage of old waste heaps will be found in Mr. Weldon's paper, read before the Society of Chemical Industry in London, in January last, and in the discussion which followed. Any communications respecting it should be addressed to Mr. Walter Weldon, who represents M. Pechiney's interests in the patent in this country.

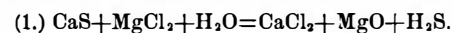
This rapid review of the main features of the principal processes actually used in England for dealing with alkali waste, and of the results obtained, will be of service, in enabling us better to realize the great advance established by Messrs. Schaffner and Helbig's process, and to appreciate the influence it is likely to exert upon the future of the alkali trade.

SCHAFFNER AND HELBIG'S SULPHUR RECOVERY PROCESS.

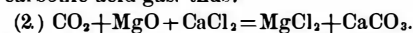
Although patented in England in March, 1878, this process did not become known to us until its publication *in extenso* in Professor Lunge's admirable and exhaustive treatise on the Alkali trade, issued in 1880, to which source, also, Dr. Angus Smith is indebted for the extracts given in his sixteenth annual report. From Professor Lunge's most valuable book, and from the original specification itself, full information can be obtained by all who desire to study the origin and the theory of this deeply interesting process.

To-night we have to consider, briefly, the chemical reactions and combinations discovered by Messrs. Schaffner and Helbig, the results obtained by our firm, as pioneers of this process into England, together with such other details and information as practical experience may have suggested.

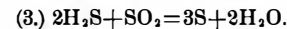
Three distinct chemical reactions, involving three separate and distinct operations, constitute this process as originated by its distinguished authors, Messrs. Schaffner and Helbig. I. The decomposition of the calcium sulphides in the alkali waste, by magnesium chloride, by which the sulphur is liberated as H₂S, without being diluted with other gases. This reaction is stated thus:



II. The reconversion of the magnesia (MgO) thus formed into chloride of magnesium, and the recovery of the calcium from the CaCl₂, in the form of carbonate of lime, by the action of carbonic acid gas, thus:



III. The recovery of the sulphur from the H₂S, by precipitating the S by means of SO₂, thus:



Let us now consider these three operations in their order. The first operation, that of the decomposition of the calcium sulphides by the MgCl₂, is very readily accomplished, if care be taken that the solution of MgCl₂ be of sufficient strength, and be present in excess. A solution of a minimum strength of 30° Twaddell works advantageously.

Analyses of vat waste show that the sulphur present is almost entirely in the form of sulphides when the waste is thrown out of the vats, and that by exposure to the atmosphere, the sulphides gradually become oxidized into hyposulphites, which are not acted upon by MgCl₂.

It is therefore essential that the vat waste should be used, and be taken from the vats to the decomposers, without loss of time, as the fresher the vat waste used, the larger is the quantity of sulphur recoverable. Of the total sulphur in the vat waste, we have found that from 90 to 95 per cent. may be thus recovered, the balance, from 5 to 10 per cent. being lost, partly in the hyposulphites, etc. of the vat waste (which are not acted upon by the MgCl₂), and the remainder in the conversion of the H₂S into its commercial product. Great care, both in the construction of the plant and in the manipulation, is of course essential to guard against escapes of this highly dangerous and offensive gas, H₂S.

As MgCl₂ has not any action upon the undecomposed carbonate of lime present in the waste, the H₂S given off is perfectly pure, except as regards a certain quantity of steam, which is readily separated by means of condensation. The purity of the H₂S is one of the special features of this process, and contributes—as will be seen when we consider the third operation—in no small degree to its success.

The second operation, known as the carbonating process, by which the magnesium chloride is recovered, and carbonate of lime is obtained, is of the highest importance. It was in this operation that appeared to Mr. Weldon (to quote his own words) "the weak point in this very remarkable process," and to the impression left upon his mind by some experiments of a similar nature, made by himself some eleven or twelve years ago, he attributes in part the fact that although he brought it under the notice of many of the principal alkali makers in England, as Dr. Schaffner's representative, yet as "he could not tell them, either that Dr. Schaffner was himself performing the process on an industrial scale, or that he could regard the industrial practicability of this operation as being as yet absolutely established, none of them cared to do more than discuss the matter."

Nothing, therefore, was done in this country with this process until, as already stated, we first learned of it from Lunge's book, and being in happy ignorance of Mr. Weldon's misgivings we took steps to try it for ourselves. We failed at first to obtain satisfactory and complete results in consequence of our power of pumping CO₂ being insufficient, but when we were able by means of a powerful compressor, specially constructed for the purpose by Messrs. Tangye, of Birmingham, to force CO₂ into the carbonators in a steady stream under pressure, we found that this operation also was completely successful.

* A paper lately read before the Society of Arts, London.

* Estimated.

† No record kept formerly; at present 17 per cent.

The carbonic acid gas used by us is supplied from a lime-kiln, heated by coke, the lime being used in our caustic soda process; the strength of the CO_2 gas thus obtained varying from 15 to 23 per cent. As yet we have not tried the flue gases from the black ash furnaces, but if the CO_2 thus produced is not too dilute, we hope eventually to use this source of CO_2 in this operation. The MgCl_2 thus recovered is used over and over again, but as the traces of soda left in the waste are converted into chloride of sodium, it will happen that each successive batch of recovered MgCl_2 will contain a little more of the NaCl so formed; a source of embarrassment, which, though slight and unimportant at first, will gradually have to be provided for. The carbonate of lime thrown down is collected on filters, and carefully washed, in order to recover all the MgCl_2 ; these washings, being necessarily dilute, require to be concentrated by means of evaporation. The carbonate of lime itself will, to a large extent at least, be available for black ash mixings; not entirely, however, as some part may, for the present, have to be treated as a by-product, and be put aside, as it remains to be proved whether the impurities of silica, alumina, etc., etc., introduced by the black-ash operations, will not, as they accumulate, render the recovered carbonate unfit for mixing purposes.

To what full extent, therefore, the recovered carbonate of lime will be available for black-ash making is at present a mere matter of conjecture; perhaps it may be used four or five times, and the next batch have to be put aside, but this part of the process offers no serious obstacle to its success. My own thoughts turn in the direction of compressing the carbonate of lime thus put aside, which may not be pure enough for mixing purposes, into bricks, and then burning these bricks instead of limestone in the lime-kiln, thus obtaining the carbonic gas required, and selling the slightly impure lime so made to lime merchants, for building purposes.

The large towns of Liverpool, Newcastle, Glasgow, Birmingham, and Bristol, which are in close proximity to the

at Oldbury, and, as we believe, for the first time, practically accomplished this operation on a large scale, it may be of interest to give some details of the process.

After the steam which is given off with the H_2S in the decomposer has been removed by means of cold water in a condensing apparatus, the dry H_2S is conveyed along a 4-inch cast-iron main, protected by hydraulic seals, to prevent the possibility of "lighting back," to a special burner, consisting of a cast-iron box, also water sealed, out of which a series of one-inch gas pipes pass into a brick oven, through a cast-iron plate, perforated for the admission of air. The H_2S gas is lighted as easily as ordinary coal-gas, and burns quite freely, giving off considerable heat, and producing, as is well known, by its combustion, just sufficient water for forming H_2SO_4 , as shown by the equation, $\text{H}_2\text{S} + 4\text{O} = \text{H}_2\text{SO}_4$, and thus saving a great deal of steam. The niter pots are placed in the flue at one or other of several potting doors, more or less distant from the burning gas, according to the increasing or decreasing supply of H_2S from the decomposers.

The oil of vitriol thus produced is of great purity, quite free from arsenic, and, upon concentration, yields rectified oil of vitriol fit for every purpose. We show samples to-night of this acid. So satisfied are we with these results, that we are making arrangements to burn the H_2S in connection with a Glover's tower, so as to derive the economy of niter, of fuel, and of labor, due to that apparatus. If by a rough and ready burner, such as described, working only at intervals, we succeeded in obtaining satisfactory results, it seems certain that alkali makers will turn their attention, by preference, to this means of utilizing the sulphureted hydrogen.

We have now seen that the chemical combinations discovered and applied by Messrs. Schaffner and Helbig do fully realize the conditions claimed for them by their distinguished inventors—that from 90 to 95 per cent. of the sulphur in the vat waste may be recovered in a commercial form; that practically the whole of the calcium compounds

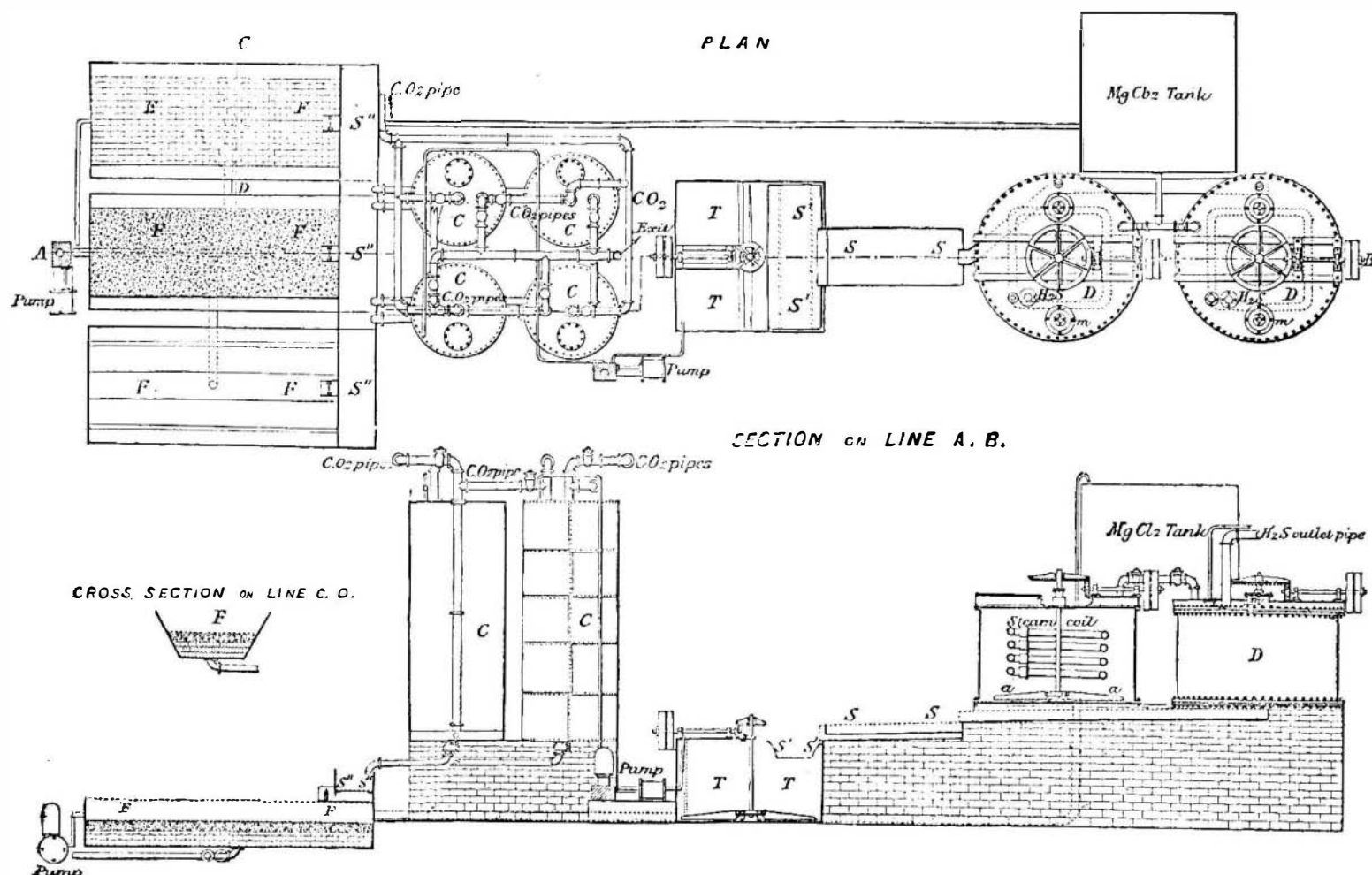
tion has hitherto been chiefly, nay, almost exclusively, directed to two points, namely:

1st. The direct manufacture of sulphuric acid, by burning the H_2S in vitriol chambers, in which we have been completely successful; and

2d. To the precipitation of the carbonate of lime, and the recovery, in the carbonators, of the MgCl_2 by means of CO_2 .

This operation, as already stated, is found to be completely successful from a chemical point of view, and the reactions claimed for it in theory have been fully realized in practice. But our experimental plant, erected temporarily, and not with a view to permanency, has, as we fully expected, been the means of educating us, so that when we proceed to erect new and more extensive plant, for the treatment of our alkali waste, we shall know more precisely what to keep, and what to alter.

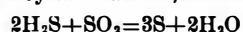
Several defects in our plant have caused losses of MgCl_2 —losses thus solely due to mechanical causes—but these defects have, unfortunately, rendered worthless our results, as to the probable unavoidable loss of MgCl_2 . The principal source of loss, however, has been due to our vacuum filters, and to our incomplete means of washing the carbonate of lime, which forms a precipitate so considerable in its moist state—exceeding in fact the bulk of the original vat waste itself—that a little MgCl_2 left behind in each ton would amount to a material total loss upon the whole quantity. Pressure filters, fitted with suitable washing apparatus, seem to offer the solution of this difficulty. During the last few days I have made inquiries from those who have had practical experience of filter presses, as to their probable value for this purpose, and from the information I have obtained, I entertain but little doubt that the use of filter presses will be crowned with success. The results of our last week's working—ending on Saturday, 6th May—are very encouraging. The loss of MgCl_2 amounted to 4.1 per cent., equal to 2 cwt. 1 qr. 22 lb. per ton of S recovered, besides about 40 lb. of calcined dolomite per



EXPERIMENTAL PLANT FOR SCHAFFNER AND HELBIG'S SULPHUR RECOVERY PROCESS, AS WORKED AT THE ALKALI WORKS OF MESSRS. CHANCE BROTHERS OLDBURY, NEAR BIRMINGHAM.

principal centers of the alkali trade, would seem to offer ample outlets for all the lime so produced, if it were not pure enough for chemical purposes.

The third operation deals with the H_2S given off in the decomposers, and converts it into commercial products. Messrs. Schaffner and Helbig propose to deal with it, by precipitating the S by the reaction, as already stated:



This operation is fully described by Lunge, vol. ii., page 690, and the difficulties to be overcome, and the means by which the distinguished originators of this process overcame them are clearly set forth in the same volume, pages 645 to 648. Messrs. Schaffner and Helbig have proved that all the sulphur can be obtained in a granular, easily separable form, and without any loss by polythionic acids, if the gases are brought into contact, not with water, but with solutions of such salts as calcium chloride, magnesium chloride, sodium chloride, etc.

The operation just described has been successfully worked, on a manufacturing scale, at Dr. Schaffner's works at Aussig. We had hoped to have been honored with Dr. Schaffner's presence here to-night, and to have heard from him further details of this very interesting process for extracting sulphur, as such, from H_2S . But, in his absence, Mr. Weldon gives me to understand, that Dr. Schaffner recovered about two cwt. of free sulphur per day for about six months.

From the outset, however, of our own investigation of Messrs. Schaffner and Helbig's process, we were struck with the facility with which the pure H_2S , so produced, burns; and we, therefore, proceeded to try whether it might not thus be converted directly into sulphuric acid in vitriol chambers. The direct production of sulphuric acid by such means would, obviously, be very advantageous to alkali makers, who would thus recover from their alkali waste the sulphur in the very form in which they need it, besides dispensing with any large outlay for special plant. Having,

are also recovered, principally as carbonate of lime; and that the reagent by which these remarkable results are obtained—namely, MgCl_2 —is itself recovered, with the exception of the unavoidable losses due to the manipulation of the process.

In this last sentence lies the key to the success or to the failure of this beautiful process. MgCl_2 is valuable—far too costly at present to admit of any large measure of waste being disregarded. It may—it probably will—become cheaper and cheaper as its uses increase, and fresh sources of supply are brought to light; but meantime, its consumption must be minimized, if this process is to be adopted with all the bright prospects which it opens out.

You will therefore ask, and I will honestly endeavor to answer, as candidly as possible, the crucial question—What have these losses been, and what is the probable prospect of loss of MgCl_2 in this process?

But before entering upon this question and bringing this paper to a close, I must invite your attention for a few moments to the model submitted to-night of the experimental plant which we have ourselves been and still are using.

Let us now enter upon the consideration of the very important question of the unavoidable loss of MgCl_2 .

So far as we have been able to determine, we have satisfied ourselves that chemically the combinations are complete, and that there do not appear to be any losses whatever of MgCl_2 , except those due to manipulation. According to Lunge, vol. ii., page 695, the loss of MgCl_2 , unavoidable in working on the large scale, is 5 or 6 per cent. Presumably, Professor Lunge obtained these figures from Messrs. Schaffner and Helbig, and if these figures can be shown to be the result of continuous working on a large scale, then the commercial success of this process is undoubtedly assured. For our own part, however, we are not, to-night, in a position to submit any actual figures as to the probable limits within which this loss can be confined. As pioneers of this process into England on a manufacturing scale, our atten-

tion of vat waste treated. But the analyses of several samples of the lime mud made last week showed that nearly the whole of this 4.1 per cent. of the MgCl_2 was present in the lime mud, so that had filter presses been used, and the bulk of this MgCl_2 been thus recovered, our loss of magnesium would have been almost confined to the dolomite added to the carbonators.

This perfectly candid confession of our imperfect manipulation of this important portion of the process should not in any way deter others from embarking in it, as it will certainly not deter us from continuing to work upon it. At present we are busily engaged in doubling our plant, and in devising suitable filtering apparatus—the best possible proof of our opinion of the value of this most comprehensive method of dealing with alkali waste.

To the members of the Society of Chemical Industry, before whom, in London, Mr. Weldon first publicly directed general attention last January to this process, I promised, in the discussion which ensued, to submit the commercial results of our experiments—a promise which I look forward with much pleasure to fulfilling without any unnecessary delay. But for practical purposes and to be of any permanent value, figures of this kind should be based upon results obtained during an extended period, and from a sufficient quantity of material employed.

Meantime, the invitation which I had the honor, most unexpectedly, to receive from the Society of Arts, to read this paper to-night, has afforded an excellent opportunity, to many interested in this subject, to learn precisely what has been and what still remains to be done.

For my own part, I should much have preferred that one of the recognized leaders of the alkali trade had been in my place to-night, and I in his; but I am paying the penalty for the boldness which tempted me to try Messrs. Schaffner and Helbig's process, while others held aloof. The attractions of this beautiful process are still to me as great as ever. To recover, henceforth, at least nine-tenths of the sulphur now lost in the vat waste, instead of at most three

tenths, as had been occasionally recovered hitherto; to recover it without the use of any hydrochloric acid whatever; to become to this large extent independent of foreign sources of supply of sulphur; and to render the deposit of alkali waste no longer necessary, are advantages too substantial to be lightly disregarded in the present state of the alkali trade. Messrs. Schaffner and Helbig have opened up entirely new ground—have suggested entirely new possibilities. Their process may be, it probably will be, ere long, rendered more easily practicable by the further inventions of its illustrious authors themselves, and if Mr. Weldon, their distinguished representative in England, will disclose to us to-night the details of the more perfect process which he stated last January was soon likely to be announced to the world by Messrs. Schaffner and Helbig, he will add yet one more to the many obligations under which he has placed alkali manufacturers, not only by his own remarkable inventions, but also by directing their attention to the inventions of eminent manufacturers abroad. As it is, the recovery of sulphur from alkali waste seems at last to be within a "measurable distance" of accomplishment, and to Messrs. Schaffner and Helbig belongs the credit of having originated the beautiful process which promises a new lease of life to the manufacture of alkali, as invented by Leblanc.

DISTINCTIONS BETWEEN ORGANISMS AND MINERALS.

CERTAIN recent investigations have shaken if not altogether overthrown one of the most striking distinctions between the inorganic and the organic world. Suppose we take up one of those bodies in which dead matter is individualized, *i. e.*, a crystal. We perceive at once that its surfaces are planes, bounded by right lines.* We may, by grinding and rubbing, bring such crystals into rounded forms, and nature may effect the same if the crystals lie in the bed of a rapid river, or on the shore of the sea. But these forms are essentially artificial, and are never assumed when inorganic matter is left to crystallize. On the other hand, if we take an animal or a plant and examine its shape, we find that, save in some of the lowest groups, it has exclusively rounded surfaces, spherical, spheroidal, ellipsoidal, cylindrical, etc., and that its outlines are curves. This distinction between the living and the lifeless is so striking that it was once proposed to view the development of animals and vegetables as a process of curvilinear crystallization, peculiar to certain kinds of matter when placed under proper conditions. The immense mathematical difficulties involved were the reason why the idea was never worked out.

Again, if we break, cut in pieces, or otherwise dis sever a mineral and an organism, we find that their respective differences of structure are not confined to the outer surface. The disintegrated particles of the mineral body are each solid; each, if cut or broken, consists, within and without, of the same kind of matter. We may find in minerals, *e. g.*, asbestos, a fibrous structure, but such fibers are not tubular, and never contain either a fluid or any solid body differing in composition or in structure from the outside layers. In the organic world all this is otherwise. If we examine the intimate structures of the plant or the animal, we find tubes, sometimes hollow, sometimes containing a fluid, or sometimes a solid matter differing in its nature from the inclosing walls. We find also round or oval vesicles known as cells and generally containing fluid matter. These well-known contrasts are presented here in the briefest and most sketchy manner, not as being in themselves novel, but as necessary to be borne in mind for the understanding of what is to follow.

In February, 1878, M. Georges Fournier, of Paris, performed, in presence of Mr. W. Crookes, F.R.S., and of the present writer, some most remarkable experiments. By mixing together certain inorganic salts, he produced pseudo-organisms, which, in form and structure, might easily have been confounded with certain cryptogamous plants by any one who was not acquainted with their origin. In the belief that M. Fournier was continuing his experiments, we considered it a duty not to make his results known in a premature and necessarily incomplete state. It was, therefore, with regret and surprise that we saw in the *Comptes Rendus* for January 2, 1882, a memoir by D. Monnier and C. Vogt, a translation of which follows:

"Figured elements presenting all the characteristics of form belonging to organic elements, such as cellulose, simple and with porous channels, tubes with sides, with septa, and with heterogeneous granular contents, may be produced artificially in an appropriate liquid by the joint action of two salts, forming by double decomposition one insoluble salt, or two such. The one of these salts must be dissolved in the liquid, while the other must be present in a solid form.

"These organic elements, cells, tubes, etc., may be produced either in a liquid of organic or semi-organic source, such as the saccharate of lime, or in an absolutely inorganic liquid, *e. g.*, silicate of soda. Hence there can be no longer any question of distinctive forms characterizing inorganic bodies on the one hand and organic on the other.

"The formation of such pseudo-organic figured elements depends on the nature, the degree of viscosity, and the concentration of the liquids in which they are produced. Certain viscid liquids, such as solutions of gum arabic, or of zinc chloride, yield nothing of the kind.

"The form of these pseudo-organic products is constant with reference to the salts employed, as constant as any crystalline form of minerals. This characteristic form is so well maintained that it may even serve for the detection in mixtures of a minute proportion of a substance.

"The form of the artificial pseudo-organic elements depends principally on the acid which enters into the composition of the solid salt. Thus the sulphates and the phosphates produce tubes, while the carbonates give rise to cellulose.

"With some exceptions, such as copper, cadmium, zinc, and nickel sulphates, the pseudo-organic forms are only produced by means of substances which are found in real organisms. Thus the saccharate of lime produces organic forms, while those of strontia and baryta do not.

"The artificial pseudo-organic elements are enveloped in true membranes possessing a high degree of dialyzing power, and giving passage merely to liquids. They have heterogeneous contents, and produce in their interior granulations arranged in a determined order. They are, therefore, in form and constitution absolutely similar to the histological elements of organic beings. It is probable that the inorganic elements contained in protoplasm play a certain part in the constitution of the figured organic elements."

The close similarity, both of the means employed and of

the ends reached by these authors, and by M. Fournier, is very interesting. Silicate of soda was one of the compounds used by M. Fournier, and salts of nickel played a prominent part in some of his most striking results. After having thus vindicated the claims of my friend, I must attempt to show some of the bearings of this discovery.

It must be admitted that the structures produced are merely pseudo-organisms. They manifest none of the phenomena of life. They do not take in, assimilate, and excrete any kind of matter. They do not propagate. Nor does it appear that if carefully preserved under constant conditions they might not continue to exist for an absolutely indefinite time. They have, therefore, no vital cycle—no periodicity.

Nevertheless we must note the points in which they seem to link the organic and the inorganic world together. As MM. Monnier and Vogt urge, one of the characters by which mere lifeless matter was till yesterday differentiated from the living organism is wiped out. There are no longer any distinctive forms by which we may distinguish the two great classes. Here a new thought will suggest itself to every reader: these pseudo-organisms have, so far as we know, been obtained experimentally only by M. Fournier, and by MM. Monnier and Vogt. But is it not very possible that such structures might be produced without human intention and interference in what we call an accidental manner? Might they not, considering the large proportion of silica which they contain, become preserved for ages, and continue to display pseudo-organic features? Suppose we find in a rock certain structures exhibiting apparently organic cells, are they the remains of true organisms or of pseudo-organisms? This consideration—at least till it has been further studied—is not without its bearing upon such questions as the organic or mineral nature of the structures found in meteorites, and, *e. g.*, of *Boroon Canadense*.

It is highly significant that, with certain exceptions, the rationale of which may become clear on future scrutiny, only those chemical elements which occur in natural organisms are able to take part in producing these pseudo-organisms. Chemists fully recognize the close analogy which exists between lime, strontia, and baryta. Yet while the saccharate of lime lends itself to organic formation the corresponding salts of strontia and baryta are excluded. This consideration is of grave import. It would seem to follow that certain chemical compounds are capable and naturally tend to produce organic structures, cells, tubes, etc., under certain conditions, just as under others they give rise to crystals. But MM. Monnier and Vogt have gone even further, and have been able to specify the classes of structures which different compounds may form. They state that sulphates and phosphates originate tubes, while the carbonates give rise to cells. May not these facts have their meaning, to be traced out, perhaps, in some country where biological research is free? May they not throw light upon the functions of different classes of salts in the process of nutrition? Has the attempt been made to quicken these pseudo organisms into a higher stage of existence by the application of varying conditions of atmospheric pressure and composition, of light, temperature, etc.? At any rate, these growths seem to be, from a structural point of view, a transition stage between the unequivocally inorganic and the decidedly organic and vitalized. It is conceivable, at least, that such has been the path taken by nature.

Apart from all special scientific considerations, the experiments of MM. Fournier, Monnier, and Vogt have a philosophical value as confirming the principle of continuity.

We must take the liberty of here calling attention to certain researches which, though not in direct connection with the experiments of M. G. Fournier and of MM. Monnier and C. Vogt, serve in some degree to lessen the gap between the organic and the inorganic world, or at least to throw light upon the cause of life from a chemical point of view.* Our readers are, of course, aware that sixty years ago all organic compounds were supposed to be due to the action of a distinct vital force, and to be quite incapable of artificial production. In 1828, Woehler succeeded in constructing urea from dead matter. Since that time not a few organic compounds, formerly obtained only from plants and animals—such as alizarine, indigo blue, vanilline—have become laboratory products. But chemists have failed in the synthesis of the more characteristically vital compounds, such as albumen. Further, till the year 1875, the idea of a chemical distinction between living and dead protoplasm was not even conceived. Prof. Pflüger ("Pflüger's Archiv," x., p. 251) advanced the opinion of a necessary chemical difference between protoplasm in these two conditions. It may be well here to remark, for the benefit of such readers as are not conversant with modern bio-chemical research, that protoplasm is not an abstract idea or a mere theoretical body. It is a substance which can be obtained from certain plants—*i. e.*, *Elthabium septicum*, and submitted to the investigations of the chemist and the microscopist. The idea was taken up by HH. Loew and Thomas Bokorny, of Munich. The former of these chemists, in establishing a rational formula for albumen, was struck by the circumstance that it contained a number of aldehyde groups immediately bordering upon amide groups. Such groups, according to modern chemical philosophy, must be distinguished by intense atomic motion. Hence, argued Herr Loew, this motion constitutes life, while the respective displacement of the aldehyde and amide groups, and the necessary cessation of the atomic motion, involve death, it may be of a mere molecule of protoplasm, or of a larger portion, or of the entire animal or plant.

Now, so far we have to deal merely with a theoretical assumption. This point requires, therefore, a little further explanation. The methods of the astronomer are utterly unintelligible to the majority even of educated men. But when an astronomer on theoretical grounds predicts the existence of a hitherto unseen planet, and another, turning his telescope to the spot, discovers it there as foretold, the public is forced to admit that the hypotheses of astronomers deserve a great degree of confidence. Very similar is the case with the speculations of the chemist. No man has seen a molecule, much less an atom. No man can say on the direct evidence of his senses, that in a molecule the atoms are arranged in this or the other manner. Nor has any one witnessed the more or less rapid vibration which the atoms in a molecule, or the molecules in a compound body, are inferred to undergo. But when we find chemists setting out from these assumptions come not by chance but intentionally to such results as the formation of artificial indigo, they are entitled to claim for their assumptions at least provisional acceptance.

*Die Chemische Ursache des Lebens, Von Oscar Loew und Thomas Bokorny. München: J. A. Finsterlin.

HH. Loew and Bokorny, however, were not content without testing their supposition experimentally. They found that living protoplasm has the power of reducing silver from a very dilute alkaline solution, while in dead protoplasm this property is wanting. By dint of a long course of investigation they determined that this reduction could be due merely to the presence of the aldehyde groups in the protoplasm while living. In living protoplasm the aldehyde groups of each molecule are brought in immediate proximity with the amide groups of the next, and thus a considerable intensification of the vital molecular motion ensues. But with increasing complexity and motility follows increasing instability. Apparently trifling agencies displace the molecules and their action ceases. During every such molecular displacement, which is in fact a combustion, heat is liberated. Hence the rise of temperature in fevers, and that which occurs upon death. On the other hand, when lifeless albumen is assimilated and converted into the protoplasm of a living cell, heat becomes latent. The absorption of oxygen, and the formation of carbonic acid, in short, the whole process of respiration, becomes intelligible, since it is admitted that an increase of molecular motion promotes chemical action, and consequently oxidation. Vital force, Herr Loew considers to be, in short, reducible to the tension of the aldehyde groups ultimately due to electric differences. Life is the total result which the protoplasmic structure yields by means of such vital force. Space does not allow us to reproduce here the experimental evidence which the authors here set forth in support of their theory. They trust that at any rate the first step has now been taken toward explaining the numerous mysteries which appear in the manifold functions of protoplasm. Even the cardinal problem, the first origin of protoplasm upon our earth, seems to them only a question of time.

While wishing the authors good speed in the arduous task they have in hand, and while admitting that they have laid down a fair working hypothesis on the nature of life, which must stand or fall by its results, we wish to point to one difficulty. They appear to regard albumen and protoplasm as substantially identical in composition. Now, according to the analyses of Reinke, referred to in the *Journal of Science* for 1881, p. 182, protoplasm contains scarcely 30 per cent. of albuminous matter, and contains upward of forty proximate principles. The question now arises whether all these principles are truly components of the protoplasm molecule?—*Journal of Science*.

THE ELECTROLYTIC COMPANY, LONDON.

THE new works of this company in Charlotte street, Blackfriars, S. E., are now in an advanced state, and all kinds of electro-deposition is being carried on under the able superintendence of Mr. William Elmore, of 91 Blackfriars road, the well-known introducer of nickel plating into this country. By means of large baths, 24 feet long by 6 feet deep, Mr. Elmore is able to deposit copper or nickel upon rough castings or polished iron objects of any size or weight. It is becoming more and more the custom to cover metal work exposed to the atmosphere, or to water with copper or nickel, and hence we find that the Electrolytic Company are engaged in coating such articles as engine boiler tubes, lamp posts, hydraulic rams, the covers of cylinders, the parts of heavy iron structures, and pieces of ordnance. Hydraulic rams are covered with a $\frac{3}{8}$ in. thickness of copper, which is turned down to $\frac{1}{8}$ in., and the copper surface, which is sufficiently hard, works very smoothly in the cylinder and does not oxidize. Moreover, when reduced in size by wear, it can readily be built up again to its old dimensions by the electro-deposition of more copper on it. Boiler tubes are coated exteriorly with $\frac{1}{8}$ in. thickness of copper, which is turned down to $\frac{1}{16}$ in. The sulphate of copper bath of Mr. Elmore is specially prepared to give a flawless and regular coating of hard pure copper, and some of the specimens of art metal work, such as stove and door panels, are singularly beautiful.

Nickel, by its hardness and its resistance to the attack of sulphurous gases, is preferable to silver as a plating for many implements and utensils, especially such household articles as sewing machines, dish covers, scissors, and so on. It is also convenient for bicycle frames and saddlery hardware. Mr. Elmore employs a solution of the double sulphate of nickel and ammonia for the nickel bath. The solution is fortified by electrodes of nickel, weighing half a hundredweight each.

In all the baths the strength of current is regulated by means of a series of resistance bars of copper at the ends of each bath, and the density of the liquid is kept equal throughout by means of a rotary stirrer. Brass is also deposited upon ornamental iron work, fenders, locks, and steel goods, as well as upon lead, pewter, zinc, tin, and Britannia metal. Tin is deposited on bright steel or rough iron, and the interiors of copper utensils; all kinds of electrotypes for printing purposes; and the most delicate natural objects, such as ferns, flowers, insects, are electroplated with copper and the nobler metals at the Electrolytic Company's works. The ordinary method of backing up an electrotypes with lead, is now giving place partially to the practice of depositing tin upon it; and copper electrotypes are also faced with steel or nickel to protect the surface from the action of printing inks, and at the same time preserve the clear brilliancy of vermilion and other mercurial colors used in printing. In short, the Electrolytic Company occupy the whole field of electro-deposition, and also supply the necessary plant for export. The Elmore dynamo-electric machine is specially adapted for the work because of its continuous current and low internal resistance, and it is gradually becoming largely introduced.

These machines are made on the premises in Charlotte street, and ten of large size are now being made for a firm in Swansea to deposit pure copper for electric cable purposes; each machine of this class is capable of depositing 500 lb. per day of pure copper from the sulphate. A smaller machine of the same kind, known as the 15 in. machine, deposits 200 lb. of copper in a day; and there is a still smaller pattern for lighter work. Messrs. Cassell, Pether & Galpin, Messrs. Waterlow & Sons, Messrs. De la Rue & Co., among others, have adopted Mr. Elmore's machine for electroplating purposes, and the last-named firm have found it very satisfactory in the preparation of the dies for postage stamps.

Before leaving the subject, we may mention that Mr. Elmore has devised an ingenious tell-tale, whereby the weight of gold or silver deposited on an article is indicated to the person in charge by the ringing of an electric bell in his office. When the proper weight of metal has been deposited the balance completes an electric circuit and the bell rings; while at the same time the current for that particular bath is cut off, and the process of deposition terminated.—*Engineering*.

*The partial exception in case of the diamond—carbon—is insignificant.