

ceeded from the heart, and drew all hearts to himself. Never frivolous, but always cheerful, he was dignified, grave and earnest, making all who heard him as a teacher and speaker, or in familiar intercourse, recognize in him, above all other things, the upright man. For he possessed eloquence of conviction, and the force of absolute honesty in all his statements, and thereby drew to himself, as enthusiastic admirers and disciples, the successive classes of students whom he taught. The college, desiring to show respect for the purity, uprightness, unselfishness, and modesty of Dr. Agnew's character; its admiration for the noble example of his life; and its sense of the value of his contributions to the science and art of surgery, directs that this minute shall be duly recorded, and a copy of it, signed by the president and secretary, be conveyed to Dr. Agnew's family. Also, that the college will attend the funeral, in a body, and that the president be requested to appoint a fellow to prepare a memoir of our late colleague."

The late Dr. D. Hayes Agnew, says the *Post-Graduate*, "was for many years a great teacher in Philadelphia, at first in a school of anatomy not directly connected with either of the colleges. At a comparatively late time in life he became Professor of Clinical Surgery in the University of Pennsylvania, but he had achieved his fame before then in a private institution, a school of medicine something like the *extra-mural* schools in Edinburgh. He will always be remembered as associated with our Frank Hamilton, in President Garfield's case. It is generally supposed now that the great uncertainty that existed, until death occurred, as to the track and final lodgment of the ball, would have been much less had the President been first seen by such surgeons as those who finally had the actual surgical responsibility. When Hamilton and Agnew were called, it was too late to make a thorough examination, without great risks. The final result, however, would have been the same, in any case, for the original lesion was necessarily fatal. Dr. Agnew—like his namesake, the great oculist of New York, Cornelius Agnew, who was in no way related to him—was a man of profound religious character, who had a great influence for good in even a larger circle than his professional life circumscribed. A really great man has fallen in our front ranks. Very few physicians, however eminent, leave an estate of a quarter of a million of dollars, as Dr. Agnew has done. He left fifty thousand dollars to the hospital of the University of Pennsylvania."

THE CHEMICAL RESEARCHES OF JEAN SERVAIS STAS.

By VAUGHAN CORNISH, B.Sc., F.C.S.

IN the last month of last year the chemical world received with profound regret the news of M. Stas's death, at the advanced age of seventy-eight.

The name of Stas has been a household word among chemists for half a century, and his writings, the celebrated *Recherches sur les Lois des Proportions Chimiques*, have come to be regarded as among the canonical books of chemistry. In all that related to the experimental art Stas stood unsurpassed. The marvelous patience with which he matured his methods, and the skillful care with which the final experiments were carried out, stand recorded in his classical memoirs with that clearness and precision of expression characteristic of French scientific writings. Stas's work bore on one subject only, the determination of "atomic weights," with a view more particularly to ascertain if there existed any simple definite relation between the weights of the chemical atoms. In order to explain how this investigation came to be the mission of Stas's life, we must refer to the state of chemical theory in the second decade of the present century. At this time the laws of chemical combination had been formulated and accepted—the laws, viz., which may be epitomized by saying that "chemical elements combine together only in the proportion of their equivalent weights, or in simple multiples of those proportions." Dalton had propounded an explanation of these laws in his "Atomic Theory," according to which chemical combination was due to the union of chemically indivisible particles, the particle or atom of each element having its own particular fixed weight.

Dalton's theory, the next great generalization after Lavoisier's explanation of the phenomena of combustion, was the result of the discovery of definite and simple numerical relations between certain chemical quantities. It was natural that other minds, impressed by Dalton's theory, should seek for other such numerical relations in the hope of fresh discoveries of Nature's laws. In 1815 a paper appeared in Thomson's *Annals of Philosophy* by Dr. Prout, in which he pointed out certain apparent relations between the atomic weights of the elements as then determined. The idea was at once taken up by other chemists, and took shape in the following form, known as *Prout's Hypothesis*: "The weight of the atom of each element is a simple multiple of the weight of the atom of hydrogen." The observed deviations were referred to errors of experiment, just as the apparent deviations from the laws of chemical combination were referred to experimental error.

It has been the life work of Stas to investigate both assumptions, and to show that while the laws of chemical combination are rigidly exact, the supposition of Prout is unsupported by experimental evidence.

Prout's hypothesis owes its importance in the history of science to the fact that it seemed to restore the old theory of the unity of matter, which appeared to have received its death blow with the discovery of the chemical elements. But if the atom of each element be exactly once, twice or thrice the weight of the atom of hydrogen, then it is reasonable to suppose that the atoms of all elements contain only one kind of matter, and that the hydrogen atoms are the one class of ultimate particles of which all matter is built up. As the art of chemical analysis developed under the hands of the great Swedish chemist, Berzelius, it became evident that Prout's hypothesis was not tenable in its original form. It was revived, however, in a modified shape chiefly owing to the influence of Dumas. In the modified form, the hypothetical unit weight was that of the half atom of hydrogen. Later on, Dumas was compelled to retreat yet further from the original position, and to take the quarter atom of hydrogen as

the greatest common divisor of the atomic weights. In this modified form the idea of Prout loses much of its interest, since the "quarter atom" of hydrogen is itself an unknown thing. Nevertheless, the idea of the oneness of matter always exerts a certain fascination, and to some minds this unity of matter appears to be almost a logical necessity. Hence the tenacity with which chemists have clung to the belief that apparent discrepancies were due to errors of experiment, rather than to the inaccuracy of Prout's hypothesis.

Stas began his researches on atomic weights with a strong prepossession in favor of the hypothesis. He chose for his determinations such substances as could be prepared in a high state of chemical purity, and worked with large quantities of substance in order to eliminate the effect of errors in weighing. A large number of experiments, which occupied several years, furnished him with extremely accurate values for the relative weights of the atoms of silver and the alkali metals, and of chlorine, bromine, and iodine. Moreover, the variety of methods employed served to eliminate possible systematic errors—errors, that is to say, not due to want of skill in the performing of an experiment, but due to the method itself. Each substance, moreover, was prepared in several different ways and from different natural sources. Not the least remarkable tribute to Stas's skill is the close accordance between the values he obtained for the atomic weights by different processes of determination. The numbers obtained in this first series of researches were closely accordant among themselves, and wholly at variance with those demanded by Prout's hypothesis. Stas concludes his memoir thus: "Prout's hypothesis must be looked upon as a pure delusion; the elements must be considered to be distinct entities, with no relation between their atomic weights."

The accuracy of Stas's work was admitted on all sides, but his conclusions were contested. The criticisms of the Genevese chemist, Marignac, are historically important, having led Stas to his second and more celebrated research. Marignac contended that it was far from being proved that the constituent elements of many chemical compounds were present exactly in the proportion of their atomic weights. It was possible that many chemical compounds contained normally a very small excess of one or other of their constituents. This criticism strikes at the basis of the atomic theory, since that theory is founded on the assumption that the laws of chemical combination are mathematically exact. For half a century the scientific world had accepted the dictum that the laws of chemical combination were *lois mathématiques*, but the original experiments on which these laws were based were far from being models of accuracy. This fact was admitted by Stas, who undertook the laborious task of a re-examination of those laws, with a view to settle by the most exact methods whether these laws were in fact of mathematical exactness, or, like so many physical laws, only *lois limites* or approximate relations. In 1865, five years after the date of his first series of researches, appeared the *Nouvelles Recherches sur les Lois des Proportions Chimiques*. In this work Stas repeated the more important of his former determinations of atomic weights, with additional precautions. He also subjected to the most rigorous tests the laws of definite, constant, and equivalent proportions which had hitherto rested on the comparatively rough experiments of Dalton, Wollaston, and other workers of the early part of the present century. In this great work Stas confirmed, on the one hand, his previous conclusion that Prout's hypothesis was unsupported by experiment, but showed on the other that the laws of chemical combination, hitherto accepted on insufficient data, were, as far as experiment could prove, actual and veritable mathematical laws. It is impossible to overestimate the benefit conferred upon science by a man who has the courage to devote years of patient labor to the re-examination of points such as this, and the reinvestigation of supposed laws which have been accepted on the evidence of insufficient experimental data. Such work is much needed in the chemical world at the present time, when a vast superstructure of theory is being built upon a comparatively small number of approximate experiments with regard to the behavior of substances in a state of solution.

From the point of view of the working practical chemist the most important aspect of Stas's researches is that relating to the preparation of chemical substances in a state of purity. Since Stas's time chemists have not been satisfied with the approximate purification of substances which in general sufficed the earlier experimenters. The approximate isolation or purification of substances is the first step in a chemical research; the complete purification is the most difficult and the most important part of exact research in the science. Stas's methods of purification have served as a model for all subsequent experimenters. In order to give a general idea of the character of his work we will describe a method he adopted for the purification of silver, a substance which is, as he says, the "pivot" of his determinations. Silver is a substance which, as Stas showed, can be obtained in a state of almost perfect purity. The way in which it resists oxidation, and the distinctive character and insolubility of certain of its salts, would lead one to suppose that its complete purification would be very readily effected. That this not exactly the case will be evident from the following description of Stas's method. In order not to make the description unduly long, we omit the special methods of purifying the *reagents* used in the work. These reagents are water, nitric acid, hydrochloric acid, caustic potash, and milk sugar. Each of these had to be submitted to special processes of purification, lest their use should introduce foreign substances into the silver.

Coinage silver was taken, and dissolved in very dilute nitric acid. Any gold present is left undissolved. The solution of the nitrate is evaporated to dryness, and heated till no more nitrous fumes are evolved. The salt is then dissolved in a small quantity of water. On filtering, any platinum present is left behind. The filtrate is then diluted with about thirty times its volume of water and an excess of hydrochloric acid added. All the silver is then precipitated or thrown down in the form of the insoluble chloride of silver. Any copper and iron present remain in solution. The liquid is poured off and the precipitate washed, first with dilute hydrochloric acid and then with water, till

the washing appears to be pure water containing no trace of copper or of hydrochloric acid. This washing of a large quantity of a precipitate is a very lengthy and tedious operation, requiring days or weeks, according to the quantity of the precipitate. The washing is effected in this case by shaking up the precipitate with water in a stoppered flask, allowing the precipitate to settle, and pouring off the liquid. All the operations with chloride of silver were carried out in a room lighted by artificial light, since daylight, as is well known, effects a chemical change in the composition of chloride of silver. The chloride of silver, purified as above, is brought on to a cloth (previously washed with hydrochloric acid) and the water squeezed out. After drying, the silver chloride is pounded fine in a mortar, and *reduced* to the metallic state by warming for forty-eight hours with a solution of caustic potash and milk sugar (both carefully purified). The finely divided metal is then fused, with special precautions to prevent access of impurities. By this process Stas hoped to obtain an ingot of perfectly pure silver, but found that, besides very slight traces of other substances, there remained an appreciable quantity, 2 parts in 100,000, of silica. Experience convinced Stas that no substance can be obtained absolutely pure except by distillation. He therefore subjected the silver obtained as above to the process of distillation from one cavity to another in a hollowed block of quicklime made from white marble. The cavity having been previously heated by the oxyhydrogen flame, in order to drive off any volatile substances such as soda, the silver was placed in the cavity and fused. No scum appeared on the surface, showing the absence of certain impurities such as iron, which under these circumstances would form a slag. The heat from the oxyhydrogen flame was then increased till the metal began to boil. The vapor had at first a strong yellow tinge, showing that sodium was still present.

This, however, soon disappeared, the vapor of the silver showing no color beyond a faint blue tinge. The absence of any green tint showed that the substance was free from copper. The metal having completely distilled into the second cavity, or receiver, in the lime block, it was found that absolutely no residue remained, the small quantity of silica, and any similar fixed substance of an acid character, having combined with the lime, and any oxidizable material having been burnt away by the flame of the oxyhydrogen blowpipe. By the above process Stas believed that he had obtained silver absolutely pure. Subsequently, however, Dumas showed that silver thus prepared absorbs, after distillation but while still molten, a certain quantity of oxygen which does not combine chemically with the silver but remains "occluded" in the metal. The elaborate precautions adopted by Stas were therefore not successful in obtaining even this well known and characteristic substance in a state of perfect purity, though he subsequently determined the amount of oxygen present. But the practical chemist owes to Stas a proper appreciation of the difficulties attending the purification of substances, an appreciation of the necessity for taking every means to overcome these difficulties, and a knowledge of methods for the carrying out of this class of work; methods elaborated by Stas thirty years since, and which yet form the basis of many of the recent researches on the determination of atomic weights. —*Knowledge*.

THE DETERMINATION OF FLUORINE.

By AD. CARNOT.

FLUORINE enters into the composition of many natural substances, but we have often restricted ourselves to establishing its presence by qualitative experiments on account of the difficulties presented by its exact determination, especially in the presence of silicates.

Many methods of determination have certainly been given by eminent analysts—Berzelius, H. Rose, Woehler, Fresenius; but in these methods accuracy has been obtained only by means of great complications or very minute precautions.

The method which I now propose, and which I have already applied to the analysis of a certain number of fluorine compounds capable of being attacked by concentrated sulphuric acid, has the advantage of being of easy execution, and of not being interfered with by the presence of carbonates or of organic substances; it can serve to show not merely the proportion of fluorine, but also that of silicon with satisfactory accuracy.

The process is founded, like several methods already known, on the disengagement of fluorine in the state of gaseous silicon fluoride; its novelty consists in the method of determining the volatile compound. In place of calculating it by the difference of two weighings (Woehler, Fresenius), or according to the weight of the calcium fluoride obtained after a tedious separation of the silica (Berzelius, H. Rose, and recently H. Lasne), I receive the silicon fluoride in a rather concentrated solution of pure potassium fluoride, with which it forms a precipitate of potassium silicofluoride, the weight of which enables us to calculate the fluorine, and if needful, the silicon, $\text{SiF}_4 + \text{KF} = \text{K}_2\text{SiF}_6$, or $\text{F}_2 + 2\text{KF} = \text{K}_2\text{F}_2$.

I indicate briefly the arrangement of the apparatus and the course of the operation.

The mixture of fluoride and silicate is acted upon by concentrated sulphuric acid in a small flask holding 150 c. c., to the bottom of which there is conveyed a slow current of air, or of carbonic acid, which has been perfectly dried by passing through bottles filled with sulphuric acid. The gaseous current is then conveyed by an elbow tube to the bottom of a flask containing a little mercury and above it 20 c. c. of a solution of pure potassium fluoride (1 part in 10). Beyond this there is an aspirator arranged so as to regulate the current.

The extremity of the tube which enters the flask should be drawn out to a point and bent back, opening 2 or 3 mm. below the surface of the mercury, so that it is not moistened by the aqueous solution.

The flask and the tube must have been perfectly dried either in the stove or after the apparatus has been connected by the action of the dry gas conjointly with that of heat, so as to avoid any decomposition of silicon fluoride by moisture. The elbow tube carries an empty bulb intended to retain the traces of sul-

phuric acid which may be carried along by the current of gas. There must be added a tube filled with pumice saturated with dehydrated copper sulphate to arrest the vapors of hydrochloric acid, when the fluorine substance contains also chlorides (apatite, etc.), for these vapors reacting upon the potassium fluoride might liberate hydrofluoric acid, which would attack the sides of the flask and the surface of the mercury.

The quantity of material taken for analysis should be such that the quantity of fluorine does not exceed about 0.100 gm.; we take therefore 0.200 gm. of rich fluorides (fluorspar, cryolite, etc.), and up to 2 grms. or upward of substances poor in fluorine (natural phosphates, bones, etc.) We mix the substance intimately in an agate mortar with ignited quartz in very fine powder, in such proportions that there may be at least 10 parts of silica to one part of fluorine. The quantity of silica must be still greater if the matter under examination contains less than 5 or 6 per cent. of fluorine.

When the apparatus has been fitted up, tested by means of the aspirator, and well dried, the current of gas is stopped for a few moments, we introduce into the flask the mixture to be attacked, and pour in 40 c. c. of pure concentrated sulphuric acid; then the current of gas is allowed to resume and the flask is heated upon a plate of iron, under which a gas burner is lighted. At the same distance from the burner we place a similar flask also containing 40 c. c. of sulphuric acid, into which plunges a thermometer which indicates in a sufficiently approximate manner the temperature at which the action takes place (Fresenius); we regulate the burner so as to reach a temperature close upon 160°, which must never be exceeded.

The small flask is shaken from time to time so as to liberate the bubbles of gas which form in the liquid or against the sides; they generally cease to be formed after 1½ or 2 hours, and we may soon after consider the attack as completed.

The potassium fluoride contains then a gelatinous precipitate of silicofluoride which is scarcely visible, and which would soon settle if the liquid were left in repose; but without waiting for this, we detach the tubes which lead to the flask, decant the aqueous solution, wash the mercury and the flask with several successive portions of water, and collect the liquids, the total volume of which should not exceed 100 c. c.; we add an equal volume of alcohol of the strength of 90 per cent., we mix the whole, and allow it to deposit.

When the precipitate is properly collected together, after having decanted off the supernatant liquid and replaced it with dilute alcohol, we collect the deposit upon a tared filter, and finish the washing with alcohol diluted with its own volume of water, making use of the filter pump until the liquid no longer occasions any turbidity in a solution of barium chloride. We dry at 100° until the weight is constant, and calculate the fluorine of the silicon fluoride. For $1\text{KF}, \text{SiF}_6$, we have $F_2 = 0.3451$.

For the accuracy of the determination it is essential that the reagents employed should be free from fluorine. This is certainly the case with sulphuric acid if it has been heated to close upon its boiling point. It is the same with ignited quartz. However, both may be tested once for all in a blank experiment. The potassium fluoride should be free from silicofluoride; it is necessary to ascertain this point by dissolving 2 grms. of the salt in 100 c. c. of water, and adding an equal volume of alcohol at 90 per cent. No deposit should be produced, even if the liquid is allowed to remain at rest for 24 hours.

In the analysis of a fluorine silicate one and the same operation may serve for the determination of the fluorine and of the silicon, provided that the sides of the flask are not sensibly attacked. This result is obtained either when we operate upon a silicate poor in fluorine or if we mix very intimately by trituration in an agate mortar the fluorine substance with a great excess of quartz finely levigated and of pure silica, which is ignited and weighed exactly. The silicon is then calculated in two portions. A small portion is found along with the fluorine in the precipitate of silicofluoride. For $1\text{KF}, \text{SiF}_6$, we have $\text{Si} = 0.12714$; $\text{SiO}_2 = 0.28154$.

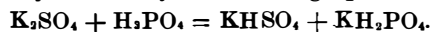
The other portion is found in the state of silica in the residue of the action of sulphuric acid, and may be separated and determined by the ordinary methods. The weight of the silica added must of course be deducted from the weight obtained.—*Comptes Rendus*, cxiv., p. 750; *Chem. News*.

PHOSPHATES OF POTASH AND AMMONIUM AS FERTILIZERS.

By Dr. T. MEYER.

THESE two commercial products, still but little known, do not consist entirely of potassium and ammonium phosphates, but contain a small quantity of sulphuric acid, which is also found in most mineral fertilizers. I started the preparation of the former five years ago and it is now made on the large scale.

The phosphates of potassium and ammonium are, according to their composition, simple products formed by the action of phosphoric acid on the corresponding sulphates, and their mode of preparation may be represented by the following equation:



It may be mentioned here that this reaction does not take place between sodium sulphate and phosphoric acid, at all events under ordinary circumstances. Experiments made upon this point have always yielded an oily deliquescent mass, simply a mixture of sulphate with phosphoric acid.

These salts contain 25 per cent. of phosphoric acid and 25 per cent. and 10 per cent. respectively of potassium and nitrogen. In addition to water, combined or otherwise, about 30 per cent. of sulphuric acid is present, as well as a few per cent. of ordinary impurities, lime, oxide of iron, alumina, magnesia, hydrofluoric acid, etc. They only contain traces of chlorine, and the potassium and ammonia are not combined entirely with the phosphoric but also in part with the sulphuric acid. It is nevertheless apparent that the quantity of sulphuric acid introduced to no useful purpose into the soil is much greater in the case of superphosphate of ammonia than of sulphophosphate

of ammonia. The former of these is a mixture of ammonium sulphate, calcium phosphate, and gypsum, while the latter may be considered as a mixture of ammonium sulphate with free phosphoric acid. The distinguishing point about these salts is their acid character, which produces the following series of properties.

1. *Great solubility in water.*—The salts composing these fertilizers dissolve readily in water, leaving only a faint residue of phosphates of iron and aluminum. They can therefore be applied like nitrate of soda as a top dressing as well as when the soil is poor in nutritive elements, a state of things which is only rendered evident by the weakly appearance of the plants.

2. *Ready admixture with lime and Thomas meal without loss of phosphoric acid and ammonia.*—It is well known to agriculturists that Thomas meal, on account of the caustic alkali which it contains, sets free ammonia when brought into contact with neutral salts of ammonium and with ammoniacal organic compounds, such as manure.

The presence of lime and a large proportion of ferric oxide transforms the soluble phosphoric acid of superphosphate into insoluble acid. There is no danger of losses of this kind when Thomas slag is used with the sulphophosphates of which we are speaking; but on the other hand, a part of the phosphoric acid of the slag is rendered soluble.

Experiments on the way in which these salts behave as compared with mixtures of slag and superphosphates have given the following results: On 100 parts of soluble phosphoric acid or nitrogen employed there were found:

A mixture composed as follows:	After standing for	With phosphoric acid, 10.24% N, 25.56% phosphoric acid.	With phosphoric acid, 21.57% N, 25.32% phosphoric acid.	With superphosphate, 15.75% phosphoric acid.
100 grs. of slag, 100 of fine meal (21% phosphoric acid), 4% of lime with 23.56 grms. of phosphoric acid soluble in water.	670 days.	Nitrogen, — Phosphoric acid, 113.3	101.6	76.8
	13 "	99.6	113.2	26.6
	32 "	99.6	111.7	100.0

It will be observed that phosphate mixed with slag retrogrades very rapidly, since at the end of thirteen days only 26.6 per cent. of the original weight of soluble phosphoric acid is present; with phosphate of potassium, on the other hand, there is no loss, but a slight gain (100.4 per cent.), while with ammonium phosphate a portion of the phosphoric acid of the slag is rendered soluble, and, far from any loss being experienced, the amount increases to 111.7 per cent. in thirty-two days.

In order to manure a piece of land simultaneously with slag or calcareous fertilizers, sulphate of ammonium and superphosphate, it would be necessary to work in each of these separately, which would greatly increase the labor expenses.

On the other hand, slag can be applied along with sulphophosphate of ammonium without inconvenience. This mixture is particularly valuable in certain cases, because a portion of its phosphoric acid dissolves rapidly, while the remainder only acts gradually as the plants develop.

3. *Rapid diffusion in the soil.*—In considering the way in which superphosphate and sulphophosphate respectively act in presence of Thomas slag, it appears probable that the soluble phosphoric acid of the sulphophosphates will be more rapidly disseminated in arable land than that of the superphosphate, submitted to the retrogressive action of compounds of lime, iron and alumina. Retrogression cannot, in fact, take place until the excess of acid has been saturated. This is why the phosphoric acid of the sulphophosphates should be more readily diffusible in heavy soil than the ordinary phosphoric acid of superphosphate.

I have also endeavored to treat this question experimentally, but the results obtained hitherto are not conclusive. I do not, however, consider it useless to discuss them here, and so draw the attention of others to the point.

The difficulty of the investigation evidently consists in reproducing the conditions of fertilization as they actually exist in practice, when small quantities of phosphoric acid are used for an enormous mass of earth. I commenced by preparing solutions of sal ammoniac and mineral superphosphate containing about 5 grammes of phosphoric acid per liter; 25 c. c. of this aqueous extract were reserved for analysis. Another portion of 25 c. c. was diluted to 500 c. c. and digested for two hours in a liter flask with 100 grammes of calcareous earth, the whole being frequently shaken. The liquid was then filtered and 400 c. c. of the filtrate, corresponding to 20 c. c. of the original solution, precipitated with ammonium molybdate.

In this way the following results were obtained:

	Sulphophosphates of Ammonium.	Mineral Superphosphate.
In 20 c. c. of solution employed...	0.0992 gr. phosphoric acid	0.0950 gm.
In 20 c. c. after treating with earth	0.0791	0.0725
Percentage of phosphoric acid rendered insoluble by treatment:	20.9	24.4

Finally, the strongly marked acid character of the two salts explains how it is possible, even with a crude phosphate containing much oxide of iron and alumina, to make a phosphatic manure only containing small quantities of phosphate insoluble in water. I have thus succeeded, only upon the laboratory scale it is true, in preparing a sulphophosphate of potassium containing, in round numbers, 14 per cent. of soluble and 15.5 per cent. of total phosphoric acid from Nevada phosphate, which is particularly rich in compounds of iron and aluminum. This salt was not oily, but had the consistency of a normal superphosphate. Special emphasis must be laid upon the fact that these salts are not hygroscopic, but as dry and pulverulent as

superphosphates in general. At the commencement difficulties were encountered in this respect, but they were long ago overcome.

I must add that in the sulphophosphates of potassium and ammonium the phosphoric acid, the nitrogen and the potash have a high fertilizing value, while their price is not much higher than that of simple mixtures of superphosphate, ammonium sulphate and potassium sulphate.

It is true that in the sulphophosphates half the base is combined with phosphoric acid, but on the other hand, their characteristic properties give them a much greater value than mere mixtures of these salts. Thanks to the absence of injurious material (compounds containing chlorine), they are suitable for the cultivation of tobacco, the vine, etc. Their great solubility in water fits them for use as a top dressing, their acid properties render them valuable for mixing with other fertilizers, and finally their great concentration means a great saving in carriage, when they are sent to places at a distance from the works.—*L'Engrais*.

BOTTLED GASES.

"LEAVE orders for oxygen under the door" is the odd legend that greets the eye in the second floor hall of an upper Broadway building. The door in question leads to the living apartments, to use a complimentary plural, of the dealer in oxygen. His office is the front hall room on the same floor, sufficiently cramped quarters for one whose stock in trade is of so expensive a nature. He is one of a great many persons whose business it is to purvey wind, sweetened and otherwise, to the inhabitants of this town.

The sale of invisible and almost intangible and imponderable merchandise is one of the most curious of the many strange business developments of this great community. You may buy bottled gases as you buy bottled beer, and have them delivered at your house as newspapers, or soda, or fresh vegetables are delivered. Oxygen, hydrogen, nitrogen and carbonic acid are sold daily, as boots and shoes are sold. They are handled with indifference, just as other freight is handled, sent by express, carried on the backs of nonchalant messenger boys, and, in fact, treated as if they were not tremendously expensive agencies packed away under a pressure of 1,800 pounds to the square inch. One factory sells 30,000 feet of oxygen per month, and keeps on hand nearly that quantity in storage tanks. That volume of the gas weighs more than a ton and a quarter. Several other concerns sell nearly as much more, and a large quantity of hydrogen is sold to go with it for use in producing the lime light at theaters, lectures and clinics.

Besides this, oxygen and hydrogen are sold in mixtures of various proportions, and a great volume of nitrous oxide or laughing gas is sold to dentists, surgeons and hospitals. The makers of aerated waters buy carbonic acid in large quantities, and it is used elsewhere in the arts. Its use for aging wines, long practiced in France, is scarcely known here. Carbonic acid is usually sold in liquid form. Nitrogen is sold in small quantities for experimental purposes. It can be produced in almost unlimited quantities for experimental purposes. It can be produced in almost unlimited quantities at low rates, since it is given off as a waste product in one process of making oxygen.

Not only are gases sold in large quantities to local consumers, but they are sent by express all over the country. Laughing gas, in particular, has an enormous sale in various parts of the United States, and is also shipped to the most remote parts of civilized South America. The express companies handle this peculiar freight without special charge, and the makers say that accidents never occur.

The local trade in oxygen has a great many curious kinks. The various kinds of medicinal air advertised are, or pretend to be, mixtures of oxygen with atmospheric air. One dealer in the wind cure, however, assured the agent of an oxygen factory that oxygen was by no means a necessary part of his cure. A little perfume furnished by himself at low cost and a good deal of imagination furnished free by the patient proved vastly cheaper and quite as effective. The use of oxygen upon physicians' prescription is considerable, and many patients order it delivered two or three times a week, and keep up the practice long after the prescription is given. It is taken finally like any other tonic or stimulant, and not infrequently recommended to others. One concern sells over 250 pounds of oxygen per month for such purposes, and supplies several thousand customers.

If you see a messenger boy carrying on his back an iron cylinder about 30 inches long and five inches in diameter, you may be pretty sure that he is taking some person his supply of gas. If the cylinder is painted red, it contains oxygen; if black, hydrogen; if particolor, laughing gas. The manufacturers have come to an agreement as to colors because such agreement seemed necessary to safety. When oxygen and hydrogen are carelessly mixed, an explosion follows. To make it the more difficult to confuse the cylinders, the screw threads on the red cylinders and on the black cylinders are run in opposite directions, so that it shall be impossible to couple a cylinder to the wrong reservoir. By way of further precaution the cylinders are tested to a pressure of 4,000 to 5,000 pounds to the square inch.

Cylinders hold from 75 to 450 gallons of gas, and gases are sold by the foot for use in the arts, by the gallon for medical use. The fight that has been made over the return of beer bottles and soda siphons has likewise been made on the return of gas cylinders. The manufacturers have finally settled down to a system under which the cylinder is in theory sold outright, though in practice the purchase price, less a charge for rent, is refunded on return of the cylinder. By a system of checks and numbers the dealers can locate each missing cylinder.

The United States government is likely soon to become an important consumer of oxygen, as it is shortly to be applied to use in the torpedo service. An expert in gases, now resident in this city, gave Goubet, the French designer of torpedo boats, an important hint on this subject. Goubet had a tiny submarine craft, and he was accustomed to load it before starting on a submarine cruise with great cylinders containing compressed air. As the air loose in the little craft became