A dictionary of arts, manufactures, and mines

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Appendix.

APPENDIX.

ALKALIMETRY. Twenty-eight years have elapsed since I was led, by peculiar circumstances, to construct a very simple method of testing alkalis, the principle of which I soon afterward applied to acids, bleaching powder, dye-stuffs, and most other chemical substances extensively used in manufactures.* In 1814 and 1815, during the summer vacation of my Glasgow classes, I was engaged in delivering courses of lectures on chemistry in the Belfast Academical Institution, and had many of the most eminent members of the Linen Board of that town for my pupils. Being occasionally consulted upon the qualities of the alkalis, which were used to the value of 200,000*l.* by the linen bleachers of Ireland, I saw the importance to them of a simple alkalimetrical test, both for purchasing and for using their barillas and potashes. The following extract from the Belfast *News Letter*, of July 9th, 1816, will show the nature of my contrivance:—

"This day one of the porters of the Linen Hall, Belfast, was called into the library-room at the request of Dr. Ure, who being quite unknown to Dr. Ure, and never having seen any experiments made with acids and alkalis, he took the instrument at our desire, which being filled with colored acid, by pouring it slowly on adulterated alkali, which we had previously prepared, he ascertained exactly the per-centage of genuine alkali in the mixture. Belfast, 25th June, 1816.

"John S. Ferguson, Chairman.
James M'Donnel, M. D.
John M. Stoupe.
S. Thomson, M. D."

Of these gentlemen, two were leading members of the Linen Board, and the others the two principal physicians of the town. The publication of the details of my method of alkalimetry was delayed till arrangements were made for its general introduction, under the direction of the Linen Board of Dublin, whose professor of chemistry, Mr. W. Higgins, as well as Dr. Barker, professor of chemistry in Trinity College, granted certificates of the "accuracy and the national importance" of the instrument. The alkaline matter then imported into Ireland was often largely contaminated with common salt, even to the extent of 80 or 90 per cent. During the procrastination of the Board, I lent my Treatise on Alkalimetry to Dr. Henry, of Manchester, who inadvertently published an account of it, though with reference to me, in the next edition of his *Elements of Chemistry*. Having, in the long interval since, contrived many modifications of the instrument, and having extended its principle to testing other articles I am induced to offer it now to the world, in consequence of the recent appearance of a publication upon the same subject, by two very ingenious chemists of Liebig's school, Drs. R. Fresenius and H. Will. Of their system of alkalimetry, &c., a copious abstract appeared in the *Annalen der Chimie und Pharmacie* for July last, and about the same time a pamphlet was published by Winter, at Heidelberg, under the title *Neue Verfahrungsweisen zur Bestimmung des Werthes der Pottasche und Soda, der Saüren, und des Braunstein;* or "New Processes for determining the Value of Potash and Soda, of Acids, and Black Oxide of Manganese." However accurate these processes may be, and however apt for a German or French student of chemistry, they are, in my apprehension, not at all fitted for the familiar use of manufacturers and dealers in any country, and certainly not for those of the United Kingdom.

Descroizilles was the first person who contrived an instrument, called an alkalimeter, to ascertain the alkaline strength of potash and soda, without much calculation. His method was described in the *Annales de Chimie* for 1806, tom. lx., and a translation of it appeared in our *Philosophical Magazine*, vol. xxviii., for July

* Among others to nitrate of potash, nitrate of soda, and to white lead, either in powder or in paint. My nitrometer enables a person not at all versant in chemistry to ascertain in a quarter of an hour, but by two distinct processes, the quantity of pure nitrate in either of these salts, to one part in 200. The cerussa-meter is equally simple and expeditious.

and August of the following year. His apparatus consisted of a glass tube, 8 or 9 inches long, and 7 or 8 lines in diameter, closed at one end, but terminated at the other in a kind of small funnel (with a beak or spout), connected to the tube by a narrow neck, having a calibre of two lines and a half. Upon the shoulder, under the throat, there was a hole for admitting air to the long tube in the act of being emptied, by sloping its mouth downward. This cylindrical vessel was to contain 38 grammes of water, which space was divided into 76 equal parts, which it was extremely important to proportion accurately. The liquor was prepared by taking concentrated sulphuric acid, at 66° Baumé (1·845 spec. grav.), and diluting it with nine times its weight of water. The instrument being poised in a balance, he introduced into it very exactly two grammes of the above test acid, and when the instrument stood upright, he scratched a line at the level of the liquor, and thus proceeded by addition of successive grammes to graduate the whole, till 36 were added, after which he subdivided these spaces by lines into 72 demi-gramme volumes. He then proceeds to describe eight different subsidiary articles required for his operations:—

"*Alkalimetrical trials of potash.*—Weigh exactly one demi-gramme of potash, put it into a glass, and pour upon it about four fifths of a decilitre of water; facilitate the solution of the potash by stirring it with a small chip of wood, three or four times in an hour and a half, a minute at each time. When the solution is effected, pour it into the small tin measure, No. 4, which is to be then filled up with water; pour it back again into the glass, in which you must still pour a measure full of pure water; stir this new mixture also three or four times within half an hour, in order to facilitate the precipitation of a slight sediment, which soon falls down. This sediment being completely formed, slope the glass with caution, in order to fill with clear liquor the small measure; then empty this last into another large glass; after this place round the edges of a plate drops of syrup of violets; pour also into the alkalimeter test liquor until the line marks 0; take it afterward with the left hand, inclining it upon the glass which contains the moiety of the clean alkaline solution: the acid liquor will fall into it by hasty drops, or in a very small thread, which you may moderate at pleasure, by retarding the entrance of the air at the lateral hole or vent, upon which must be placed the end of the finger; at the same time, with a small stick or match, assist the mixture and facilitate the development of the carbonic acid which is manifested by effervescence. When you have emptied the alkalimeter to about the line 40, try if the saturation approaches, by drawing your small stick from the mixture, and resting it upon the drops of syrup of violets, which should become green, if the potash is not of a very inferior quality. If, on the contrary, the violet color is not altered, or what would be worse, if it be changed into red, there would be, in the first case, an indication of saturation, and in the second a proof of super-saturation. But this is not the case with good potashes; at that line, the liquor tried can alter the syrup of violets into green only; or cause to return to the violet, and even to the green, the drops which had been changed into red at the time of a former trial; we must, therefore, in general add more acid, which occasions a new effervescence. This addition must always be made with caution, and we must touch every time a drop of syrup of violets in order to stop. When at last the latter assumes a red hue, then, after having restored the alkalimeter to a perpendicular position, in order to see at what line the testing liquor stops, you must reckon one degree less, in order to compensate the excess of saturation. The mean term of potashes is 56; this implies that they require for their saturation *fifty-five hundredths* of their weight of sulphuric acid."

For the analysis of commercial sodas of all kinds, M. Descroizilles prescribes using ten and a half deci-grammes of this alkali, instead of the ten deci-grammes for potashes, and proceeds as above detailed. In his table of results annexed, we find American potashes called 60° to 63°.

American pearlashes - - -	50° to 55°
Dantzic potash - - - -	45 to 55
Alicant soda - - - -	20 to 33

It is obvious, from these statements, that the alkalimeter so made and graduated denoted comparative, but not absolute, quantities of alkalis present in the commercial samples. The rest of his very long memoir is occupied with what he calls the graduation of potashes and sodas, the economy of their graduation, the proportions of carbonic acid in them, the processes of caustification, the presence of potash in all lime which is burnt by a wood fire, origin of neutral soda, and probable origin of natrum; without any more explicit instructions. The instrument, as left in this vague state, never was employed, nor could it come into use, among English manufacturers and dealers

The next alkalimeter, of which an account has been published, was my own. In constructing this instrument, I availed myself of the lights recently shed on chemical proportions by Dr. Dalton's atomic theory, and I thus made it to represent, not relative, but absolute measures of the amount of real alkali existing in any commercial sample. The test-liquor used at that time was sulphuric acid, which is most readily and accurately diluted to the requisite degree by means of a glass bead, very carefully made, of the specific gravity that the standard acid should have. In order to make the test-liquor, therefore, nothing more is requisite than to put the bead into distilled water, and to add to it somewhat dilute but pure sulphuric acid, slowly and with agitation, till the bead rises from the bottom, and floats in the middle of the liquor at the temperature of 60° Fahr. The delicacy of this means of adjustment is so great, that a single degree of increase of heat will cause the bead to sink to the bottom—a precision which no hydrometer can rival. The test-tube, about 14 inches long, contains generally 1,000 grains of water, and is graduated into 100 equal parts by means of equal measures of mercury. The test-liquor is faintly tinged with red cabbage or litmus; so that the change of color, as it approaches to the saturating pitch, on adding it to 100 grains of the commercial alkali, becomes a sure guide in conducting the experiment to a successful issue. One hundred measures of this test-liquor neutralize exactly 100 grains of absolute soda (oxide of sodium), and of course very nearly 150 of potash. A bead may also be adjusted for test-liquors, of which 1,000 grain measures neutralize 100 of potash, and therefore $66\frac{2}{3}$ of soda, as well as other proportions, for special purposes of greater minuteness of research. One may be so graduated as to indicate clearly a difference of $\frac{1}{100}$ of a grain of ammonia. In making such nice experiments, it is of course requisite to free the alkaline matter beforehand from sulphurets, sulphites, and hyposulphites, by igniting it in contact with chlorate of potash, as long since recommended by Gay-Lussac. With such means in careful hands, all the problems of alkalimetry may be accurately solved by an ordinary operator.

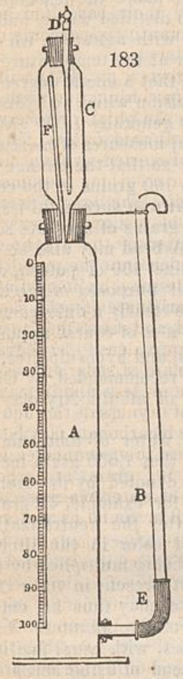
On the same principle, my *Acidimeter* is constructed; pure water of ammonia is made of such a standard strength by an adjusted glass bead, as that 1,000 grain measures of it neutralize exactly a quantity of any one real acid, denoted by its atomic weight, upon either the hydrogen or oxygen scale or radix; as for example, 40 grains of sulphuric acid. Hence it becomes a universal acidimeter; after the neutralization of 10 or 100 grains of any acid, as denoted by the well-defined color in the litmus-tinted ammonia, the test-tube measures of ammonia expended being multiplied by the atomic weight of the acid, the product denotes the quantity of it present in 10 or 100 grains. The proportion of any one free acid in any substance may thus be determined with precision, or to one fiftieth of a grain, in the course of five minutes. Like methods are applied to Chlorometry, and other analytical purposes, with equal facility; adapting the test-liquor to the particular object in view. Instead of using beads for preparing the alkalimetric and acidimetric test-liquors, specific gravity bottles, or hydrometers, may of course be employed; but they furnish incomparably more tedious, and less delicate means of adjustment. To adapt the above methods to the French weights and measures, now used generally also by the German chemists, we need only substitute 100 *deci-grammes* for 100 grains, and proceed in the graduation, &c., as already described.

The possession of two reciprocal test-liquids affords ready and rigid means of verification. For microscopic analyses of alkaline and acid matter, a graduated tube of small bore, mounted in a frame with a valve apparatus at top, so as to let fall drops of any size, and at any interval, is desirable; and such I have employed for many years. Of this kind is my ammonia-meter, used in the ultimate analysis of guanos and other azotized products, in conjunction with a modified apparatus on the principle of that of Varrentrapp and Will. It may be remarked, that when the crude alkali contains some hyposulphite, it should not be calcined with chlorate of potash, because one atom of hyposulphurous acid is thereby converted into two atoms of sulphuric, which of course saturate double the quantity of alkali, previously in combination with the hyposulphurous acid. In such cases it is preferable to change the condition of the sulphurets, sulphites, and hyposulphites, by adding a little neutral chromate of potash to the alkaline solution, whence result sulphate of chromium, water, and sulphur, three bodies, which will not affect the accuracy of the above alkalimetrical process.

In the *Annals of Philosophy* for October, 1817, I described a new instrument for analyzing the earthy and alkaline carbonates, and for determining the quantity of base present in them from the volume of carbonic acid, disengaged by their solution in acids, upon the data of the atomic theory. This method was applied to the analysis of the carbonates of ammonia, soda, potash, lime, magnesian limestone (dolomite), &c.

"The indications of the above analytical instrument are so minute as to enable us, by the help of the old and well-known theorem for computing the proportions of two metals from the specific gravity of an alloy to deduce the proportions of the bases from the volume of gas disengaged by a given weight of a mixed carbonate."*

That small instrument consisted of a bent glass tube, open at one end, and terminated at the other with an egg-shaped bulb from two to three inches in diameter, and it required for operating with it, about five pounds of quicksilver. The following glass apparatus (*fig.* 183) will be found more generally convenient, and equally exact. A is a cylinder, 2 inches in diameter, and 14 inches long. It contains 10,000 grains of water in the graduated portion; 0, or zero being at the top. It has a tubulure in the side close to the bottom, through the cork of which a short tube passes tight, and is connected to a collar of caoutchouc, E, which serves for a joint to the upright tube, B, resting near its open upper end in a hooked wire. Through the cork in the *mouth* of the cylinder, the taper tail of the flask C passes air-tight. The small tube F, open at both ends, is cemented at bottom into the tail of C, and rises to the shoulder of the flask. The cork of C is perforated, and receives air-tight the taper tube D, which can also be closed with the stopcock.



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In operating with this apparatus, proceed as follows :—

Fill the cylinder with water, and cover its surface with half an inch of oil. Insert the tail of the flask. Put into the flask C, 58·6 grains of carbonate of potash, or 45·2 of carbonate of soda, according as common pearl-ash or soda-ash is to be tested, along with as much water as will cover fully the lower end of D, and then introduce this tube. Have a bottle containing about 40 parts of oil of vitriol, previously mixed with 60 of water, and cooled. Take of this, in a pouring or dropping glass, 100 water grain measures, and suck this quantity gradually up into the tube D, then shut the stopcock. On opening it slightly the acid will fall into C, and as slowly as may be prudent. The carbonic acid gas, forthwith disengaged, will depress the water in A, cause an overflow of it from the tube B, which, being held in the left hand, must have its swanbeak placed over a basin, and progressively lowered to the level of the descending water in the cylinder. When all the sulphuric acid has been introduced by the right hand, the orifice of D is to be corked, and the tube B continually lowered with the left, till the effervescence being finished, the water in A remains stationary. The number on the centigrade scale, opposite to the surface of the oil, deducting 100 grain measures for the bulk of dilute acid added, denotes the per-centage of pure carbonate of potash, or of soda, in the sample under examination. The above prescribed weights of these two carbonates, when pure, disengage each by the action of sulphuric acid (used here in small excess) 10,000 water grain measures of carbonic acid gas, or 100 measures of the scale on A. The cylinder which I employ contains about 12,000 water grain measures, so that the bottom of the centigrade scale is fully two inches above the level of the lower tubulure. This capacity and the graduation into 120 parts, will be found convenient in certain cases, particularly in analyzing bicarbonates of potash and soda.†

We may estimate 10,000 water grain measures of carbonic acid at 60° Fahr., to weigh 18·4 grains, and we thus perceive what a magnified scale we should possess, if we applied the *vernier* contrivance here, as we do to barometers. At any rate, he must be an awkward operator who can not determine the value of an alkaline carbonate, by the above means, to one part in a thousand.

In operating upon limestones, marles, &c., 42·1 grains should be taken as the standard weight of assay, because that weight of pure carbonate of lime should give out on solution in dilute muriatic acid 10,000 water grain measures of carbonic acid gas. Since 100 water grain measures of liquid hydrochloric acid, specific gravity 1·14, will supersaturate the lime in the above weight of carbonates, that quantity may be used in the experiment. The preceding instrument will be found more convenient in experimenting, as also the system of indication, than one on similar principles constructed by the ingenious Dr. Mohr, of Coblenz.

In examining bicarbonates of potash and of soda, the weights to be used in the above apparatus are 42 grains of the former, and 35¼ grains of the latter, each of which

* *Dictionary of Chemistry*, 1821.

† For the greatest precision hot acid may be used in the above experiment, by taking in a graduated test-tube seventy-five grains of water, and filling it up to the line 100 with concentrated sulphuric acid. This mixture being poured in successive portions into the flask C (represented much too large in proportion to the cylinder A), will ensure the expulsion of all the carbonic acid from C, which may be afterward cooled by wrapping round it a towel dipped in cold water.

quantities, if the salts be perfect, will disengage 10,000 water grain measures of carbonic acid gas, by the action of sulphuric acid. There will be no harm in taking the formerly prescribed measure of the sulphuric acid though considerably less would answer the purpose. The centigrade measures of gas obtained in A will indicate the carbonated state of the two alkalis respectively. Their alkaline force may be most readily ascertained by my old alkalimeter, with colored test acid. Since the bicarbonates usually sold in our shops, especially that of soda, are far from being exact atomic compounds, they should be always examined, both for their base and acid, which may also be well done in the following way, where the quantity of carbonic acid gas is determined by weight instead of by volume.

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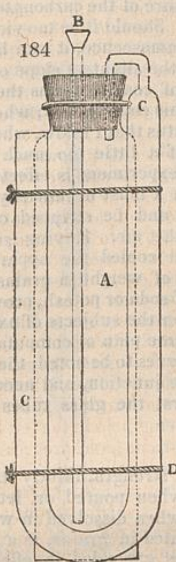

For this purpose, a small compact apparatus of the annexed form (*fig.* 184) will be found convenient; it is to be used in conjunction with my alkalimeter. A in the dotted line is the phial for receiving the carbonate to be tested. B, the funnel into which the test acid is to be poured; C C, an inverted syphon filled with pieces of chloride of calcium for absorbing the aqueous vapors exhaled by the carbonic acid. The loss of weight in the phial above that in the tube of test acid shows the quantity of acid gas, and the indication of the alkalimeter tube, that of alkaline base, from which data the proportion of neutral carbonate and bicarbonate may be immediately deduced. Thus, 100 grains of bicarbonate of soda should give out $51\frac{3}{4}$ grains of carbonic acid, and saturate 37·6 centigrade measures of the test acid, equivalent to 37·6 grains of real soda. But if neutral carbonate of soda be present, less gas will be given out, and more or less alkali may be indicated, according to the degree of dryness of the neutral soda. The amount of water in the bicarbonate may be determined by igniting 20 grains in a test tube, connected with the chlorcalcium inverted syphon; $10\frac{1}{3}$ grains of carbonic acid gas should be expelled, and $2\frac{1}{8}$ of water, making a total loss of $12\frac{11}{24}$ grains, of which $2\frac{1}{8}$ will be found as water absorbed by the chlorcalcium. But since a very moderate heat suffices to expel the second atom of carbonic acid from the bicarbonate of soda, the readiest mode of estimating its quality is to heat, over a spirit lamp, in a small flask, or retort, connected air-tight by a tube with the mouth of the cylinder A, (*fig.* 183), $70\frac{3}{4}$ grains of the supposed bicarbonate. Of the perfect salt this quantity should give out pretty exactly 10,000 grain measures of gas; and whatever aliquot part of this volume is evolved will indicate, without calculation, the relative value of the substance as a bisalt. Thus if 8,500 grain measures of gas are obtained, 85 parts of bicarbonate of soda are present in 100. The crystalline form of bicarbonate of potash is a tolerably good criterion of its quality.

The quantity of caustic alkali mixed with carbonate may be readily determined, with sufficient accuracy, by the expert use of my alkalimeter: because, till the caustic portion be nearly neutralized, little or no carbonic gas is expelled. When the effervescence at length begins, the test measures already expended denote the per-centage of caustic alkali. It is not right to disregard the alkali which is present in the state of sulphuret, because as such it is effective in many processes of the chemical arts; in the manufacture of yellow soap, crown glass, in the bleaching of linen and cotton goods, &c. The alkalimeter, directly applied, will show the alkali present in this form, when compared with that indicated after ignition of the crude alkali with chlorate of potash, or after its treatment with yellow chromate of potash.*

A few years ago I had the following apparatus made for the ready analysis of carbonates, by ascertaining the loss of weight they suffered from the disengagement of their carbonic acid gas, during their solution in an acid. A, B (*fig.* 185) are two globes, of about two inches in diameter each; A has its inferior neck strangled into a bore nearly capillary; B stands lower, with its centre line on a level with the narrow neck of B. The tubes of these globes are about one half inch in diameter. C is shut at top with a perforated cork, through which enters, air-tight, a small glass tube, which is bent across to the mouth of the tube E, and then passes down into it a little below the centre line of

* If the alkaline carbonate contains sulphuret, sulphite, or hyposulphite, a teaspoonful of yellow chromate of potash may be added to it, wherefrom result sulphate of chromium, water, and sulphur, which remain in the apparatus without effecting its weight. The mutual action of neutral chromate of potash, and of sulphuret of potash, &c., has been discussed in an ingenious paper published by Dopping, in the *Annalen der Chimie* for May, 1843, p. 172.

the globe B. This globe is rather more than half filled with sulphuric acid, when the instrument is employed in the analysis of the carbonates. The standard weight of carbonate of soda = 24⅛ grains, or of carbonate of potash = 31⅛ grains, is then put into A, having previously laid a minute globe of glass over the lower orifice; the cork, with its small tube, is now firmly adjusted; and the apparatus is weighed in its upright position, either by suspension with a hook to the end of the beam, or by resting it on the scale in a light socket of any kind. It is next laid hold of, and inclined so as to cause a little of the acid in B to pass over into A. Effervescence ensues with greater or less vehemence, according to the nature of the carbonate and quantity of the acid introduced. Should it be too violent, and threaten an overflow by intumescence, it can be instantly abated to any degree by the slightest slope of the instrument. Now, this power of control forms the peculiar feature and advantage of this contrivance; whereas in all other forms of such apparatus that I know, whether by sucking over or pouring in, if a little too much acid comes upon the carbonate, the experiment is effectually marred. The gas disengaged in A must necessarily traverse the sulphuric acid in B, and be stripped of its moisture before escaping into the air. Having supersaturated the alkaline base, and cooled the apparatus, we weigh it again, and the loss of weight in grains and tenths denotes the per-centage of soda or potash, provided their neutral carbonates had been the subjects of experiment. For limestone, on the same plan of computation, 22¾ grains may be taken. It deserves to be noted, that the present instrument has only one junction, and needs no chloride of calcium, a substance so apt by its swelling to burst the glass tubes that contain it.*

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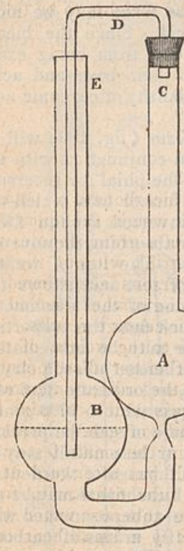

II. ACIDIMETRY.

I have already stated, that water of ammonia of standard strength, faintly tinted with litmus, affords a most exact and convenient acidimeter, when poured or let fall from a graduated dropping-tube. Bicarbonate of potash also, when dissolved in water, so that 1,000 grain measures contain one atom of the salt counted in grains, is a good test-liquor for the same purpose; for if the centigrade measures expended in effecting neutralization are multiplied by the atomic weight of the given acid, the product is the quantity in grains of acid present.

Acidimetry may be likewise exactly performed by measuring in the cylindric gas-meter (*fig.* 183) the volumes of carbonic acid gas disengaged from pure bicarbonate of potash or soda, by a given weight of any acid, taking care to use a small excess of the salt. Thus, for example, 16·8 grains of dry and 20⅔ of hydrated sulphuric acid disengage 10,000 water grain measures of gas from bicarbonate of potash. Therefore, if 20⅔ grains of a given sulphuric acid be poured into the flask of *fig.* 183, upon about 50 grains of the bicarbonate, powdered and covered with a little water, it will cause the evolution of a volume of gas proportioned to its strength. If the acid be pure oil of vitriol, that weight of it will disengage 10,000 grain measures of gas; but if it be weaker, so much less gas—the centigrade measures of which will denote the per-centage value of the acid. If the question be put, how much dry acid is present per cent. in a given sulphuric acid, then 16·8 grains of the acid under trial must be used; and the resulting volume of carbonic acid gas read on the scale will denote the per-centage of dry acid.†

For nitric acid, we should take 22·6 grains; for hydrochloric or muriatic acid, 15·34; for acetic acid, 21·6; for citric acid, 24·6; for tartaric acid, 28 grains: then in each case we shall obtain a volume of carbonic acid gas proportioned to the strength and purity of these acids respectively. The nitric, hydrochloric, and acetic acids are referred to in their anhydrous state; the tartaric and citric in their crystalline. If the latter two acids be pure, a solution of 24·6 grains of the first and of 28 of the last

* 1,000 water grain measures of sulphuric acid of specific gravity 1·032, or 32 above water, neutralize 32 grains of soda, and, consequently, one atom, on the hydrogen scale, of each of the other bases, reckoned in grains.

Having in the course of many years subjected my tables of sulphuric, nitric, and muriatic acids, as well as of ammonia, to strict cross-examination, I have found them trustworthy for all alkalimetrical and acidimetrical purposes.

† The bicarbonate must be free from carbonate, a point easily secured by washing its powder with cold water, and drying it in the air.

will disengage from 50 grains of bicarbonate of potash 10,000 grain measures of carbonic acid gas.*

Acidimetrical operations may likewise be performed by determining the *weight* of carbonic acid gas expelled from the bicarbonate of potash or soda, by a given quantity of any acid, in the apparatus either *fig.* 184, or *fig.* 185. Here the weights to be taken are as follows, in reference to

	Grains.
Dry Sulphuric acid - - -	9·127
" Nitric - - - - -	12·33
" Hydrochloric - - -	8·29
" Acetic - - - -	11·67
Crystallized Tartaric - - -	13·31
" Citric - - -	15·13

Each of these quantities of real acid, with 25 or 26 grains of bicarbonate of potash, will give off 10 grains of carbonic acid gas; and hence whatever weight the apparatus loses, being reckoned in grains and tenths of a grain, denotes the per-centage of acid in the sample under trial, without the necessity of any arithmetical reduction. Persons accustomed to the French metrical system may use deci-grammes instead of grains, and they will arrive at the same per-centage results.

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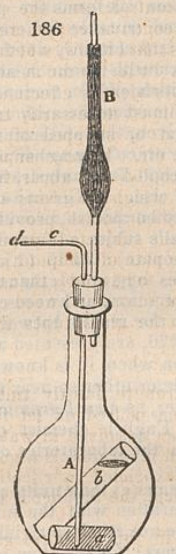

The preceding experiments, in reference to the weight of carbonic acid gas expelled for the purpose of either alkalimetry or acidimetry, may also be made by means of the ordinary apparatus represented in *fig.* 186. A is a small matrass which contains the acid or carbonated alkali at its bottom; and conversely the alkali or acid, for their mutual decomposition in the small test-tube, shown first at *b* nearly upright and filled, but afterward at *a*, horizontal and emptied. B is a bulbous tube filled with fragments of chlorcalcium for absorbing the aqueous vapor that rises with the carbonic acid gas, and *d c* is a small bent tube which dips into the liquid in the matrass. The weighings, &c., may be conducted as already detailed; and when the effervescence is completed, the residuary gas is sucked up through B, while the atmospheric air enters to replace it at the orifice *d* of the bent tube.

The NEW methods which pervade the whole treatise of Drs. Fresenius and Will are all based on the principle of estimating alkalinity, acidity, and the oxygen in manganese (or chlorometry) by the weight of carbonic acid gas evolved. As in taking these measures the gas must be discharged without carrying water off with it, an elegant and ingenious little piece of apparatus has been invented by the authors for effecting that purpose, and it will do it well. A and B (*fig.* 187) are two flasks (wide-mouthed medicine-bottles may be employed). A must have a capacity of from 2 ounces to 2½ ounces of water; it is advisable that B should be somewhat smaller, say of a capacity of about 1 to 1½ ounces. Both flasks are closed by means of doubly perforated corks. These perforations serve for the reception of the tubes *a*, *c*, and *d*. *c* is a tube bent twice at right angles, which enters at its one end just into the flask A, but descends at its other end, near to the bottom of B. These tubes are open at both ends when operating; except the top end *b* of the tube *a*, which is closed by means of a pellet of wax. The substance to be examined is weighed and put into the flask A, into which water is then poured to the extent of one third of its capacity. B is filled with common English sulphuric acid to about half its capacity. Both flasks are then corked (by which they become united by the rectangular tube), and the apparatus is weighed.

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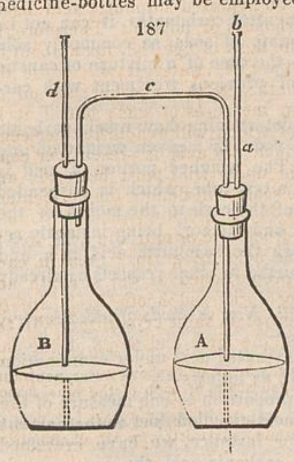


The air of the whole apparatus is next rarefied by applying suction to the tube *d*: the consequence is, that the sulphuric acid contained in B ascends into

* The expulsion of the gas may be completed by surrounding the flask with a towel dipped in hot water.

the tube *c*, and thus a portion of it flows over into B. Immediately upon its coming into contact with the carbonate contained in A, carbonic acid gas is disengaged, and in its escape must necessarily traverse the oil of vitriol in B, and therein deposite all its aqueous vapor before issuing from *d*. The sulphuric acid in passing over into A heats the mixture at the same time, and thus promotes the expulsion of the gas. Whenever this ceases to flow, a little more sulphuric acid must be sent over into A by suction from *d* (or rather from a recurved tube attached, *pro tempore*, to it); an artifice which may be repeated till no more gas can be expelled, even when the contents of A are heated, as they must be at the end by the excess of oil of vitriol.

"From the aperture *b* of the tube *a*, which has been all the time closed, the bit of wax is now to be removed, and to the tube connected with *d*, suction is to be applied, till all the carbonic acid lodged in the apparatus be replaced by atmospheric air. The whole is to be then cooled, wiped, and weighed; the loss of weight indicates exactly the quantity of carbonic acid which existed in the carbonate submitted to experiment. The process is no less neat than it is simple, and does honor to the ingenuity of its inventors. Their mode of deducing the per-centage of alkali from the quantity of carbonic acid discharged in the operation is also quite exact, and suitable for continental chemists familiar with gramme weights and calculations, but certainly not for persons conversant only with ounces, drams, and scruples, or even with grain subdivisions. The whole book, however excellent, needs, for the British public, transposition, before it can serve in this country the purpose intended by its scientific authors. Thus, in section 4, where several results of their analyses are given, the statements have a somewhat mysterious aspect. Should any one ask why the oracular number of 4·83 grammes of carbonate of soda is used as their standard weight for analysis, he can obtain no response in the book, either in a note or anywhere else. A German or French student, familiar with chemical computation, will probably be able to discover that 4·83 grammes of pure carbonate of soda contain, by Berzelius's tables of atomic weights, 2 grammes of carbonic acid; for 53·47 (1 atom of carbonate): 22·15 (1 of carbonic acid) : : 4·83 : 2·00. Such is the simple solution of this apparent enigma, and of some other similar puzzles in the book. Indeed, unless the reader is aware of that proportion, he can not see the grounds of the accordance in the results between experiment and theory, or why the numbers 2·010, 1.993, and 2·020, are presented as specimens of great precision. This accordance gives satisfaction when it is known that these numbers, in experiments 1, 2, and 3, oscillate on one side or other so near to the theoretical number 2·00. But 4 grammes and 83 centi-grammes, as also 1 gramme and 995 milli-grammes, are awkward weights for an ordinary English chemist or apothecary, which would require a month or two's residence in the laboratories of Giessen and Paris to manipulate with readiness.

Again, in testing carbonate of potash, our authors take 6·29 grammes as their unity of weight, undoubtedly, because, if pure, it should discharge, by saturation with the sulphuric acid, 2 grammes of carbonic acid. Here, however, they have not stuck so rigidly as the school of Giessen usually does to Berzelius's atomic numbers; for his atom of carbonate of potash is 69·42; whence, 22·15 : 69·42 : : 2·00 : 6·68, hydrogen = 1·00; or 276·44 : 866·33 : : 2·00 : 6·268 oxygen = 100.

Admitting the value of the new method in testing neutral carbonates, it can not be directly applied to the mixed carbonate and bicarbonate of soda, so commonly sold in this country for bicarbonate; nor is it applicable to the case of a mixture of caustic and carbonated alkali, without the tedious process of previous treatment with carbonate of ammonia and heat.

The new German method of *acidimetry* consists in determining how much carbonic acid gas is disengaged from a standard bicarbonate of soda, by a given weight of any acid. The twin-flask apparatus (*fig.* 187) is used. The weighed portion of acid is put into A, and a sufficient quantity of the soda into a test-tube, which is suspended upright with a silk thread fastened by the pressure of the cork to the mouth of the flask. On letting the thread loose, the test-tube falls, and the cork being instantly replaced, the whole gas evolved is forced to pass through the sulphuric acid in B, and there to deposite its moisture. The experiment is conducted in other respects as already described for alkalimetry.

The following extract from Drs. Fresenius and Will's *New Methods of Alkalimetry*, &c., will show the Giessen plan of calculating results:—

"The amount of anhydrous acid contained in the hydrated acid under examination is determined from the amount of carbonic acid escaped, as follows:—

"Two measures of carbonic acid bear the same proportion to one measure of the anhydrous acid in question, as the amount of carbonic acid expelled does to the amount sought of anhydrous acid. Thus, let us suppose, for instance, we have examined dilute sulphuric acid, and obtained 1·5 grammes of carbonic acid, the arrangement would be:—

$$550\ (2 \times 275) : 501 = 1{\cdot}5 : x$$
$$x = 1{\cdot}36.$$

The amount of sulphuric acid operated upon consequently would contain 1·36 grammes of anhydrous acid. Let us suppose the weight of this amount to have been 15 grammes, the sulphuric acid under examination would contain a per-centage amount of 9·06; for

$$15 : 1{\cdot}36 = 100 : x$$
$$x = 9{\cdot}06."*$$

"SECTION XXIX. *Stating the Quantities of the various Acids to be used in their Examination.*—To enable our readers at once, without the trouble of calculation, to determine from the weight of carbonic acid expelled, the exact amount of anhydrous acid contained in those acids which are of most frequent occurrence, we have subjoined lists of certain quantities to be taken of each acid for experiment, so that the number of centi-grammes of carbonic acid expelled will directly indicate the per-centage amount of anhydrous acid in the acid under examination.

"Multiples of those weights may of course be substituted for the numbers given, according to the degree of dilution of the acid under examination. In such cases the number of centi-grammes of the carbonic acid expelled must be divided by the same number, which has served as the multiplier.

"These numbers are obtained by dividing the atomic weight of the acid by 550 (2 × 275, one eq. of carbon),† as follows:—

"Two eq. of carbonic acid, corresponding to one eq. of the acid to be examined, how much should be taken of the latter to expel 1·00 grammes of carbonic acid?

"The arrangement of sulphuric acid, for instance, is as follows:—

$$550 : 501 = 1{\cdot}00 : x$$
$$x = 0{\cdot}91 \text{ (or, more correctly, } 0{\cdot}911).$$

"When examining acids, it is most advisable to use that multiple of the unity (according to the degree of concentration) which will expel from one to two grammes of carbonic acid.

"I. SULPHURIC ACID.

"Unity 0·91 grammes (or, more correctly, 0·911 grammes).

"Multiples:—

2 × 0·911 =	1·822	grammes.
3 × 0·911 =	2·733	"
4 × 0·911 =	3·644	"
5 × 0·911 =	4·555	"
6 × 0·911 =	5·466	"
7 × 0·911 =	6·377	"
8 × 0·911 =	7·288	"
9 × 0·911 =	8·199	"
10 × 0·911 =	9·110	"
15 × 0·911 =	13·665	"
20 × 0·911 =	18·220	"
30 × 0·911 =	27·330	" &c.

"Thus, knowing that 0·91 of anhydrous sulphuric acid will expel 1·00 of carbonic acid, it will be easy to determine what multiple ought to be used, according to the degree of concentration of the acid to be examined."‡

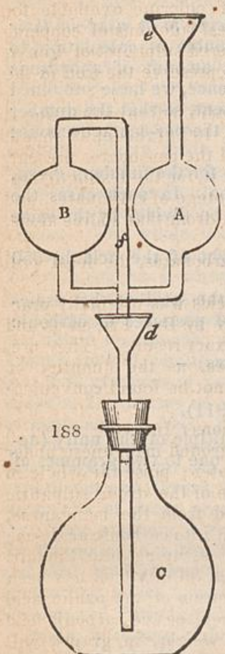
III. CHLOROMETRY,

And the testing of Black Oxide of Manganese for its available Oxygen.

The value of manganese may be estimated very exactly by measuring the quantity of chlorine which a given weight of it produces with hydrochloric acid; the chlorine being at the same time estimated by the quantity of solution of green sulphate of iron, which it will peroxidize. A process of this kind was long ago practised with chloride of lime (bleaching powder or liquor) by Dr. Dalton; and it has been since improved by Mr. Waltercrum. As the conversion of two atoms of green sulphate of iron into red sulphate requires only one atom of oxygen, this change may be effected by the reaction of one atom of chlorine in liberating one atom of oxygen, while this appropriates one of hydrogen from the hydrochloric acid.

* *New Methods of Alkalimetry, &c.*, pp. 93, 94.
† A typographical error in Mr. Bullock's edition; it should be *carbonic acid.*
‡ *New Methods of Alkalimetry, &c.*, pp. 103–105.

The weight of 2 atoms of green sulphate of iron is 278 = (139 × 2), consisting of 2 atoms of protoxide = 72, × 2 of sulphuric acid = 80, × 14 of water = 126; in all = 278; and this weight is equivalent to 36 of chlorine, to 8 of oxygen, and to 44 of peroxide of manganese.* Therefore, if we take a solution of copperas, containing 278 grains in 1,000 water grain measures, that volume of liquid will represent, by the conversion of its protoxide into peroxide, exactly one atom, either of peroxide of manganese = 44 grains, or 1 atom of chlorine = 36. Hence the following plan of research :—



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Into the flask or phial c of my chlorometric apparatus (*fig.* 188), put 100 grains of the manganese to be tested, and into the globes A, B, pour out of an alkalimetrical tube charged with 1,000 grain measures of the above *equivalent* copperas solution, from 200 to 500 grain measures, according to the supposed quality of the manganese; then introduce through the funnel *d*, some hydrochloric acid of known specific gravity (suppose 1·1), containing nearly 20 per cent. of chlorine, also from a charged alkalimetrical tube, and apply gentle heat to the bottom of the flask by placing it in a capsule of water standing over a spirit-lamp. The chlorine evolved will rise up through the tube *f*, which passes merely beyond the cork, and will enter into the solution in B and A, converting it into red sulphate. Have ready some dry paper imbued with solution of red ferrocyanide of potassium (red prussiate of iron). Dip a slip of whalebone into the liquor in the globe A, through the funnel *e* (represented in the figure rather too high above the globe), and touch the paper with its point. As long as it forms a blue spot, some of the iron still exists as black oxide, and the process is to be urged by the addition of a little more hydrochloric acid to the manganese, as long as chlorine gas continues to be disengaged, and while it maintains the level of the liquor in A above that in B. Whenever the liquor, by the reaction of the chlorine, ceases to stain the test-paper blue, more of the solution from the graduated tube must be added till it begins to do so. By the cautious administration of the hydrochloric acid on the one hand, and of the copperas liquor on the other, the term of saturation will be arrived at in a few minutes. The manganese has then produced all the chlorine which it can yield. The number of water grain measures, of the liquor, or degrees of its alkalimeter scale being multiplied by 44, will give a product denoting the per-centage of pure manganese present in the sample; or being multiplied by 36, a product which will denote the quantity of chlorine by weight which 100 grains of it can serve to generate.

Since one atom of pure manganese (44 grains), in producing 36 grains of chlorine, consumes 2 atoms = 74 grains of hydrochloric acid, the quantity of this acid expended from the graduated tubes, beyond the due proportion of chlorine obtained, will show how much of the acid is unprofitably consumed by foreign substances in the manganese. In fact, every grain of chlorine should, with pyrolusite, be generated by an expenditure of little more than 2 grains of real muriatic acid, or 10 grains weight of the dilute acid, = about 9 grain measures of the graduated tube. Liquid hydrochloric acid of spec. grav. 1·093 contains in 1,000 grain measures exactly 200 grains of real acid. Hence 100 grains of pure pyrosulite should produce about 82 grains of chlorine, and consume about 169 of real muriatic acid = 845 grain measures of liquid acid, spec. grav. 1·093. Instead of taking 100 grains of manganese as the testing dose, 10 or 20 grains may be taken, according to the dimensions of the apparatus and the exactness of the operator.

But if it be wished to obtain direct per-centage of *manganese* by the graduated tubes without the trouble of reduction, then for a dose of 10 grains take a solution of fresh green copperas (free from adhering moisture), containing 632 grains in 10,000 grain measures. Proceed as above directed. If the manganese be a pure peroxide, 10 grains of it

* Berzelius, in the 4th edition of his *Lehrbuch*, rates the atom of the green sulphate of iron (ferrous sulphate) at 129·43, hydrogen = 1, and considers it, after Mitscherlich, to contain only 6 atoms of water. I have ascertained, by the most careful experiments, that it contains 7 atoms of water; and that 139 grains of it, or 138·44 (Berzelius) are equivalent to 1 atom of chlorbarium, and to very nearly 40 grains of peroxide of iron.

This remarkable error has probably arisen from an attempt to measure the proportion of water in the salt from its loss of weight by desiccation. But I have found it impossible by this means to expel more than 6 atoms of water without causing partial decomposition of the salt by disengagement of sulphuric acid. The copperas so dried acquires such an affinity for water, that it absorbs fully one tenth of its weight of moisture from the atmosphere in the course of an hour.

will generate as much chlorine as will peroxidize exactly 1,000 grain measures, or 100 degrees by the test-tube of the copperas solution. But if the manganese contain only 40 or 50 per cent. of peroxide, then 40 or 50 centigrade measures of the said solution will be equivalent to the chlorine evolved from it by the reaction of hydrochloric acid.

If the object is on the other hand to obtain direct indications as to *chlorine*, then a test solution of copperas, containing 772 grains in 10,000 grain measures, will serve to show, by the peroxidizement of each 10 grain measures, or of one degree of the centestimal scale of the test-tube, the reaction of one grain of chlorine available for bleaching, &c., in the chloride of lime or of soda, &c. The test solutions of copperas should be kept in well-corked bottles, containing a little powdered sulphuret of iron at their bottom, which is to be shaken up occasionally in order to preserve the iron in the state of protoxide.

The manganese should always be treated with dilute nitric acid before submitting it to the above-described ordeal; and if it exhibits effervescence, 100 grains of it should be digested with the acid for a sufficient time to dissolve out all the carbonates present, then thrown upon a filter, washed and dried before weighing it for the testing operation. The loss of weight thereby sustained denotes the per-centage of carbonates, and if calcareous it will measure the waste of acid that would ensue from that source alone, in using that manganese for the production of chlorine.

That manganese is most *chlorogenous* which contains no carbonates, the least proportion of oxide of iron, and of sesquioxide of manganese.

The plan of testing manganese with oxalic and sulphuric acids was originally practised by M. Berthier and Dr. Thomson, but is lately modified by Drs. Fresenius and Will, who employ oxalate of potash, as likely to afford more exact results. They prescribe a multiple by 3 of 993 milli-grammes = 2·979 grammes, as the quantity of manganese best adapted to experiment; but this quantity will not be found convenient by ordinary British operators.

I, therefore, take leave to prescribe the following proportions: Into the vessel A of my twin-globe apparatus (*fig.* 185), put 100 grains of the ground manganese under trial, along with 250 grains of oxalate of potash and a little water; poise the whole in the scale of a balance; then, by gentle inclination, cause a little of the strong sulphuric acid to pass from B up into A. The oxygen thereby liberated from the manganese, reacting in its nascent state upon the oxalic acid, will convert it into carbonic acid gas; which, in passing through B, will deposite its moisture before escaping into the air. Whenever the extrication of gas ceases, after such a quantity of oil of vitriol has been introduced into the globe A, as both to complete the decomposition of the oxalic acid and to heat the mixture, withdraw the cork for a moment, to replace the carbonic acid with air, then cool, and weigh the apparatus. The loss of weight, in grains, will denote the per-centage value of the manganese; that is, the proportion per cent. of perfect peroxide in the sample. If the manganese be pure no black powder should remain.

The preceding experiment is founded upon the following principle: One atom of peroxide of manganese = 44, contains one atom of oxygen separable by sulphuric acid, and capable of converting one atom of oxalic acid into two atoms of carbonic acid, also = 44, which fly off; and cause therefore a loss of weight equal to that of the whole peroxide. To one atom of oxalic acid, which consists of three atoms of oxygen, and two of carbon—if one atom of oxygen be added, the sum is obviously four atoms of oxygen and two of carbon = 2 atoms of carbonic acid.

The apparatus (*fig.* 187) of Drs. Fresenius and Will will answer perfectly well for making the same experiment, the manganese being put into A, with about two and a half times its weight of oxalate of potash, and the sulphuric acid being drawn over into the mixture by suction, as above described.

The economy of any sample of manganese in reference to its consumption of acid, in generating a given quantity of chlorine, may be ascertained also by the oxalic acid test: 44 grains of the pure peroxide, with 93 grains of neutral oxalate of potash, and 98 of oil of vitriol disengage 44 grains of carbonic acid, and afford a complete neutral solution; because the one half of the sulphuric acid, = 49 grains, goes to form an atom of sulphate of manganese, and the other half to form an atom of sulphate of potash.

The deficiency in the weight of carbonic acid thrown off will show the deficiency of peroxide of manganese; the quantity of free sulphuric acid may be measured by a test solution of bicarbonate of potash, and the quantity neutralized, compared to the carbonic gas produced, will show, by the ratio of 98 to 44, the amount of acid unprofitably consumed.

In *fig.* 183, the tube, D, may also be graduated, and may contain the quantity of acid, for the purpose either of alkalimetry or acidimetry; and if the lower orifice be capillary, it will allow none of its contents to flow out, till the stopcock in the top orifice is opened.

In *fig.* 184, such a tube as D (*fig.* 183) may be substituted with advantage for the funnel, B; and as that tube, D, may be made of such dimensions as to contain enough of acid to supersaturate the bases of the carbonates in the phial, A, there will be no necessity for a separate vessel to hold the decomposing acid. Thus the apparatus becomes very light, convenient, and may be placed in the small scale of a fine balance; whereas the twin matrasses of Drs. Fresenius and Will (*fig.* 187), as furnished by Mr. Bullock, require a very large pan or scale to stand in. I flatter myself that the instrument, *fig.* 184, so mounted, will be found an acceptable present to practical chemists, and that it will enable them readily to examine, not only carbonates, but also manganese and bleaching substances, with great precision, by the weight of carbonic acid gas disengaged, on the principles above explained.

Into the twin globe apparatus (*fig.* 185), after the sulphuric acid is poured into B, a little water should be poured into C, before the carbonate is introduced into the latter. By this means, the capillary throat of the tube under A will not be apt to get choked with concrete salt.

The following quotations are from the work of Drs. Fresenius and Will, as edited by Mr. Bullock for the English reader. An accurate comparison may thus be made between the relative utility of their methods and mine to the practice of ordinary operators:—

"SECTION XXXIV. *Examination of Manganese: having at the same time due regard to the amount of Acid required for its complete Decomposition.*—We have stated, at Section 30, that it is not a matter of indifference, with regard to the amount of acid employed in the production of chlorine from manganese, what are the minerals which this substance contains in admixture with the peroxide. The following modification of our method will give the most correct information on this point:—

"Sulphuric acid of commerce is taken, and its amount of anhydrous acid determined, as directed at Section 26, or by means of an accurate hydrometer. Of this sulphuric acid as much is weighed into A (*fig.* 187), as to give an amount of 5·47 grammes of anhydrous acid.

"The following table will show the amount which ought to be taken, acoording to the various degree of concentration of the acid:—

Specific weight found.	Per-centage amount of anhydrous acid found.	Amount to be used for the examination.	Specific weight found.	Per-centage amount of anhydrous acid found.	Amount to be used for the examination.
1·8485	81·54	6·708	1·8336	76·65	7·136
1·8480	81·13	6·742	1·8313	76·24	7·174
1·8475	80·72	6·776	1·8290	75·83	7·213
1·8467	80·31	6·811	1·8261	75·42	7·252
1·8460	79·90	6·846	1·8233	75·02	7·291
1·8449	79·49	6·881	1·8206	74·61	7·331
1·8439	79·09	6·916	1·8179	74·20	7·371
1·8424	78·68	6·951	1·8147	73·79	7·412
1·8410	78·28	6·987	1·8115	73·39	7·453
1·8393	77·84	7·027	1·8079	72·97	7·495
1·8376	77·40	7·067	1·8043	72·57	7·537
1·8356	77·02	7·101			

"As much water is then poured into A as will fill the flask to about one fourth; and, lastly, from 6·5 to 7 grammes of neutral oxalate of potash, or from 5·5 to 6 grammes of neutral oxalate of soda, are added; 2·98 grammes of the (finely-pounded) manganese to be examined are then weighed (the manganese must have been previously tested for carbonate alkaline earths: compare this section at the end) into a small glass tube, such as used in acidimetry, and described in Section 25. About the same quantity of pure pyrolusite,* in powder, is then put into another similar tube. The tube, with the manganese to be examined, is then suspended in A (*fig.* 187), as described at Section 26, and the apparatus prepared, as directed at Section 3. The

* "Any variety of pyrolusite will serve this purpose, provided it be free from other manganese ores. If it contains heavy spar, it may be employed directly; but should it contain alumina or lime, it must be treated first with dilute nitric acid, at a gentle heat, until all soluble parts have been dissolved; it is then washed and dried. Artificially prepared, hydrated peroxide of manganese may be substituted for pyrolusite."

apparatus is then placed on one scale of a balance, together with the other little tube containing the pyrosulite, and exactly weighed.

"The cork of A is then somewhat raised to allow the little tube with the manganese to fall into the flask. The evolution of carbonic acid commences immediately, and continues until all the manganese is decomposed. When the operation begins to get on more slowly, the flask, A, is placed in boiling water, and allowed to remain there until no more bubbles appear. The little wax-stopper is then removed* from *a*, the flask, A, taken out of the hot water, and suction applied to *d*, until the sucked air tastes no longer of carbonic acid. The apparatus, after having been allowed to cool, is wiped dry, and replaced in the original scale, where the little tube with the pyrolusite still remains; weights are then substituted for the loss of carbonic acid. The number of centigrammes required, divided by three, directly indicates the per-centage amount of peroxide of manganese (*vide* Section 32). The centigrammes substituted for the loss of carbonic acid are then removed from the balance, and the little tube with the pyrosulite is thrown into A. (The little wax-stopper must of course previously be replaced on *a*). If no fresh evolution of carbonic acid takes place, the manganese examined consists of pure pyrosulite, and the experiment is at an end. But should a fresh evolution of carbonic acid take place, the operation must be further conducted, and brought to a close, exactly as just stated (*vide suprà*). The apparatus is then replaced on the balance, with an additional weight of three grammes on the same scale. If this is sufficient to restore a perfect equilibrium, no loss of acid has taken place; the manganese, indeed, contains other matters in admixture, but only such as do not consume any acid. But if the scale with the apparatus sinks, this is a certain sign that a portion of the acid has been lost by combining with the oxides which the manganese under examination contains. The number of centigrammes required to restore the perfect equilibrium of the balance, multiplied by 0·6114, immediately indicates how much anhydrous sulphuric acid has been wasted in the decomposition of 100 parts of the manganese under examination. The same number, multiplied by 0·333, indicates the amount of acid wasted in every 100 parts of sulphuric acid employed for the decomposition of the manganese in question. The same number, multiplied by 0·5552, indicate how much anhydrous hydrochloric acid would be wasted in the decomposition of 100 parts of the manganese. The same number, multiplied by 0·333, indicates also how much acid would be wasted in every 100 parts of hydrochloric acid employed for the decomposition of the manganese.

"These figures result from the following equations:—

"I. 275 (eq. of carbonic acid) : 501 (eq. of sulphuric acid) = the carbonic acid obtained *minus* (in proportion to the sulphuric acid used) : x.

$$x = \text{this carbonic acid} \times \tfrac{501}{275},\ i.\ e.\ \times 1{\cdot}822.$$

Thus, the number obtained for x indicates the amount of sulphuric acid corresponding to the amount of carbonic acid obtained *minus*.

"II. 2·98 of manganese: $100 = x$ of equation I. : x.

$$x = x \text{ of I.} \times \tfrac{100}{298},\ i.\ e.\ \times 0{\cdot}33557.$$

"The x of the first equation tells us how much sulphuric acid has been wasted without contributing to the decomposition of 2·98 grammes of the manganese; the x of the second equation tells us the same for 100 parts of manganese.

"If, therefore, the amount of carbonic acid obtained *minus* be directly multiplied by the product of the quotients of I. and II.,

1·822 and 0·33557,

i. e. with 0·61141 (the number given above), the amount of anhydrous sulphuric acid wasted in the decomposition of every 100 parts of manganese will immediately be found.

"III. 5·47 (the amount of sulphuric acid used):

$100 = \text{the } x \text{ of I.} : x.$

$$x = \text{the } x \text{ of I.} \times \tfrac{100}{547},\ i.\ e.\ \times 0{\cdot}18282.$$

"Of 5·47 of sulphuric acid, the x of I. has been wasted, 100 corresponds to the x of III.

"The x of III. is, therefore, found directly by multiplying the amount of carbonic acid obtained *minus* with the product of the quotients, 1·822 and 0·18282, *i. e.*= 0·33301.

"The figures for hydrochloric acid are found in the same manner (4·967 of hydrochloric acid must be taken instead of 5·47 of the sulphuric acid)."†

* "This must of necessity be done while the flask is still standing in the hot water, or else the sulphuric acid will recede upon the apparatus being removed from the hot water."

† *New Methods of Alkalimetry, and of determining the Commercial Value of Acids and Manganese.* By Drs. C. R. Fresenius and H Will. Edited by J. Lloyd Bullock: pp. 123–128.

ARTESIAN WELLS. *Fig.* 189, is that referred to in the foot-note of page 10.

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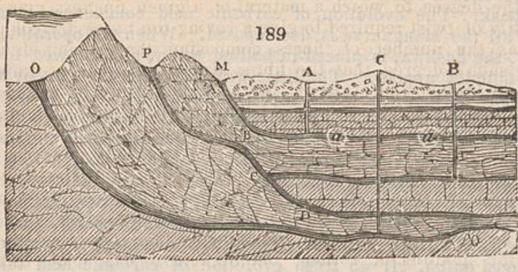

BEER. A gentleman well acquainted with the brewing of porter in London has favored me with the following information.

Essentia bina has been discontinued by the London porter brewers since the employment of black malt, which is prepared by roasting in such a cylinder as coffee is usually roasted in over a fire. A peculiar flavor has sometimes been imparted by using roasted barley instead of malt. The usual quantity of yeast employed in the London porter breweries is from 5 to 7 tenths per cent. The grist, as it is technically termed, or charge for a mash-tun, is composed of from $\frac{3}{5}$ to $\frac{4}{5}$ pale malt, and the rest of high dried malt, of which about from $\frac{1}{15}$ to $\frac{1}{25}$ black. The oil of birch bark is not used by any respectable brewers in this country. The proportion of hops for double stout is seldom more than 15 pounds to the 8 bushels of malt.

FLAX. The new roving machine, called by the ingenious inventor, Mr. W. K. Westley, of Leeds, the Sliver Roving Frame, seems to be a *philosophical induction* happily drawn from the nature of the material itself, and accommodated to its peculiar constitution. It is remarkable for the simplicity of its construction, and, at the same time, for its comprehensiveness; requiring no nicety of adjustment in its application, and no tedious apprenticeship to be able to work it.

It is known, that the glutinous matter of the plant may be softened by water, and hardened again by heat; of this fact advantage is taken, in order to produce a roving wholly without twist; that is, in the form of a riband or sliver, in which the fibres are held together by the glutinous matter which may be natural to them; or which may, for that purpose, be artificially applied. The sliver roving, as long as it remains dry, possesses all requisite tenacity, and freely unwinds from the bobbin, but on becoming again wetted in the spinning frame, it readily admits, with a slight force, of being drawn into yarn, preserving the fibres quite parallel.

The diagram, *fig.* 190, shows in explanation, that

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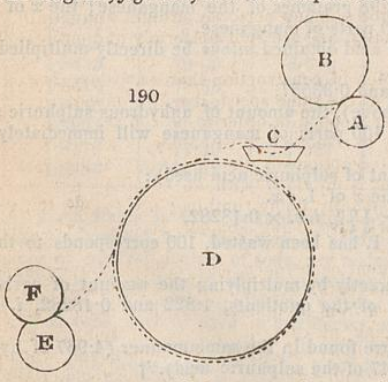

A, is the drawing roller of the roving frame in front of the usual comb.

B, the pressing drawing roller.

C, a shallow trough of water.

D, a cylinder heated by steam.

E, a plain iron roller for winding.

F, a bobbin lying loose upon the winding roller, and revolving upon it, by the friction of its own weight.

The roving, or sliver, as shown by the dotted line, after leaving the drawing rollers A B, passes through the water, in the trough C, which softens the gluten of the fibres; and then it is carried round by the steam cylinder D, which dries it, and delivers it hard and tenacious to the bobbin F, on which it is wound by the action of the roller E.

This is the whole of the mechanism required in producing the sliver roving. All the complex arrangements of the common cone roving are superseded, and the machine at once becomes incomparably more durable, and easier to manage; requiring only half the motive power, and occupying only half the room. A frame of 48 bobbins is only 6 feet long, and affords rovings sufficient to supply 1,200 spinning spindles.

The machine is very general in its application, being equally well adapted for heavy as for fine rovings.

In making a roving in the usual way, the twist, in addition to other circumstances, sets a limit to the degree to which a materal of a given fineness may be roved; because the quantity of twist required to give a roving the necessary cohesion, increases in proportion as the number of fibres composing that roving diminishes, till it accumulates to such a degree, that the fibres are prevented from drawing regularly, or, if drawn, are broken and scattered by the violence of the action. It is impossible, therefore, to make a light roving, good for anything, out of a coarse material; but in the sliver roving, there is no difficulty in making a roving of almost any fineness, with little reference to the quality of the material employed, because, while one fibre can be glued to another by any portion of its extremity, a roving may be made.

It becomes easy, with a sliver roving, to use a double or triple roving on the spinning frame. The great advantage of this practice has long been well known, and acted upon, in the spinning of cotton; but in that of flax, it has hitherto been unattainable: yet the vast benefit to be expected, from doubling on the spinning frame all the equalization of the previous preparation, is too self-evident to be insisted upon.

The sliver roving, made however fine, is perfectly solid, tenacious, and compact; no fibres in it, when once laid straight, can afterward be ruffled or disturbed; and, as they are placed in the yarn in the exact position in which they leave the combs, being kept straight without any ruffling or tangling from twist, the inelastic nature of the material is not injured, and the yarn acquires a superior lustre, roundness, and strength.

The sliver roving is drawn with less force than the twisted roving, and is therefore less liable to make *snarls* in the yarn; while it has another advantage arising from the absence of twist. The fibres of flax and tow being various in length, a uniform twist upon them will naturally retain the longer fibres more effectually than the shorter ones, which will hence have a tendency to run into thick places in the yarn. From this inconvenience the sliver roving is completely free.

In the spinning frame, there is also a benefit derived from the bruising action of the detaining roller: the pressure is supposed to split the fibres laterally, and thereby make them finer, in the same way as a board would be split by being passed through iron rollers, under a pressure; but it is evident that in a twisted roving a portion of each fibre must escape this action, by winding round the body of the roving, and, consequently, the fibres can be but partially split. By this circumstance, in addition to the direct loss of benefit, a new and serious evil is created; a fibre split has always, in the split portion, one end longer than another, and the longest end, of course, arrives first at the drawing rollers. Now, if the fibre be only partially split; if that portion whose end arrives first be not wholly separated from the rest of the fibre; it follows, that when the longer end is seized by the drawing rollers, the shorter end will be drawn into a knot, or thickening; because its fore end is still held back by the adhesion of its contiguous fibres, while its back end is drawn forward, by being still attached to its original fibre. In the sliver roving, the fibres, being perfectly straight and parallel, are exposed to the bruising of the rollers equally, and are split uniformly and entirely from end to end.

The sliver roving, being so much simpler in construction than any other, is capable of running quicker; but if running only at the same speed, it will produce from 25 to 30 per cent. more work, because it is never stopped in order to be doffed. The bobbins are so placed, that the attendant has only to remove a filled bobbin, and replace it with an empty one, without the slightest interruption to the progress of the machine. Owing to this circumstance, the attendant is provided with an easy and uniform employment for her time, instead of occasionally doing nothing, and again hurrying through the labor of doffing; and the work also, being simpler, may be performed by cheaper hands.

It must be noted that doffing is of frequent occurrence, especially in heavy numbers, and occupies much time where one person has to doff a great many spindles, and it is often inconvenient, where other hands are called from their work to assist: but it is not only in doffing that time is lost; it is in wiping, picking, and oiling the numerous flyers and spindles carefully, and which should not be hurried; and, moreover, when the machine requires thorough cleaning, the complication of its mechanism materially increases the loss of time as well as expense; so that the saving effected by not stopping the frame to doff becomes very considerable, and soon repays the whole cost of the machine.

Each bobbin has in fact its own regulating motion, independent of the rest; and this is at all times correct, without requiring any fresh adjustment or adaptation to different thicknesses of roving, enabling the spinner to rove at the same time, on the same frame, as many sorts or thicknesses of roving as there are bobbins in a frame; whereas on the common machine he is compelled to rove but one sort or thickness at a time; and whenever he alters the sort, the mechanism requires a fresh adjustment, involving the chances of error, and attended with loss of time and waste of material.

THE END.