further investigation in the future. So far as carried they open an interesting field for study, and furnish suggestions for a better solution of the telephonic problem.

Stevens Institute of Technology, July, 1887.

VISCOSITY OF LUBRICATING OILS.

THE accompanying sketch shows the form of apparatus used for determining the viscosity of oils by the author's method. A is a Mariotte bottle filled with water, which serves to compress air in the reservoir, B, and to keep the pressure constant. B is connected by means of pipe and cock to the efflux apparatus, H, consisting of the bulb, G, provided with two marks, so that the volume of liquid to be discharged may be measured. E is a capillary tube through which the oil is dis-

charged. By using a series of three capillary tubes with diameters of about 0.5, 0.8, and 1.5 mm. respectively, and comparing the times of efflux of water and 80 per cent. glycerol from the first tube, of 80 per cent. and 100 per cent. glycerol from the second tube, and of 100 per cent. glycerol and a viscous oil from the third tube, the corrected time of efflux of water from every tube may be arrived at without knowing the diameter of the tubes. The time of efflux will thus be in direct proportion to the viscosity. The apparatus may be adapted to a water bath, so that determinations at high temperatures may be made if necessary.—Dr. T. Traube, in *Industries*.

A NEW PROCESS FOR ESTIMATING CARBONIC ACID IN COAL GAS.

THE APPARATUS BEING ALSO APPLICABLE FOR THE ESTIMATION OF AMMONIA AND (POSSIBLY) OF SULPHURETED HYDROGEN.

By JOHN T. SHEARD, F.C.S., Chemist to the Salford Corporation Gas Department.

NUMEROUS as are the methods in use, or that have been proposed, for the quantitative determination of carbonic acid, there is room, I am bold to think, for yet another. Those hitherto most chiefly relied upon are two, viz., the absorption and weighing of the impurity in U tubes charged with soda lime or stick potash, or noting the determination in volume of a measured quantity of gas in a closed vessel after absorption by potash or soda. The latter takes various forms, according to the different kinds of apparatus employed. Of other methods may be mentioned Wanklyn's, which consists in agitating a solution of barium hydrate in a measured volume of gas, and weighing the barium carbonate produced; and a peculiar method, proposed by Heine, founded upon the variations in pressure produced by different gases when exposed to radiant heat in a closed chamber. In a general sense it may be said, with regard to all these various methods, that where accurate they are tedious, and unreliable or inaccurate where expeditious; while in addition to being slow, the most reliable methods—those dependent upon weighing—involve the use of a delicate balance. It has therefore seemed to me that a method based upon volumetric principles of analysis, and thus doing away with the necessity for a chemical balance, and fairly expeditious, while at the same time as accurate (supposing equal care to be exercised) as the more tedious gravimetric methods, must be a desideratum in the laboratory of every well-equipped gas works. Such a method, I venture to hope, will be found in the process which it is the object of this article to describe.

FIG. 1.—VOLHARD'S ABSORPTION APPARATUS.

The novelty of this process consists chiefly in the special form of apparatus employed; but, in addition thereto, some of the details of the method of estimating carbonic acid will, I believe, be found to be such as have not hitherto been taken advantage of for this purpose. It may be stated at the outset that the apparatus is a modification of Volhard's absorption apparatus, which latter is well known in chemical laboratories, and deservedly esteemed. In Fig. 1 two forms of Volhard's apparatus are shown, both of which, but specially the two-bulbed form, I have used now for many years as receivers for absorbing the liberated ammonia in the valuation of gas liquor by the distillation test. For this purpose, attached to the lower end

of an upright worm condenser, it is by far the best form of apparatus I have seen or heard of. At the end of the distillation, the contents of the receiver are titrated direct, without any intermediate washing out; and it is then that the advantages of the apparatus are most apparent. The liquid in the bulbs acts the part of a reserve; so that if, in titrating, apparently too much of the standard alkali is run into the receiver, it may be more than neutralized, on agitation, by the liquid contained in the bulbs. Having experience of the utility of the apparatus in connection with the analysis of ammoniacal liquor, I was led to try its capabilities in another direction, viz., for the estimation of the ammonia and other absorbable constituents of crude coal gas, by causing the gas to bubble through suitable absorbents. On making an experiment with a current of air, holding in suspension a known quantity of ammonia, I proved (what I had indeed suspected would be the failing of the apparatus) that the current of air carried forward mechanically some portion of the liquid from the bulbs, causing a loss of unknown extent, and precluding any possibility of obtaining accurate results by its means. To remedy this defect, I devised an addition to Volhard's apparatus, which constitutes the special characteristic of the apparatus about to be described. This was a continuation of the bulbs in the form of a wide tube, which could be partially filled with glass beads, or other inert substance, on which the drops of liquid carried forward by the current of gas or air might condense and be retained, or flow back into the bulbs beneath.

The improved apparatus, to which I give the name of the "gas absorption tube," and which is shown in Fig. 2, may therefore be described as consisting of three parts, viz., the reservoir, or body of the apparatus, the bulbs, and the scrubber, as the long tube filled with pieces of broken glass, or small glass beads, may be called. The apparatus is made of blown glass, and its total capacity is from 250 to 300 c. c. Not more, however, than about 40 c. c. of liquid, or the contents of rather more than one of the bulbs, can be employed in it for one estimation. When in operation, the pressure of the gas forces the liquid out of the reservoir into the bulbs, and there bubbles through it. To use the absorption tubes, a known quantity and value of the absorbing liquid is run into the reservoir, and a measured quantity of gas caused to bubble through it. The scrubber is subsequently rinsed with pure water, to wash down any portion of the absorbent that may have been mechanically carried into it by the gas; and the whole of the resultant liquid is titrated in the reservoir. As the weight of the scrubber,

FIG. 2.

charged with beads, causes the absorption tubes to have an unstable support, I have arranged for their accommodation when in use a wooden stand, the construction of which is shown in Fig. 3.

The method adopted for the estimation of carbonic acid consists in absorbing it in a solution of barium hydrate of known strength; the resultant liquid being afterward titrated, in order to ascertain the amount of free hydrate remaining in solution, whence the amount of carbonic acid absorbed is deduced. So far the process is similar to Pettenkofer's method of determining the carbonic acid existing in the atmosphere. Instead, however, of employing turmeric paper for indicating the neutral point in the titration (as in Pettenkofer's method), I use a solution of phenolphthalein, which is prepared by dissolving 0.5 gramme of that substance in a liter (1000 c. c.) of 50 per cent. alcohol. In presence of the hydrates of the alkalies and alkaline earths, this indicator gives rise to a beautiful purple-red color, which is destroyed on neutralization of the alkali by an acid. The end reaction is extremely sharp and distinct. Mr. Robert M. Thomson, in a paper "On the Use of Various Indicators," which he read before the Chemical Section of the Glasgow Philosophical Society, Dec. 10, 1883, and which subsequently appeared in the *Chemical News* (vol. xlix, p. 34), has shown that carbonate of barium, precipitated in a solution of the hydrate, does not develop a red color with phenolphthalein, but remains neutral. It follows that, the value of the barium hydrate solution employed being known, a simple titration of the liquid, after absorption of carbonic acid, will show the diminution in the amount of free hydrate present, and, inferentially, the amount of carbonic acid absorbed.

The solution of barium hydrate is obtained by dissolving the ordinary crystallized hydrate of baryta in water to saturation, and siphoning off the clear liquid into a well-stoppered bottle. The strength of the clear liquid is then determined very accurately by titration with decinormal hydrochloric acid, and should be approximately equal in strength to that acid, i. e., if (say) much more than 10 c. c. of the acid are required to neutralize this quantity of the baryta solution, a little water should be added to the latter to bring down its strength. The strength of the solution should be checked by titration from time to time, as, unless very carefully preserved from contact with the air, it gradually loses power through the absorption of carbonic acid.

The measures and standard solutions that I use are those of the metric system, now almost universally employed in chemical laboratories. Accurately graduated vessels on this system, and standard solutions of

definite strength, may now be obtained in most large towns. For the estimation of carbonic acid, in addition to the gas absorption tubes, an aspirator, two 500 c. c. flasks, two 50 c. c. burettes (graduated into 0.1 c. c.), and provided with stopcock and glass float), a supply of soft water free from carbonic acid—which may be insured by boiling the water, and allowing it to cool—and a solution of hydrochloric acid of decinormal strength, are required. Each cubic centimeter of this latter solution is equal to 0.0022 gramme of carbonic acid (CO₂). To obtain the result in the form of grains per cubic foot of gas, or percentage by volume, a calculation is required. This may seem to some of my readers a drawback to the use of a system of measurement founded on the gramme unit, and solutions based on the chemical equivalents of the reagents. It would, of course, be a comparatively easy matter to prepare solutions of such a strength that each cubic centimeter should be equal to a certain percentage, or number of grains per cubic foot, of carbonic acid. But, considering the facility of obtaining commercially the standard solutions described, and their general utility (to say nothing of the inconvenience of having in a laboratory several standard solutions of the same reagent, differing in strength), the advantages more than counter-

FIG. 3.

balance, in my opinion, the slight trouble involved in the very simple calculation that it required.

To make a test for carbonic acid (the gas being free from sulphureted hydrogen), a measured quantity—varying from 15 to 30 c. c., according to the amount of carbonic acid existing in the gas—of the barium hydrate solution is run from a burette into the reservoir of one of the gas absorption tubes, and from 10 to 20 c. c., likewise accurately measured, into another. If the smaller quantities mentioned are employed, an equal amount of the water is added; as the best results are obtained when the lower bulb of the first absorption tube is quite filled with liquid, as the current of gas bubbles through it. About 30 c. c. is, therefore, the proper charge of liquid. If much more than this is employed, it is liable to be carried forward into the scrubber. The absorption tubes are placed in the stand, and the apparatus connected up by means of India rubber tubing and stoppers pierced by glass tubes; the inlet of the first tube being connected to the gas supply, and its outlet to the inlet of the second tube; the outlet of the latter being connected, in its turn, to the inlet of the aspirator. In connecting the gas supply tube to the inlet of the first absorption tube, gas must first be allowed to blow away, and the India rubber tube pushed over the bent glass tube while the gas is issuing; care being taken that the pressure of the gas supply is not so great as to force its way through the liquid in the bulbs, without the aspirator being in operation. All being now in readiness, the measuring flask is brought under the tap of the aspirator, and water allowed to flow, so as to draw the gas in bubbles through the liquid in the bulbs. After making sure that the connections are gas tight (which is done by turning off the gas supply and the tap of the aspirator, and observing whether the level of the liquid in the bulbs remains stationary or not) the current of gas is continued until 500 c. c. have passed, as shown by the water that is run out of the aspirator. (The best speed of current, I find, is obtained when the flow of water from the aspirator is adjusted to the point at which it breaks from a series of drops into a nearly continuous stream. The gas supply is then disconnected from the inlet to the first tube—which is best done without stopping the flow of water, by slipping off the India rubber gas tube as the water in the flask passes the mark—a fresh flask brought under the aspirator, and a further quantity of 500 c. c. of air drawn through the apparatus, in order to drive forward the gas remaining in the reservoirs of the two absorption tubes at the end of the first aspiration. The tubes are afterward disconnected, and a little water (free from carbonic acid) run through the scrubbers, in order to wash down any of the barium hydrate solution that may have been carried forward mechanically by the gas. A few drops of phenolphthalein solution are added, and the liquid is titrated

FIG. 4.

with decinormal hydrochloric acid; the point of saturation being shown by the disappearance of the purple color imparted to the liquid by the phenolphthalein. (In titrating the carbonated liquid, the acid must be added a little at a time, and allowed to run down the sides of the reservoir, not dropped directly into the liquid; the liquid being gently agitated after each addition of acid.) The difference between the quantity of free barium hydrate found at the close of the experiment and that which was run into the tubes at its commencement shows the bulk of carbonic acid absorbed; and from this the amount of the latter impurity existing in the gas may be calculated into grains per cubic foot or percentage by volume.

Example.—Two gas absorption tubes were charged, the first with 30 c. c. and the second with 20 c. c. of barium hydrate solution, and 500 c. c. of gas, followed by an equal quantity of air, drawn through them in the manner above described. After rinsing the scrubbers with water, and adding phenol-phthalein, the liquid in the tubes was titrated; 21.6 c. c. of decinormal hydrochloric acid being required to neutralize that in the first tube, and 21.4 c. c. for the second. The titre of the barium hydrate solution employed being 1 c. c. = 1.09

N
c. c. — acid, therefore :

	First Tube.	Second Tube.
Equivalent of barium hydrate employed	32.7 c. c.	21.8 c. c.
N — acid required to neutralize		
10		
resultant liquid.....	21.6 "	21.4 "
Equivalent of barium hydrate neutralized.....	11.1 c. c.	0.4 c. c.
$100 \times 0.0022 \times 11.5$		
0.914		

(the weight of 500 c. c. of CO₂ saturated with moisture), which may be shortened to $11.5 \times 0.241 = 2.77$ percentage by volume of carbonic acid; or $11.5 \times 1.92 = 22.08$ grains of carbonic acid per cubic foot of gas.

The entire operation, from its commencement to the end of the titration, occupies not more than 15 or 20 minutes; and with duplicate apparatus two tests can, of course, if necessary, be kept working simultaneously.

It will be obvious, from what has gone before, that the gas absorption tubes may be used in a similar manner to their employment in the carbonic acid estimation, and with equal advantage, for the estimation of the ammonia existing in crude gas. For this purpose, decinormal sulphuric or hydrochloric acid is required as the absorbent, and a solution of pure ammonia, of corresponding strength, for the subsequent titration—the indicator being cochineal. Operating upon a comparatively large volume of gas, they may also be applied to the determination of the minute quantity of ammonia sometimes present in purified gas. I am in hopes that it will further be possible, by means of the absorption tubes and a suitable absorbent, to estimate the sulphureted hydrogen in unpurified gas with the same ease, and as great accuracy, as in the case of carbonic acid. This, however, I have not as yet been able to establish. I have tried a dilute solution of iodine; but with disappointing results. Arsenious acid in hydrochloric solution may perhaps answer; but I have been unable up to now to put it to the test. As opportunity serves, however, I shall make further experiments in this direction. If a suitable absorbent for sulphureted hydrogen, neutral to carbonic acid, can be found, the gas absorption tubes will furnish a most valuable means of estimating readily, in one operation, the three chief removable constituents of crude gas—a consummation not only "devoutly to be wished," but of imperative necessity, if the era of ammonia purification is fully to come.

There remains only to add that the gas absorption tubes were supplied, to my instructions, by Messrs. Mottershead & Co., laboratory furnishers, of Manchester, and that their cost is very slight. The entire outlay (including the provision of burettes, reagents, stand, and other apparatus necessary) need not be more than about 30s.—*Jour. Gas Lighting.*

EXPERIMENTS WITH KITES.

WITHIN a few months of sixty years ago, I made use of kites with a scientific object in view. It was then a question of electric researches, and I had read my first paper to the Institute during the course of the year, and showed therein that the current produced by electrical machines, Leyden jars, and even the electricity of the clouds, was capable of deflecting the magnetic needle and of establishing a relation between the effects of the Volta pile and the electricity produced by friction, or even that of the clouds.

In the fall of 1827 I came to Switzerland, bringing my galvanometer with me, and renewed my experiments in perfectly calm and rainy weather. After ascertaining that in calm weather it suffices to ascend about 325 feet in order to have visible and tangible signs of positive electricity, and after showing that the tokens of electricity upon a mountain are sensibly the same as they are 2,300 feet lower in the plain, and that they have the same intensity, I endeavored in rainy weather to measure the electricity of the clouds, and for this purpose undertook to reach an elevation of a thousand feet above ground. I made these experiments with kites of medium size, formed of canvas and provided with conductors of silver wire running round the cord; but, rather than construct a kite of extraordinary size, I used three kites attached in succession, one back of the other. In fact, if we give a kite more cord than it can lift, it goes forward well, but it no longer rises, and the cord drags on the ground. But attach the kite to another one, and the second will rise to double the height of the first, and a third kite attached to the back of the second will treble the height. I thus reached an elevation of nearly a thousand feet with a conducting cord.

These experiments have to be performed with caution if one wishes to keep from getting struck by lightning as Reichmann was. I performed these experiments at the country seat of a relative near Geneva, and, knowing the subject, I had taken care to bury in moist earth a bar of iron that extended up to the window, where it ended in a ball. I operated in a large room having high windows. I paid out the cord with a glass windlass, and finally attached my kite with a long silk cord in the room, allowing the sparks to jump from the ball at the end of the cord to the one connected with the earth, which they did with a sound like that made by a small pistol. I then had a beautiful spectacle that filled me with enthusiasm. It did not thunder out of doors, but the electricity led by the cord, which was in all 1,300 feet in length, continuously escaped and produced sparks ten feet in length that formed zigzags and were white, red, and violet in color.

I ran to look for my relative, in order to have him enjoy the spectacle but he was more than seventy years

of age, and saw with eyes different from mine. He did not understand electricity, and thought that his house was in danger from the lightning, as it had no lightning rod, and he begged me to stop the experiment. Fortunately I had had the time to see what I wished, and I put an end to the experiment and my relative's

which, after serving as a motor to carry up the tube and basket, unhooked, leaves the kite, and, acting as a parachute to the basket, slowly descends.

To this effect, a wire, *ee'*, properly bent, serves as a point of suspension, and, on reaching the stop, B, placed near the kite, unhooked itself. After this, the

FIG. 1.—EXPERIMENT WITH A KITE.

fears. In the summer of 1844, I was a neighbor, at Cologny, near Geneva, of my brother-in-law, Mr. Perier Ador, who had passed his youth in England, and made commercial studies there. Married in Switzerland in 1841, he had left his commercial career to devote himself to the study of infusoria, and then, as a pastime, he had amused himself in constructing an immense kite having a surface of about four feet. The kite was of canvas, with a frame of bamboo, and was provided with a nine hundred foot cord made especially for it. With it Mr. Ador amused himself in sending

FIG. 2.—DETAILS OF A DUMMY MAN RAISED BY A KITE.

baskets of flowers and fruit to his relatives in the vicinity.

Every one is acquainted with those little cardboard disks called messengers that are placed on the string of a kite, and, thrust by the wind, rise, and do not stop till they reach the upper end of the string. It was with a device on the same principle, but one that could detach itself, that Mr. Ador sent up his baskets. To this effect, he constructed parachutes that he sent up along the cord tautened by means of an ingenious apparatus which, on arriving within two or three yards of the kite, unhooked itself with the motive apparatus that

FIG. 3.—PARACHUTES FOR A KITE.

served as a parachute. The device is shown in Fig. 3. A A A is the cord of the kite. C C I is an apparatus composed of a tube designed to ascend along the cord, and the appendage, I, of which serves to hold both the basket of flowers or fruit and a kind of parasol,

tube, being no longer held by the parasol, H, runs down the cord.

This experiment suggested to me a bolder one, and that was to send up the figure of a man of natural size seated upon a chair and drawn by an umbrella that had the appearance of shading him from the sun.

The figure weighed a little less than thirteen pounds, and I prepared it as follows: An eider-down coverlet weighing about a pound was inclosed in a blouse and placed upon a Florence chair weighing four and a half pounds. A head with a mask, a colored handkerchief, and a hat were added. The figure had two arms sewed in the blouse, and these were crossed upon the breast, while the hands held a huge umbrella which was to serve as a motor, and the ribs of which were strengthened so that the umbrella could not be turned inside out. Two legs represented by light boots were attached to the chair, and the whole was very well arranged. One day, when the wind was blowing with violence, I brought out my man duly harnessed to the chair. We used two tubes, one for the upper part of the body and the umbrella, and the other for the chair, as shown in Fig. 2, where AA is the taut cord, B and C are the two tubes just mentioned, H D I are the points of attachment of the chair, and E is the open umbrella, whose position is such that it serves as a propeller under the wind's action. Upon the latter's producing its effect, the figure was raised to a height of 650 feet, to the great amazement of the curious, who abounded on the road. A stage coach which was passing stopped for some moments, and a goodly number of the curious took the dummy for a genuine man (Fig. 1). In the former experiment, the baskets always arrived in the same direction. I proposed to Perier to send the balloon to the right or left at will, and I set about it in this way: If the belly band were shifted a little to the left in a kite, the latter would deviate to the left; and if it were shifted to the right, the kite would deviate to the right. If we had a double belly band out of center and a double cord, and a stop that would not permit of exceeding certain limits, the kite might be able to deviate a third of the length to the right and a third of the length to the left, and we would thus have with 900 feet of cord a kite that could vary 300 feet to the right and 300 to the left, and would obtain a divergence of 600 feet. This experiment succeeded well, and we were enabled to reach points whose distance at right angles with the direction of the wind varied about 600 feet. As Cologny was only 325 feet from the lake, we projected the construction of a kite to be sent across the latter. To this effect, we constructed a kite of ordinary size—

FIG. 4.—A PROPOSED FLOAT FOR BALLOONS.

of about half the dimensions of the large one—and, with the double belly band, we made it draw to the right to traverse the lake, and we added to it a float that was to serve to hold it in the wind and at the same time retard it. We had a board that did the retarding