THE GLOVER TOWER AND THE WORKING OF SULPHURIC ACID CHAMBERS.

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It may be conceded that systematic observation, with proper qualification of observers and sufficient means, is a never-failing source of improvement.

In the mechanical and chemical arts this continues to be true where development is well advanced no less than during the early stages of development.

The construction of tower which I submit to the notice of the Section admits of the widest application in the chemical arts, but for the present I speak of it only as applied to the Glover and Gay-Lussac towers in the working of sulphuric acid chambers.

Last year, Mr. Henry Bower, the president of the Chemical Section, went to inspect some improvements I had made in the construction of towers and sulphur burners. In a conversation I had with him at the time, he remarked that there was a lack of mathematical precision in the action of all towers in use. A tower might work well or it might not work well. There were no means known by which it could be definitely determined beforehand that a tower would work in a precise manner after it was constructed; and when once constructed there was no directional control over its working. I showed him what I had done in the way of constructing towers designed, at least, to work with exactness.

I also pointed out a line of experiment by means of which, if not exactness, at least great improvement would result. I invoked Mr. Bower to use his influence with the Manufacturing Chemists' Association to induce it to undertake the burden of conducting the experiments. I have not since heard from him.

It is a fact that many Glover towers, especially, do not act in the smooth, efficient way of denitrating nitrous vitriol mentioned by Lunge. Where the acid from the Glover tower is used in the manufacture of alkali, the occasional presence of a small quantity of N_2O_3 is not observable, and even in larger amounts not prejudicial; but where the acid is used in other branches of manufacture, as is exclusively the case in America, such as the manufacture of alum, chlor-

hydric acid, etc., the presence of a small amount of nitrous acid becomes seriously manifest, as more than one manufacturer has found.

It was just such manufactures as these, where even traces of nitrous acid were prejudicial, that led me to seek a method by which certainty of denitration in the Glover tower could be insured.

Fig. 1.

that under the best circumstances $2\frac{1}{2}$ per cent. to $3\frac{1}{2}$ per cent. of nitrate of soda were required to maintain the waste of nitre going on in the chamber process. Little or no nitrous acid would be found in the acid from the tower, while the amount of nitrate potted was small, below 3 per cent.; but when the percentage was increased from any

The incentive to seek in this direction was increased by the fact

cause, such as starting up after stoppage, the acid from the tower would contain very sensible quantities of nitrous acid, and the chamber process would be robbed of "nitre" by so much as went to injure the manufacture in which the acid was used. Loss of "nitre" elsewhere in the process could be accounted for and controlled. In each case brought under observation, the re-absorption of nitrous acid at the bottom of the tower was found to be due to mechanical causes originating in the defective construction of the Glover tower. One of these towers was supplied with burner gas through a pipe of 900 inches sectional area. The gas entered underneath an arch perforated with sixteen holes having an aggregate area of 260 inches, and the whole of the gas from the 900-inch pipe had to pass through these holes.

Interior observations were made of the descending acid and the ascending gases while the tower was at work, with simultaneous observations in the chambers and analyses of the acid coming from the tower. The object was to determine connection between mechanical conditions and chemical results.

The chambers connected with the tower had 88,000 cubic feet capacity, not counting towers nor draught pipes. The chambers having been stopped for repairs, were started with 4,320 lbs. seconds sulphur in 24 hours and 10 per cent. of nitrate. Acid began to form at once in the tower, but the chambers were slow in getting into condition, and the acid running from the tower was found to contain nitrous acid equal to 4 per cent. of the nitrate of soda potted. An assay of this acid was made every hour, and this and all other observations recorded. At the proper time the nitre potted was decreased, and Gay-Lussac and chamber acid run on, maintaining between the two as nearly as could be 10 per cent. of nitre.

The charge by potting was reduced to $2\frac{1}{2}$ per cent., and it was not until then that the acid from the tower ran free from nitrogen oxides, and if at any time afterwards the charge of nitre by potting was increased beyond 3 per cent. or $3\frac{1}{2}$ per cent., the acid from the tower was found to contain "nitre."

The acid in the tower was observed to descend in large drops and broken streams. These results were arrived at:

1. The acid distributed in the upper portions of the tower was collected into streamlets in the lower portion.
2. The acid in drops and streamlets, and in proportion to the volume of the drops and streamlets, is in a condition more favorable for the

absorption of nitrous acid than it is for denitration by sulphurous acid.

For comparison afterwards I state results of working these chambers for one whole year.

Chamber space per lb. sulphur, 20·37.

Nitrate of soda potted, 2·8 per cent.

By the rule in Mr. H. Pemberton, Jr.'s paper, the case stands thus :

$$10 \times 20\cdot37 = 203\cdot7$$

instead of 280 to 300. The yield of H_2SO_4 was 288 per 100 sulphur consumed.

Mr. Pemberton, Jr., omitted to state this last result in the enforcement of his rule.

Fig. 2.

Being called upon to design and construct a Glover tower for another set of chambers, of 148,000 cubic feet capacity, I determined to avoid most of the defects observed in towers previously constructed. With this object, I had recourse to a device which I had designed some years before. This was to dispense with the arch entirely, with its disadvantages of contracted apertures and heavy side thrust, and also to avoid the use of lead covered bearings. This latter plan is quite inadmissible in the construction of the Glover tower, although I have heard of Glover towers being so constructed, with what result I never heard ; but to run such a tower dry, even for never so short a

time, must result in disaster. Lead covered iron bars are bad, as I have seen, because the acid trickling over the lead wears grooves in it and eventually exposes the iron to destruction.

It will be seen from the accompanying sketches that my device is something in the form of a Gothic arch, forming a large chamber at the bottom of the tower, and so constructed that the whole weight of the contents of the tower rests upon the bottom. It will be seen from Fig. 2 that the bond of the tower, with the pipe, effectually protects the lead from the action of the hot burner gas, if at any time the tower has to be run dry. If one stands inside the chamber. Fig. 1, he can see that some hundreds of apertures are provided for the ascending gases, and that the descending acid can nowhere form a drop or a streamlet. It must of necessity form an extremely thin and continuous film over a very extensive surface.

Thus the conditions observed in the tower before described are reversed in this tower.

1. The acid distributed in the upper portions of the tower are still further distributed at the bottom.

2. The acid in a thin film is in a condition more favorable for denitration by sulphurous acid than it is for the absorption of nitrogen oxides.

In these chambers 7,250 lbs. sulphur were used, and 10 per cent. nitrate of soda, 8,400 lbs. sulphur for a time was used, with nitrous vitriol and pot charges equal to 11 per cent. to 12 per cent. nitrate.

The pot charges of nitrate were decreased to 3 per cent., 2 per cent., $1\frac{1}{2}$ per cent., 1 per cent., and $\frac{3}{4}$ per cent. The acid running from the tower was frequently assayed, and from the first no trace of nitrous acid was found.

Taking a month's run of 30 days, 217,500 lbs. sulphur were burned, and 2,466 lbs. nitrate of soda potted. This gives a chamber space of 20.4 cubic feet per lb. sulphur burned, and 1.13 per cent. nitrate of soda potted.

The daily test of nitrous vitriol for the month showed that the average supply to the chambers from potting and nitrous vitriol combined was equal to 10.11 per cent. nitrate of soda.

$$10.11 \times 20.4 = 206.24.$$

The yield of H_2SO_4 for a whole year was 300.48 from 100 sulphur. But the average consumption of nitre for the year was 1.48 per cent.

This result was traceable to three causes :

1. Perfect absorption in the Gay-Lussac tower.
2. Perfect denitration in the Glover tower.
3. Practically eliminating the influence of some of the most serious causes of disturbance in the chamber process, viz., high and variable winds, gusts of wind and the states of the atmosphere indicated by the barometer.

In another set of chambers of 98,692 cubic feet capacity, working without Glover or Gay-Lussac towers, 4,320 lbs. sulphur were used in 24 hours with a consumption of 8 per cent. nitre. This gives a chamber space of 22·8 cubic feet per lb. sulphur. Where 4,800 lbs. sulphur were used, giving a chamber space of 20·5 cubic feet, 10 per cent. nitre had to be used. The yield of H_2SO_4 for one whole year was 294·24 per 100 sulphur.

By the rule of Mr. H. Pemberton, Jr., the case would stand thus :

$$8 \times 22\cdot8 = 182\cdot4$$

$$10 \times 20\cdot5 = 205\cdot$$

$$\text{Mean, } 192\cdot7$$

And Mr. Pemberton's rule that percentage of nitre multiplied by chamber space shall equal 280 to 300, giving a mean of 290, when applied to chambers in which sulphur is used, is wrong by just this difference of one-third. The rule applies, and is followed when pyrites is used instead of sulphur, for making sulphuric acid, as then the chamber space is virtually reduced one third on account of the introduction of atmospheric nitrogen through the combustion of the Fe into Fe S_2 simultaneously with the combustion of the S_2 . The rule when applied to the use of sulphur, is a very safe one to follow, as respects yields, as it should give the best results even where skill is not the best, but where the best return for outlay of capital upon sulphuric acid chambers is sought, that is dollars and cents, the chambers will have to be worked by another rule, viz., the product of the percentage of nitre by the number of cubic feet of chamber space per lb. sulphur burnt in 24 hours shall equal 200.

I hope, with Mr. Pemberton, that others will give the result of observation and experience in this matter.