at least 10 per cent. per annum, and the stock of the company costs nearly double of the paid sum.

The line of the Niphon Railway Company extends from Tokyo on one side to Maebashi, which is the center of silk districts in Japan, and on the other to Awomori, which is an important harbor situated on the northern extremity of Honshin (or the main island). From the latter line there is a branch to Nikko, which is famous for beautiful natural scenes and splendid temples, being remains of shrines of ancient Shōgun Tokugawa.

Besides the Niphon Railway Company there are other companies, known as Sanyō, Kiushin, Kansei, Sangū, Iyo, Isaka Hankai, Kōbu, Ryōmō, Mito, Sōbu, Tankō railway companies, etc., having their lines from 20 to 200 miles long.

In addition to the lines already completed and working, there are projects both in government and private railways to prolong the lines. Since last year proposed new lines of more than 2,000 miles in length were surveyed and estimated. It was decided by the House of Commons to construct the Fukushima Awomori section and the Tsuruga-Toyama section, which has 414 miles in both. The capital for constructing the two lines decided by the Parliament is $18,451,080, which is the amount decreased about 20 per cent. from the estimates made by the government engineers. These railways are, of course, important for internal communications and transportations, and will be very much more so if the Siberian Railroad would be completed.

The gauge of Japanese railways is 3 ft. 6 in. The steepest gradient is 1 in 40, and the shortest curve is 15 chains radius. For the Usui toge Railway, between Yokokawa and Karuizawa, in Takasaki and Naoyetsu section of the Imperial Government railways, the Abt system of permanent way was adopted, and the gradient is mostly 1 in 15. The length of the Abt system of permanent way in that section is 5 miles 6.45 chains, in which there are 26 tunnels from 107 ft. to 1,803 ft. long, the total lengths amounting to 2 miles, 61.882 chains. This section between Yokokawa and Karuizawa (7 miles long) was completed in February of this year, and it was opened for traffic on the first of last April, while the sections on both sides of Usui-toge were opened eight years ago.

The weight of the Abt system locomotive is 35 tons, which can draw 100 tons of loads in the steep incline. Most of the locomotives of Japanese railways are of English manufacture, but some American and German locomotives are used. There are also locomotives of Japanese make, which were built in the Kōbe Locomotive Works of the Imperial Government railways.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

Chemistry Applied to Railroads.

SECOND SERIES.—CHEMICAL METHODS.

II.—METHOD OF DETERMINING CARBON IN IRON AND STEEL.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(*Continued from page 399, Volume LXVII.*)

The double chloride of copper and potassium solution is made by dissolving 10 lbs. of the commercial salt in 13 liters of water, filtering through ignited asbestos, and adding 1 liter of concentrated C. P. hydrochloric acid (sp. gr. 1.20).

The caustic potash solution used both in the purifying potash bulb and the absorption potash bulb is made by dissolving 1 lb. of commercial stick caustic potash in a small amount of water, and then diluting until the resulting liquid when cold shows a specific gravity of 1.27. A pound of potash makes about a quart of solution.

The granulated oxide of copper may be made by igniting the nitrate in a Hessian crucible until nitrous fumes cease to come off, but not fusing the material, or may be obtained in the market. If the ignition of the nitrate is properly conducted, a porous granular material is obtained, which gives very satisfactory results. Most of the material in the market has been fused and is very dense, and liable to contain impurities. We regard it essential, therefore, to place this fused material in the preheating and combustion tubes, as described, fitting them at the exit end with a small jet tube, then place in the furnace and reduce with hydrogen gas. It is essential during the reduction that the tube where the oxide of copper is should be heated to a full red heat, and in order to insure complete reduction, the gas should be passed for half an hour after it will burn at the jet. This being accomplished, allow the tube to cool and then replace the hydrogen with air, then heat up again, and pass oxygen gas until the reduced material is oxidized, which will take some time. The use of coal gas in place of hydrogen for the above reduction is admissible, provided the porcelain tube is heated two burners more each way, during the subsequent oxidation, than during the reduction in order to burn out any separated carbon that may have deposited in the tube.

The silver foil may be easily obtained in the market.

The acid ferrous sulphate solution is made by dissolving crystallized ferrous sulphate in water to nearly a saturated solution, and adding three or four drops of sulphuric acid to every 50 c.c.

The sulphate of silver is made by precipitating nitrate of silver with carbonate of soda. Filter and wash thoroughly. Then place the precipitate in the vessel in which it is designed to keep the salt with a little water, and then add sulphuric acid at last, drop by drop, with thorough agitation, until all the carbonate is decomposed and the liquid is clearly acid to test paper. In filling the bubble tube shake the vessel and pour in enough of the milk to have ½ in. of the solid salt in the bottom when it has settled, and then fill the bubble tube about half full of water. If care is taken to wash the carbon in the boat thoroughly, once filling of the sulphate of silver bubble tube will be sufficient for 30 or 40 combustions. Sulphate of silver may be obtained in the market, but we have no experience with this material.

The granulated chloride of calcium used in the chloride of calcium tubes and prolong is obtained in the market. We use the grade marked C. P., and like to have it as free as possible from other substances. The size we prefer is what will pass through holes about a tenth of an inch square and not pass through holes a twentieth of an inch square. Before filling the chloride of calcium tubes it is essential to dry the material, best in a platinum dish over a Bunsen burner for 20 minutes or half an hour, taking care, however, not to fuse it. Of course the chloride of calcium used should not be alkaline, but for fear that it will be sufficiently so to absorb carbon dioxide, even if not sufficiently so to show by test, it is recommended to pass dry carbon dioxide into each freshly filled chloride of calcium tube and allow it to remain over night, and then replace with dry air, before using such tubes in actual work.

The oxygen gas used may be obtained in the market in cylinders compressed to almost any desired pressure. We transfer to the small gas holders shown in the cut, rather than take the gas direct from the cylinders, since the gas holders can be adjusted to give uniform pressure in the tube. This commercial material may be contaminated by oil or vapors containing carbon from the pump used in compressing it, and we accordingly deem it essential to pass it through the preheating tube, as described, before it goes into the combustion furnace.

After the combustion train is arranged, as above described, it is essential to see that there are no leakages, and to make not less than two blank combustions. For the first of these, close the connection from the gas and air holders, and then open the cock controlling the flow from the aspirator bottle, which has been previously filled with water. This puts suction of a column of water 12 to 18 in. high on the train, and is abundant to indicate any leaks. After the suction has had time to act on the whole apparatus, and come to rest, it is satisfactory if nothing passes the absorption potash bulb for five minutes. If this result does not follow, the leaks must of course be found and stopped. The combustion train being found tight, the two blank combustions should be made in every respect as though they were real ones, except, of course, no iron or steel should be put in the dissolving jar. If these blanks change the weight of the absorption potash bulb and prolong more than about 1 milligram, something is wrong, and the apparatus and chemicals should not be regarded as satisfactory, until one or more blanks are obtained, which come within the limit above mentioned. In this connection the paragraph below on necessary errors should be read.

CALCULATIONS.

Since the carbon is weighed as carbon dioxide, and since $\frac{3}{11}$ of the carbon dioxide is carbon, the percentage of carbon in the iron or steel under test may always be found by the following formula : $a : 100 :: \frac{3}{11} b : x$ in which a represents the amount of iron or steel taken, expressed in grams ; b the increase in weight of the absorption potash bulb and prolong expressed likewise in grams, and x the carbon sought. This proportion reduces to the form $x = 300b \div 11a$, and when 3 grams are used to start with, it becomes $x = 100b \div 11$. When 3 grams are taken to start with, this may be briefly stated as follows : Express the increase in weight of the absorption potash bulb and prolong in grams, move the decimal point two places to the right, and divide by 11. The result will be the percentage of carbon in the sample. Thus if the increase in weight is 0.1661 gram, the carbon will be (16.61 ÷ 11) 1.51 per cent.

NOTES AND PRECAUTIONS.

It will be observed that this method releases the carbon from the iron or steel by dissolving the metal in an acid solution of the double chloride of copper and potassium, and after filtration and thorough washing burns the carbon in a tube in oxygen gas, and after freeing the carbon dioxide formed from impurities, catches it in caustic potash solution, the amount being determined by the increase in weight of the absorbing material.

There is much reason to believe that many discrepancies in duplicate analyses, as well as between different chemists, are due to the borings or drillings. The place from which the drillings are taken ; the size of the drill : the depth of the hole ; whether it goes through the sample or not, and especially whether the drillings are partly coarse and partly fine, are all believed to have considerable influence on the final result. This difficulty will be diminished (1) by drilling the hole as near through the sample as practicable ; (2) by having this hole transverse to the line of final solidification, and cutting it, and (3) by having the drillings as fine as possible, and thoroughly mixing them. This latter precaution—viz., to have the drillings fine, is also important in its influence on the rapidity of subsequent work.

The use of acid, and the use of the potash double salt, rather than the ammonium double salt to dissolve the metal, both of which differ from old practice, are copied from the work of the American Committee on International Standards, for the analysis of iron and steel. It will be remembered that the work of this committee seemed to show very conclusively that these changes led to much more accurate results.

If the solution contains more of the double salt than is recommended above, solution will not be so rapid. A saturated solution works very slowly.

The influence of stirring on the rapidity and completeness of solution is very great. With the stirring apparatus recommended above, if the borings are fine it is not at all rare, especially in the case of steels, to get such complete solution in 15 to 20 minutes that but little more than a stain is left on the asbestos filter in the boat after the combustion is finished.

In washing the carbon in the boat, after it is transferred from the beaker or dissolving jar, loss of substance is apt to result, if the jet from the wash bottle is used direct. It is better to always put the liquids into the beaker or dissolving jar, and then pour them into the boat. Too great care can hardly be taken to wash thoroughly. A little sub-chloride of copper or a little chloride of iron left in the asbestos filter, or in the boat, may cause difficulty in the combustion tube later on.

The carbon from some steels, and in general from pig iron, filters readily like sand, but from other steels it seems to separate in such a form as to clog the filters badly. This gelatinous carbon does not seem to be characteristic of any special kind of steel, but may occur in any. We know of no way to facilitate filtration in such cases, except to follow the directions closely.

In drying the carbon in the boat too high temperatures should be avoided. There are indications that loss of substance may result from neglect of this precaution, although we have not positively demonstrated this.

The use of the preheating furnace complicates the train somewhat, but no other method of freeing the oxygen gas from possible injurious impurities has proven so successful in our experience as this one. It is clear that if there is anything in the gas that would react with oxygen or with oxide of copper in a red-hot tube, and later be absorbed by caustic potash, this material must be removed from the gas by the preheating furnace and purifying potash bulb before the gas goes into the combustion tube. Purifying the oxygen gas without preheating does not seem so satisfactory.

The use of rubber corks and rubber tubes is open to some objection, but we do not know of any successful substitutes for these materials.

The combustion tube we recommend is longer than customary, but we think not longer than essential. The danger of volatile matter from corks affecting the result is considerably diminished by this additional length. We prefer the porcelain tube, although we have never used platinum ones. Tubes of larger bore enable a little larger boat to be used, but they are much slower to heat, and do not in our experience give any more reliable results.

The use of a roll of fine copper gauze in the combustion tube in place of granulated oxide of copper has been recommended. In our experience it is difficult to be sure that the metallic copper is all oxidized before regular work is begun. If this is not so, and if the metallic copper contains any carbon, there would of course be danger of error, due to the slow progressive oxidation of the metal and carbon during combustion.

Many devices have been suggested to prevent the possibility of hydrochloric acid, chlorine or chlorine compounds, which may be formed in the tube during combustion from reaching the absorption potash bulb and thus introducing error. We have tried many that we have seen suggested, but have found none that seem so efficient as the roll of metallic silver foil. If proper care is taken in the washing of the carbon, if the tube is arranged as described, and in good order, and if the rate of movement of the gases is not too rapid, neither chlorine nor hydrochloric acid escape from the tube. If, however, the washing is incomplete, leaving some sub-chloride of copper or ferrous chloride and free hydrochloric acid in the boat, which latter is not expelled by the drying ; if the tube is foul from having been used for many combustions, without cleaning and recharging, or reduction by hydrogen, and especially if the combustion is hurried, resulting in a too rapid movement of the gases in the tube, the silver roll may not be a complete protection. We accordingly introduce into the train an acid ferrous sulphate, and a silver sulphate bubble tube as additional precaution, the former to catch chlorine and the latter hydrochloric acid. Direct experiments with each of these tubes separately show that they are a complete protection against the gases mentioned, provided the rate of movement is not more than four or five bubbles a second, and also provided the amount of these gases is not greater than would arise in even the rather carelessly managed combustion mentioned above. Of course it may be questioned whether these two bubble tubes do not retain carbon dioxide and thus cause error. Direct experiments made by taking a weighed potash bulb and prolong, properly filled with water, protecting it with chloride of calcium tubes at each end, and charging it full of carbon dioxide, and reweighing and then aspirating air through it with frequent weights during the aspiration show that a very much less amount of air than that used for aspiration in a regular combustion is sufficient to remove the carbon dioxide completely from the amount of liquid in the bubble tubes.

It is highly desirable to pass hydrogen or coal gas, preferably the former, through the combustion tube, as described above, after a tube has been used for 50 or 60 combustions. In lieu of this, the tube should occasionally be cleaned out and filled with fresh material. The frequency with which either of these should be done depends largely on how completely the carbon is freed from other substances during the solution, washing and drying.

A slight pressure in the tube is thought to be less liable to lead to error from leakages than to have a vacuum in the tube, caused by drawing everything through the train by means of the aspirator bottle. It will be observed that the pressure specified is equal to about half the column of water in the first bubble tube. From this point the aspirator bottle is relied on to move the gases forward.

The combustion tube should always be kept closed, and after a combustion is finished, the connection between the air gas-holder and the train should be left open, or the liquid in the bubble tubes will suck back into the combustion tube as it cools. We also deem it essential after the furnace has been standing idle some time to make a blank before proceeding with regular work in order to be sure that everything is right.

It is quite essential that the chloride of calcium tube which precedes the absorption potash bulb and the prolong should dry the gases to the same extent and no more. If one is more efficient than the other error may result. Thus if the gases which go into the absorption potash bulb are drier than they are after they leave the prolong, it is obvious that moisture that has been weighed is lost. On the other hand, if the gases that go into the absorption potash bulb are not as dry as when they leave the prolong, it is equally obvious that something besides carbon dioxide has increased the weight of the absorption potash bulb and prolong. It seems probable that some of the difficulty in getting absolute blanks may be accounted for in this way. It is a little hazardous to use a freshly filled chloride of calcium tube with an old prolong, and *vice versa*.

Likewise it is not advisable to use sulphuric acid or other means of drying the gases between the furnace and the chloride of calcium tube.

It is not necessary to recharge the absorption potash bulb for each combustion. Depending, of course, on the amount of carbon in the sample, they may be used for from three to six or eight combustions without recharging. We have made agreeing duplicates on the same sample, one with a potash bulb, freshly charged, and the other with a potash bulb, showing a cloudiness in the first bulb due to bicarbonate.

The weight of the potash bulb and prolong before and after the combustion is affected by a number of circumstances other than the carbon dioxide absorbed. It is obvious that if all the conditions are the same at the second weight which prevailed at the first, there is no error due to weighing. But it seems to be difficult to get these conditions exactly the same. Temperature, barometric pressure, the deposit of something from the air of the laboratory, or from the fingers on the parts weighed, and especially the humidity of the air may all be different at the second weighing than at first. If we may trust our experience, it is almost impossible to make satisfactory combustions in showery weather.

Where combustions are made in large numbers, say 16 to 18 a day, by one operator, with two furnaces, very satisfactory results may be obtained by weighing direct from the furnace, finishing the aspiration with oxygen instead of air, and using the last weight of one combustion as the first weight of the next one. Of course in very critical work this procedure should not be thought of.

Direct experiments show that with the apparatus arranged as above, the oxygen in the potash bulb and prolong is all removed by air during aspiration, when about 800 c.c. of water has been run out of the aspirator bottle. The experiments were made by weighing a potash bulb and prolong, introducing it in the train, passing oxygen until it was filled, then reweighing and then aspirating air with frequent weighings until the first weight was obtained.

If the aspirator bottle is fitted with a tube reaching nearly to the bottom, as shown, the suction on the train will be the same irrespective of the amount of water in the bottle, until the bottom of the tube is reached.

Notwithstanding all precautions, there seem to be some almost unavoidable sources of error in the combustion method of determining carbon. Among these may be mentioned the possibility of hydrocarbon vapors from the rubber tubes and corks, the unequal drying of the gases by the chloride of calcium tube and prolong, the difficulty of getting absolute blanks, and especially the difficulty of making the second weight, under exactly the same conditions as prevailed when the first one was made. We do not think all these errors combined should amount to more than one or two hundredths of a per cent. of carbon.

USES OF METALLIC TIES.

By A. Flamache.

Every engineer has been struck by the extreme variation of opinion concerning the use of metallic ties on railroads. Some, such as the English railway companies, the great majority of French managers, the Belgium State Railway, and as a general thing the managers of the lines of Western Europe, where the traffic is very heavy and fast, are systematically opposed to the use of metallic ties. The rare applications on the lines which have just been cited are the result of absolutely outside causes, such as the powerful influence which could be brought to bear upon an English road, which was soon compelled to remove these ties, in spite of its desire to please the inventor. Sometimes it is in order that the inventive faculty of the officers of the company might not be discouraged, that the latter consents to use a few ties which were designed by their engineers. Sometimes the railroad company which handles the freight of an important steel works buys a few tons, and pays for them by transporting raw material. More often still, it is a governmental movement, which, in a moment of distress, does it in order to make work.

In all this there is no such infatuation as metallic ties have inspired in Germany and Austria, where engineers seem to have considered the question as solved. It is true that they formerly manifested the same inclination to use metallic stringers, which are now used by a few managers only who are more or less interested, as inventors, in their success. There is, nevertheless, some singular facts arising from this divergence of opinion. How can it be that a system of tracks, which lasted only eight days on an English line, such as the Haarrmann, which was made in two pieces, has been tried and lasted for several years on certain German lines?

Many, however, are agreed that when the metallic tie has reached a firm basis, its maintenance is far less expensive than that of a wooden one; while others, resting upon 20 concurrent results obtained in different sections, declare that the maintenance of the metallic tie is twice and a half or three and a half times as expensive as that of the wooden one. These great differences of opinion between men of equal ability and indisputable veracity are not inexplicable.

The object of the present article is to lay down a few observations which I have had occasion to make, and which, if they do not throw any definite light upon the subject, may lead at a later time to a complete knowledge of the truth. All the differences of opinion which have been produced are derived from the fact that hollow ties, with opening turned down, have invariably been used upon lines where the work is very heavy, and that the maintenance of these ties was very expensive, while upon lines where the traffic was light, they have been easily maintained. This fact being recognized, I have proceeded into the examination of different metallic ties, with hollow supports of different shapes, and have watched the metallic track very attentively where it had to be reconstructed and put in good condition. The passage of trains upon supports which have edges vertical or nearly so has an effect of forcing these edges down into the ballast and then withdrawing them, according as the tie descends or ascends with the wave motion of the rail. However hard the fragments which composed the ballast made may be, they are worn out, and form a sort of mud, which fills the interstices, and transforms the ballast contained in the open part into a very hard macadam, which is more or less hard upon its edges. At the same time the volume occupied by this diminished ballast is obliged to flow again in order to maintain the tie at its proper height. That is the first period for the maintenance of metallic ties observed by everybody, and recognized as being particularly difficult even by the advocates of metal, but not being likely, according to them, to last more than a few months. Starting from this point, the tie is seated upon a hard core, is anchored by its lower portion into the sub-adjacent ballast, and is absolutely immovable. At the first the track is excellent except that it is a trifle hard, but at the end of about a month accidental causes intervene either under the action of the vibrations, caused by the passage of trains or to the wave motion, or by a deformation of the roadbed, the cores are displaced and carry with them the lower portion of the sub-adjacent ballast. The tie embedded in this core is displaced with it, and the track soon presents a series of sags, not very deep, it is true, but still of a very disturbing character. At the same time the distance between the centers of the ties is changed, and some of them are brought into an oblique position with the rails.

Such is the condition of all the German railways which I have examined. As long as the speed of the train does not exceed 47 miles to 50 miles per hour, these sags have no other disadvantage beyond that of shaking up the passengers pretty badly, but without putting their lives in danger; but when a speed of 62 miles or more per hour is obtained, the situation becomes unendurable, and must be remedied at any cost. A difference of from 6 to 12 miles in the speed modifies the whole running of a train. In experiments which I have made with my deflectograph I have seen a train of passenger cars, hauled by an excellent engine, admirably balanced, running at different speeds over a new and thoroughly good track, take a sensible deflection and balance upon its springs at 56 miles per hour, and while it was in that position remain exempt from all other movements. Further on, at 62 miles per hour, the swaying was very annoying upon a less perfect track, and the strain, as shown by the instrument, was double that observed at 44 miles. Upon a poorly ballasted or tamped track the train reaches a disturbing speed more quickly and in a more pronounced manner, and engineers of lines where rapid express trains are running ought to keep their tangents in true alinement, both vertically and horizontally, lest they cause disastrous derailments or destroy in the course of a few years the best built track.

No one believes that a few blows of the tamping-bar or pick is sufficient to obtain a perfect dressing of a track with hollow ties. A track which is thus brought to alinement is forced back to its old position by the first train which passes, each tie falling back upon the core which sustains it. To obtain a suitable dressing, the old core should be demolished and the tie tamped up afresh; then the period of expensive maintenance begins, which we pass as soon as the cross-ties are well seated, and which follows at once a greater or less intensity of traffic. Is it not plain, then, that where one is contented with a poorly tamped track the hollow tie can only lead to fresh ex-