Castings.

Pieces: 24 straps *A*; 636 of B_1; 136 of B_2; 36 of C_1; 8 of C_2; 2 of *D*; 24 of *E*; 4 of *F*; 12 of G_1; 8 of G_2; 48 of *H*; 72 of *I*; 8 of *J*; 4 of *K*; 8 of *L*.

113 an end view and part of the details, and in Plates 114 and 115 the remaining details.

The bill of materials is also given, and, it is believed, the plates and bill will show the design and construction of the bridge clearly enough, without further description.

(TO BE CONTINUED.)

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.*

CHEMISTRY APPLIED TO RAILROADS.

X. BATTERY MATERIALS.

BY C. B. DUDLEY, CHEMIST, AND F. N. PEASE, ASSISTANT CHEMIST, OF THE PENNSYLVANIA RAILROAD.

(*Continued from page* 313.)

To those who do not understand the details of railroading at the present day, it may perhaps be somewhat of an astonishing statement to say that the train movement on any busy railroad at present would be an impossibility without the telegraph; and this does not mean that the operation of a railroad requires that the telegraph shall be used for the officers to communicate with each other on matters of policy, or about the purchase of supplies, or other general questions which are constantly coming up, important as these may be for the general operation of a railroad, but it does mean that the actual movement of the trains, the getting of the traffic over the road, the prevention of delays, collisions, and accidents of all kinds, and the meeting of the dozen and one emergencies, which are constantly arising in train movement, are all regulated by means of the telegraph, and that without the telegraph complicated train movement would be impossible, at least without such a multiplication of tracks as would double or treble the investment of most railroads.

In view of the great reliance placed on the telegraph in modern railroad operation, the question of materials used in the battery to furnish the electricity with which to operate the lines assumes new importance, and the object of this article is to give the experience of the Pennsylvania Railroad in *Battery Material*. The questions of the telegraph lines, of the construction used, of size of wire, of distance of poles from each other, of overhead and underground lines will not be discussed in this article. Possibly in some future article of this series these questions may be treated at length, but at present only the materials used in generating the electricity will be discussed.

The history of the battery as applied to telegraph work and the development of the present simple form, which, so far as our knowledge goes, is almost universally used for this purpose, would be very interesting reading, but this likewise is foreign to our purpose. Suffice it to say that, so far as we know, what is known as the "Gravity Battery," the elements of which consist of one pole of metallic zinc, one pole of metallic copper, the latter being surrounded by a concentrated solution of sulphate of copper, and the former with a more or less dilute solution of sulphate of zinc, is now almost everywhere in use for telegraphic purposes. In this battery, as is well known, the containing cell is usually made of glass, and the ordinary size in most common use holds about one gallon. It should be placed in a dry, moderately warm room, and is best if insulated on a porcelain insulator. It is a great mistake, made many times, to locate the battery in a damp, cold cellar, and to set the cells forming the battery on any damp support. Being itself a part of the line, the battery should be as well insulated as the wire, and experience shows that the leakages and difficulties in service disappear more and more the better the insulation.

It is well known that in an ordinary gravity battery the copper pole occupies the bottom of the cell, being connected with the zinc of the next cell by a copper wire, usually insulated with rubber or gutta percha. The copper pole is surrounded by crystallized sulphate of copper, the usual custom being to fill the battery cell perhaps one-quarter full with the dry material. Soft water as free as possible from mineral matter—rain water is best—should be used to fill the battery cell up to within an inch or an inch and a half of the top. The zinc pole of the cell suspended from the cover, or by a bar across the top of the cell, is then put into the water, and it is best to add to the clear water solution a little sulphate of zinc solution, taken from an old battery cell. Many prefer to connect the two poles of a newly charged cell together for a few hours, thus doing what is technically known as "short circuiting" the cell to start the action. This is not very good practice, but it is quite frequently done. Quite serious difficulties would be experienced with this method, if a large number of cells in any battery that was being worked were renewed at one time, since the resistance of pure water is so much higher than the resistance of water containing salts in solution. The best method of starting a battery cell is to put the copper pole in the bottom of the cell and surround it with the crystallized sulphate of copper, as above described. Then fill about one-third full of water, or a little above the crystallized sulphate of copper, and allow it to stand over night. Then fill in above this blue solution to within 1 in. or 1½ in. from the top of the cell with a liquid made of one part sulphate of zinc solution, taken out of an old battery cell, and two parts clean water. In introducing this solution into the new battery cell, it is best to put a thin board, a little smaller in diameter than the inside of the cell, on top of the blue solution, and then pour the sulphate of zinc solution on to this board. In this way there is very little disturbance of the blue solution, it being well known that it is essential in the action of the battery that the blue and white solutions should not mix. Suspend now the zinc pole in the white solution as above described, and the cell is ready for use. It is not necessary, of course, to say that the copper pole of one cell is connected with the zinc pole of the next, and so on to the end.

In the practical operation of the battery as above described, it is found that the liquid evaporates badly, especially during dry and warm weather, and many devices have been made use of to overcome this difficulty. Some people use a layer of paraffine oil, possibly ½ in. thick, on top of the battery liquid. This was formerly the custom on the Pennsylvania Railroad, and the only serious objection to it that we are familiar with is that it is somewhat dirty. Later practice has been to have a wooden cover made for the purpose, which fits fairly tight to the battery cell, which cover likewise serves as a support for the zinc pole, and has in it a two-inch hole for the introduction of the sulphate of copper from time to time, and to enable the sulphate of zinc solution to be drawn out if desired, which hole is covered with a small metallic slide cover. This keeps the battery cleaner and is in every way the most efficient scheme which has been tried, and we believe the practice is becoming universal throughout the system.

The chemical action of the gravity cell is probably quite complicated, and we are not sure that all the reactions which take place have ever been fully investigated or worked out. If the battery works as we would expect it to work theoretically, the result of the action would be as

* The above is one of a series of articles by Dr. C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad, who are in charge of the testing laboratory at Altoona. They will give summaries of original researches and of work done in testing materials in the laboratory referred to, and very complete specifications of the different kinds of material which are used on the road and which must be bought by the Company. These specifications have been prepared as the result of careful investigations, and will be given in full, with the reasons which have led to their adoption.

The articles will contain information which cannot be found elsewhere. No. I, in the JOURNAL for December, is on the Work of the Chemist on a Railroad; No. II, in the January number, is on Tallow, describing its impurities and adulterations, and their injurious effects on the machinery to which it is applied; No. III, in the February number, and No. IV, in the March number, are on Lard Oil; No. V, in the April number, and No. VI, in the May number, on Petroleum Products; No. VII, in the June number, on Lubricants and Burning Oils; No. VIII, in the July number, on the method of purchasing oils; No. IX, also in the July number, on Hot Box and Lubricating Greases. These chapters will be followed by others on different kinds of railroad supplies. Managers, superintendents, purchasing agents and others will find these CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION of special value in indicating the true character of the materials they must use and buy.

follows: Metallic copper from the sulphate of copper is deposited on the copper pole in the bottom of the cell. This releases the sulphuric acid with which the copper was combined in the sulphate of copper. This sulphuric acid ultimately combines with the zinc, forming sulphate of zinc, which goes into solution and stays in the top of the cell around the zinc pole. We say theoretically this is the action of the battery, namely, a transfer of sulphuric acid from its combination with copper in sulphate of copper, to the metallic zinc, and forming sulphate of zinc; but in addition to this, there is always a coating of oxide and basic sulphate of zinc formed on the zinc pole. This deposit is usually said to be the result of "local action," but whether this explains the phenomenon or not we are unable to say, and it is hardly essential to our purpose to go into this part of the subject. It will be observed that as the action of the battery continues, there will be an increase in the amount of metallic copper, a diminution in the amount of sulphate of copper, a diminution in the amount of metallic zinc, and an increase in the amount of sulphate of zinc. The care of the battery, therefore, requires the addition of two things, and the removing of two things, namely, sulphate of copper and new zinc must be added, and the metallic copper and the sulphate of zinc must be removed. In practice it is usually customary to add the sulphate of copper from time to time through the hole in the cover, and to draw out the sulphate of zinc, as the solution becomes too concentrated, replacing it with pure water from time to time. Whenever it is necessary to furnish new zinc or to remove the metallic copper, usually the cell is cleaned out entirely and a fresh start made.

It is very easy to see when more sulphate of copper is needed, and it not infrequently happens, if a battery is neglected, that a difficulty arises from the exhaustion of sulphate of copper. The most common difficulty, however, is in allowing the sulphate of zinc to become too concentrated.

When this occurs a thin layer of crystallized sulphate of zinc frequently forms on the inside of the cell at the top of the solution, which layer gradually extends to the top of the cell, and the liquid creeps up between this layer and the glass of the cell, until it runs over the top. This creeping up of the liquid makes very dirty cells and interferes seriously with the insulation, since as soon as the liquid gets to the top it runs down on the outside and interferes with the insulation of the cell. In good battery practice the sulphate of zinc solution should never be allowed to become as concentrated as this. Most of the books of instruction to those having the care of batteries contain directions in regard to allowing the sulphate of zinc solution to become too concentrated, and recommend to employ a hydrometer to take the density of the solution, and never allow it to reach the danger line of concentration.

With good materials and with proper care the gravity cell gives very good results, although its electro-motive force is, as is well known, rather low, and the number of cells required consequently much greater than could be desired. We do not, however, know of anything better at the present time than the ordinary gravity cell, and when, as is the ordinary custom we believe almost everywhere, the lines are worked on closed circuit, the behavior of this cell, if it gets the care it ought to have, is fairly satisfactory.

If the action of the battery was simply confined to that which has been described above, namely, to the deposition of the metallic copper and the formation of sulphate of zinc, it is unquestioned that the purer the sulphate of copper and the purer the metallic zinc, the better the action of the battery would be. We have expressed a doubt as to whether even the normal action of the battery was wholly explained by this simple reaction, and still further expressed a doubt as to whether the impurities which are necessary concomitants of the zinc and sulphate of copper used, or "local action" are complete explanations of all the additional reactions which may take place in the battery. Every effort has been made for a number of years past on the Pennsylvania Railroad to secure the purest possible materials for battery use, but this effort has not succeeded in preventing the deposition of scale on the zinc pole, and, as above described, it is possible that the impurities in the zinc, or "local action" may be the cause of this difficulty, and that no commercial zinc can be obtained which will be free from it, or, in other words, although the purest commercial materials are used, there is still enough impurity left to set up "local action," with the result of forming a scale on the zinc pole, as above described. We are hardly able to set this point at rest. One thing is certain, however, that impurities in the zinc are not desirable, and certain impurities are exceedingly objectionable, as will be described below. In order to reduce the impurities to the least possible amount, zinc for battery use has for some time been bought on the Pennsylvania Railroad, in accordance with the following specifications:

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Specifications for Zinc.

Ordinary Slab Zinc or Spelter, and Rolled or Cast Rod Zinc used for battery purposes, will be bought under this specification. It does not apply to Sheet Zinc nor to Galvanized Iron.

The material desired is Metallic Zinc, as free as possible from every other substance.

Shipments will not be accepted which show on analysis in addition to the Zinc more than one-fourth of 1 per cent. of Lead, or more than one-tenth of 1 per cent. of any other substance.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of the General Superintendent Motive Power, Altoona, Pa., April 2, 1887.

When a shipment of zinc is received, it usually comes in the form of slabs about an inch thick, 7 or 8 in. wide, and 2 ft. long. These slabs are known in the market as spelter.

A sample from the shipment is sent to the Laboratory and examined. It will be observed that more than 0.25 per cent. of lead is excluded, and more than 0.10 per cent. of any other substance. The ordinary impurities in zinc that we search for are lead and iron, these being the most common ones. The zinc may likewise contain small amounts of arsenic, tin, cadmium and copper. We have also always suspected the presence of carbon, but have never positively demonstrated whether it was there or not. American zincs have very small amounts of arsenic; most of the foreign zincs have very perceptible amounts of it. We have never had any very serious difficulties due to any impurities except iron and lead, and so far as our examinations have gone, the tin, cadmium and copper are very small in amount. The worst impurity is lead, and it is very evident why this should be so. As has already been described, the action of the battery consists in the transfer of the sulphuric acid combined with the sulphate of copper to the zinc. If now the zinc pole contains 1 or 2 per cent. of lead, the sulphuric acid forms with this lead sulphate of lead, which being insoluble in the solution, remains on the zinc pole, and sooner or later the zinc pole becomes so coated with a compact, dense layer of sulphate of lead, that the action of the battery almost entirely ceases. We have examined a number of times zincs which have been complained of where this was entirely the explanation of the difficulty. The zinc was not half worn out, simply because the sulphate of lead formed prevented further action, and, of course, without action no electricity results. We would be glad if we could get zinc entirely free from lead, and at one time succeeded pretty well on this point; but zinc free from lead is so much more expensive than that containing such amounts as our specifications allow, that we deemed it not advisable to buy the more expensive material. We have very little if any difficulty arising from this cause if the zinc fills the requirements of our specifications.

The iron is limited, as is seen, to 0.10 per cent. Unquestionably the iron is the most fertile cause of so-called "local action"—that is to say, the iron and the zinc in contiguous parts form a battery by themselves, resulting in the decomposition of the metal, but affording no useful current, and it is possible, as above stated, that the scale which forms on the zinc pole may be fully accounted for by the local action due to the impurity. That the iron has an important influence in this matter is clear, we think, from this fact. The more iron there is present in the zinc, the more scale there is formed on the zinc pole, and likewise the more this scale breaks up and falls off from the zinc. Indeed, one of the objections made to our specifications, is that they give a zinc which is too pure, and that the scale on the zinc pole does not disintegrate and break up owing to the lack of impurity. Many practical battery men believe that the white scale which forms on the zinc pole should be detached from time to time, or else the battery will cease to act. Our experience has not indicated this to be true, unless this white scale on the zinc pole is largely sulphate of lead, in which case it is true. We prefer to meet the difficulty of the scale adhering to the zinc pole by the addition of a few drops of sulphuric acid to the cell from time to time, or perhaps better still by a modification of the zinc. We are making experiments upon this point at present, which experiments are hardly sufficiently advanced to warrant publication. So far as our experience goes, however, very little difficulty will be experienced by the white scale on the zinc pole, provided the scale is not due to lead, and at present the best remedy is to add a few drops of oil of vitriol to the battery cell from time to time.

In casting battery zincs out of the slab spelter the metal should never be melted in an iron vessel, since it is well known that the zinc alloys with iron rapidly. In our experience we have found the amount of iron doubled in the finished zinc from what it was in the zinc with which we started, when we melted in an iron vessel. At present the melting is done in a large flat graphite crucible, made for the purpose.

We determine the amount of iron present in the zinc by dissolving the zinc in dilute sulphuric acid in a flask, using a rubber tube valve, to prevent the air getting at the liquid, and then titrate direct with permanganate of potash in the ordinary way. For the lead the metal is dissolved in nitric acid, and the lead precipitated in ammoniacal solution with phosphate of soda, according to Abel and Field's method, the lead being subsequently weighed as sulphate.

The sulphate of copper used in the batteries is purchased on the following specifications :

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Specifications for Sulphate of Copper or Blue Vitriol.

The material desired under this specification is the Normal Crystallized Sulphate of Copper, as free as possible from all other substances. From this date this material for the use of the Pennsylvania Railroad Company must meet the following requirements :

I. It must not contain more than ½ of 1 per cent. of Crystallized Sulphate of Iron.

II. It must not contain more than ¼ of 1 per cent. of other impurities.

III. Each shipment must be crushed so as to go through a sieve 1½ in. mesh, and must contain nothing that will go through a sieve of $\frac{3}{16}$ in. mesh.

Shipments which fail to meet above requirements will be rejected.

THEODORE N. ELY,
General Superintendent Motive Power.

Office of the General Superintendent Motive Power, Altoona, Pa., January 25, 1887.

It is well known by those who are well informed on the subject that the ordinary impurity of the sulphate of copper is almost entirely sulphate of iron, and sand or dirt. There may likewise be other substances present, especially other soluble sulphates, which crystallize along with the sulphate of copper. Since these other substances, to quite an extent, at least, would be direct falsifications, and are so easily detected, we think there is very little attempt among the manufacturers to give a material that is not what it should be. At least, so far as our experience goes, we have found very little to contend against in this material except the sulphate of iron. This at times might become quite a serious source of difficulty, and accordingly every shipment is examined for this impurity, the search for other impurities being confined to occasional more thorough analyses. With proper care on the part of the manufacturers, the specifications in regard to sulphate of copper are not difficult to fill. Much of the blue vitriol in the market runs as high as 0.75 to 1.00 per cent., and indeed we have seen it as high as 1.50 per cent. sulphate of iron. The object of excluding this material is to render the action of the battery as simple as possible, as well as to prevent the purchase of sulphate of iron, which is an exceedingly cheap substance, at the price of sulphate of copper. The crushing of the crystals is to facilitate the introduction of the material in through the hole in the cover of the battery cell, as above described. The specifications for blue vitriol have worked with very little difficulty for a number of years, and it has been a long time since we were compelled to reject material on these specifications. We determine the sulphate of iron by dissolving a weighed amount of blue vitriol as we receive it in water, heating nearly to boiling, and adding a few drops of nitric acid to be sure that the iron is oxidized to the form of the sesqui salt. We then precipitate hot with ammonia, filter and treat the oxide of iron obtained on the filter with dilute sulphuric acid, and then reduce this with zinc and titrate with permanganate of potash. The figure obtained, representing the iron, is then calculated to the crystallized sulphate.

The gravity cell as above described is growing in use continually, but a small number of Leclanche cells are used, especially on call and signal bells, and where intermittent work on open circuit is required. For this work even, in many places, the ordinary gravity cell is constantly taking the place of the Leclanche cell. Also some of the various forms of dry battery which are coming forward at the present time are being experimented with for this work, and especially is the dry battery being used where it is necessary to transport the battery, as on the call bells in cars. The Leclanche cell, as is well known, is a carbon-zinc cell—that is, one pole is carbon and the other zinc. There are various modifications, but in general the carbon pole is surrounded with crushed coke and black oxide of manganese, and contained in a porous cell. This cell is placed in a somewhat larger glass cell, which glass cell contains the zinc pole, the space between being filled with a solution of sal ammoniac or chloride of ammonium. Of late years the porous cell has been removed ; what was originally the carbon pole being made of crushed carbon and binoxide of manganese pressed into a solid mass with some binding material. The pole thus formed is then placed in the chloride of ammonium solution, alongside of the zinc, but separated from it. The Leclanche batteries are mostly bought with the carbon pole already prepared, and consequently our specifications have to do with the zinc and sal ammoniac. The same zinc is used to make the Leclanche poles that is used for the gravity cells, the only difference being that they are cast in rods, about ⅜ in. to ½ in. in diameter. The sal ammoniac used in these batteries is purchased on the following specifications :

PENNSYLVANIA RAILROAD COMPANY.

Motive Power Department.

Specifications for Sal Ammoniac.

The material desired under this specification is granulated Chloride of Ammonium [NH_4Cl] as free as possible from every other substance. The fibrous materlal is unobjectionable, provided it is crushed finely enough.

Shipments will not be accepted which :

I. Are not in the granulated form, or in case the crushed fibrous material ls sent, if the pieces are larger than a wheat kernel.

II. Contain less than 65.15 per cent. of Chlorine.

III. Contain less than 31.20 per cent. of Ammonia [NH_3]

THEODORE N. ELY,
General Superintendent Motive Power.

Office of the General Superintendent Motive Power, Altoona, Pa., October 31, 1887.

In our experience, the difficulties with sal ammoniac are largely due to dirt, to oxide of iron, and sometimes to the presence of sulphates, especially sulphates of the alkalies. We accordingly determine the amounts of chlorine and ammonia, the amounts represented by the figures being sufficiently below the theoretically pure material to allow for the presence of about 1.50 to 2.00 per cent. of moisture, and a trace of other impurities. These specifications work very smoothly, except that occasionally a new party, who is not accustomed to furnish material as good as our specifications require, furnishes material which fails to meet requirements.

We determine the chlorine by taking a weighed amount of the sal ammoniac, dissolving in water, and then triturating with a solution of nitrate of silver of known strength, using chromate of potash as an indicator to determine the end reaction. The ammonia is determined by taking a weighed amount of the material, dissolving in water in a flask, then treating with an excess of caustic potash and boiling. The ammonia is set free and is caught in a standard sulphuric acid solution. A known amount of this solution is taken, and the excess that is not satisfied with the ammonia is determined, the difference giving the ammonia.

With the development of electric light plants along the line, both those under the control of the Company and the local companies furnishing light to the towns, there is quite a disposition to operate telegraph lines with electricity obtained from dynamos. This is believed to work very satisfactorily, and where the electricity can be obtained in this way, it results in great economy. If it is necessary to put in a special plant for the purpose, it would be quite otherwise, since the amount of electricity required to operate telegraph lines is so small. It may be not generally known that the total current required to operate 30 or 40 telegraph lines side by side is not greater in amount than would be required to run two incandescent lamps. The great difficulty with dynamo electricity for telegraph service is that usually in the telegraph service the lines are so long, and the number of instruments are so great, that very high electro-motive force is required, with a very small amount of current. On the other hand, most of the dynamos used for incandescent lighting, at least, are built with moderately low electro-motive force, and with very high capacity. Where the electro-motive force is sufficiently high to overcome the resistance of the telegraph circuit, it is, as said above, very desirable to use this source of electricity, provided it can be obtained from the lighting service. Where the resistance is too great, or where a special plant has to be put in for the purpose, we are inclined to think the batteries will have to be used for a period of time, at least.

In the next article a discussion of paints will be begun.

(TO BE CONTINUED.)

AN INDIAN ENGINEER'S PREDICAMENT.

THE striking illustration given on this page—which is reduced from the London *Graphic*—shows the unexpected and somewhat startling predicament of an engineer making a little trip of inspection on an East Indian railroad. He has come suddenly upon a little family party which has camped out, without leave, upon the right-of-way, apparently in entire disregard of the claims of the company; he has no automatic brake, and cannot reverse, for his motive power has deserted him.

The predicament, as shown in the picture, is bad enough, but it is on record that the result was *not* a vacancy in the maintenance-of-way department, as might have been expected. Either the family party was conscious of the fact that its members were trespassers, they were frightened at the car, or else they were not hungry, for before the hand-car reached them they rose and quietly walked off into the jungle—very much to the relief of their unwilling visitor, who survived to make the sketch from which this drawing was afterward elaborated.

AN INDIAN ENGINEER'S PREDICAMENT.

The artist has drawn the scene graphically enough, but a railroad man *might* make the criticism that the curve which he has put in his picture would be, in real practice, almost as dangerous to a train as the tiger is to the unhappy engineer who confronts him so unwillingly.

THE PROPOSED LONDON TOWER.

SOME time since the Tower Company, of London, advertised for designs for a tower, the height of which was intended to exceed considerably that of the Eiffel Tower—984 ft.—and which was to be used substantially for the same purposes—that is, as a point from which visitors could obtain a very wide view and to which they would be attracted for that purpose, and which would be a marked point for all sightseers. Prizes of $2,500 and $1,250 were offered for the best and second best designs, and the decision was to be made by a jury of engineers.

In response to this offer 68 designs were sent in, of very