CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

CHEMISTRY APPLIED TO RAILROADS.*

I. WHAT THE CHEMIST DOES.

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THE question has often been asked what a chemist can have to do on a railroad, and the query is a very natural one. Those whose ideas of modern railroads are based on what they see when a train passes by, have very little conception of the infinite detail in the work required to produce this result. Those best informed in such matters, however, know that no phase of human effort in modern times makes demands on so many sources of knowledge, or utilizes under one general management, so many of the useful arts, as a modern railroad does. The relation between the Chemist and the movement of trains, and the carrying of passengers and freight, is not at all apparent at first sight. That chemistry plays no insignificant part in the final result, it is hoped will be made clear by what follows:

The reason why experts in any branch are employed by railroad companies, is found in the fact that there are constantly a large number of questions arising before railroad operating officers, which questions require for their solution, some knowledge of the laws of nature, and that the average operating officer is not generally fitted by training or acquired information, to obtain satisfactory answers from nature with reference to these questions, and even if he be so fitted, he has not the time to make experiments. Many such questions can be answered by the Civil Engineer or the Mechanical Engineer; many of them require for their answer, experiments in the domain of heat, light, or electricity, or physical tests, and some of them can only be answered by the Chemist. This has led to the employment of experts in two fields—namely, those who make physical experiments and tests, commonly called Engineers of Tests, and experts who make chemical experiments and tests, known as Chemists. It is interesting to note that during the last 15 years the recognized place of chemistry in the operation of railroads has grown to such an extent, that now no less than nine of the large railroad corporations of the country have a regularly employed Chemist. In some places this Chemist is also the Engineer of Tests, or, in other words, the general scientific expert, who makes both the physical as well as the chemical tests.

It is, perhaps, fair to say that when the question came up some 14 years ago of employing a chemist on the Pennsylvania Railroad, so little was the possible uses of such an expert appreciated, and so little work was known that he could do on a railroad, that permission to have a chemist was granted more as a concession and as an experiment than with any faith or belief that the scheme would prove to be permanent or valuable. It is also fair to say that at that time the field for work was as much unknown to the Chemist himself as to the railroad officers, and that for the first two or three years of the life of the laboratory, progress was necessarily very slow in consequence. It was not only necessary for him to have the chemical knowledge requisite to do the work when it was once in hand, but it was also necessary for the Chemist and officers both to study carefully the practical problems involved in railroad operation, and find the work for the laboratory to do. Chemists starting in on railroads at the present time, find a large amount of work ready for their hands, as the result of the work already done in this field, and it is not at all difficult now for one who has had two or three years' experience in one of the older railroad laboratories, to show marked results from his first or second year's work. It is, of course, clear that as the number of railroad chemists increase, they gradually expand the field, and necessarily give mutual help to each other, both by direct communication, and by the effects of their work on the manufacturers. The field is so large, however, that even though the number of chemists was increased four or fivefold, there would be, we think, no lack of new work for them to do for a number of years to come.

The Chemist having been secured, one of the first things that is usually given him, is to explain some peculiarity that has been observed in the service. The first work done after the laboratory of the Pennsylvania Railroad was established, was to make an investigation into the reason why the valves and steam cylinders corroded so badly. The ordinary life of a valve was about a year, and whenever an engine came in for repairs, there was always more or less corrosion about the seat where the steam-chest rests on the cylinder. A careful study was made of the conditions, and the conclusion reached was that the difficulty was due principally to the acids in the tallow used for lubricant, and that corrosion was assisted by the sponginess of the castings in the valves, since the cavities in the castings afforded places for the lodgment of the tallow. At the time this investigation was started, no record could be found in the literature of the case to show that the fat acids characteristic of tallow would corrode iron at the temperature of steam cylinders, and direct experiments were made with these acids demonstrating this point. The explanation of the difficulty having been obtained, of course attention was directed toward securing a mitigation of the trouble. The details of this subject will be presented later.

As another illustration of the application of chemistry to bad results obtained in service, the following may be cited: One of the special cars after having been cleaned by the car-cleaners was noticed to look badly, and on examination by the Foreman of Painters, it was declared that the varnish had nearly all been removed by the cleaning. As a matter of discipline, the Foreman Car-Cleaner was asked to explain why the varnish had been so badly used, and he claimed he could do no better with the soap he had. A sample of the soap used was submitted to the Chemist, who found not less than 3 per cent. of caustic soda, and 7 per cent. of carbonate of soda, in addition to the soda combined with the fat as legitimate soap. This, of course, explained the peculiarity and justified the foreman, as the soap solution used in washing the car was in reality a concentrated solution of sal soda and lye, which readily dissolves varnish.

Another field for the activity of the Chemist of a railroad is to protect against fraud. Not a few cases could be cited, showing attempts to sell at excessive prices, under some special name, common articles, which can be obtained in the market at very small figures. One of the most common of these attempts is that of selling some cheap materials for use as anti-incrustating boiler compounds. Dry material has been offered at 25 cents per lb., which on examination has been found to be nothing but sawdust and sal soda. Again, boiler compounds have been offered at 50 cents per gallon, which have been found to be apparently spent tan liquor, containing a little sal soda, 95 per cent. of the material being water simply. A very common field, likewise, is the one of alloys. Some composition of metal, which can be made at a slight excess over the cost of the metals entering into it, is offered under a special name, at two or three times the cost of the ingredients. Disinfectants are likewise another special field for imposition. Ordinary sulphate of iron, or copperas, which can be purchased in the market at 90 cents per 100 lbs., has been offered under some high-sounding name at 10, 15, or 20 cents per lb. This list could be enlarged to almost any extent. One of the most recent instances which has come to our notice is that of a material to protect iron from rusting, which was offered under a special name at from 15 to 25 cents per lb. On examination it proved to be nothing more than ordinary 500° fire-test petroleum, known in the market as cylinder stock, and which can be bought at from 1¼ to 2 cents per lb. by the 100 barrels, if required. That the material is

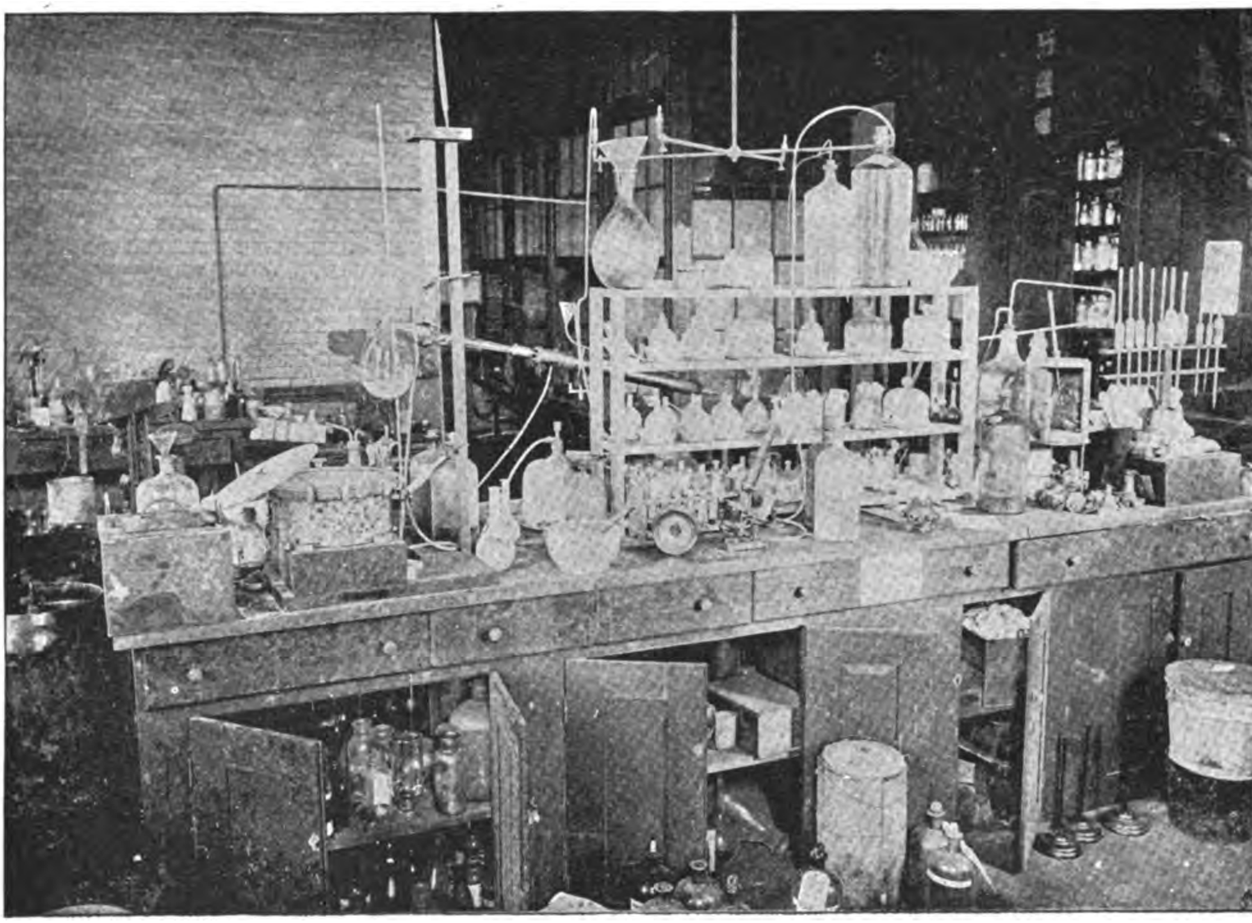
* This is the first of a series of articles relating to various subjects connected with the operation of railroads, upon which more or less definite information has been obtained in the Motive Power Department of the Pennsylvania Railroad during the last 15 years. They are contributed by permission of Mr. Theodore N. Ely, General Superintendent of Motive Power of that line, and the earlier articles will be devoted more especially to Railroad Supplies.

efficient and good for the purpose, is common knowledge, and it is difficult to see how any one could offer such material for sale at the price above mentioned, and call it legitimate business.

Another line of activity of the Chemist is to prove whether the assertions made by commercial men are true or false. It is common experience with railroad officers, especially Purchasing Agents, to meet men having materials for sale, for which they claim most extraordinary results. Houses engaged in legitimate trade claim for their products much better results than those obtained from the goods of their rivals, and between the representations of different firms of equally good standing, the Purchasing Agent, who is anxious to get the best thing, is often sorely puzzled. Almost the whole realm of supplies used by railroads is subject to this peculiarity, and it is difficult to pick out examples. Possibly paints, oils, and greases, are most commonly misrepresented in this way. The statements made by the men anxious to sell are often not only absurd, but laughable in the extreme to persons who are well informed. The representative of a certain grease offered for general lubrication, recently called upon us, to set forth the merits of his wares. In the course of the conversation with him, it was remarked that the usual difficulty with regard to greases, and the cups which were usually used for feeding them, was that, upon the journal getting a little warm, the grease would melt and all run out, leaving the journal without any lubricant whatever, the ordinary control over the feed in the case of grease being obviously inapplicable. To this statement the representative of the grease, with the utmost coolness, and with the evident expectation of being believed remarked that "This grease is entirely unaffected by changes of temperature." Upon our offering to place an order with him for three 10-lb. cans of the grease, to be put in as many museums, and labeled as "The only substance in nature not affected by temperature," he saw the absurdity of his position, and as gracefully as possible modified his statement to one that the material was *only a little* affected by temperature.

Again, not infrequently, parties anxious to sell represent their materials as being first-class in every respect, or in accordance to the specifications then in force. Often this is misrepresentation, and many times parties are perfectly honest and believe what they say, being simply misinformed themselves about their own goods. In either case, if a trial order is placed with them and a shipment made, difficulty often arises in the service, and too late it is found that the material is inferior. To such an extent is this the case, that at present it is quite the custom when a new party desires to furnish materials for the use of the Pennsylvania Railroad, to require him to send a sample of his material for examination before the Purchasing Agent feels willing to place an order with him. The saving in annoyance and vexatious disputes by this method is no small relief, not only to the Purchasing Department, but also to those who have to use the materials.

It is not, of course, claimed that chemical verification of the statements of commercial men, is the only method open to the puzzled railroad officer. Often his practical men can make tests sufficiently accurate to decide many of the questions, but no small number of assertions can only be checked up in a chemical way, although it should be fairly confessed that time and the whole resources of our chemical knowledge frequently fail to put a quietus on the misrepresentations of those who are anxious to sell.



INTERIOR OF PENNSYLVANIA RAILROAD LABORATORY AT ALTOONA.

Another field of activity for a good chemist on a railroad is to make investigations, to guide the practices of the road, and the expenditures of money. One or two illustrations will probably make this point clear. It is well known that natural waters, as they occur along the line of a road, must necessarily be used in the boilers for steam generation. It is also well known by those who are at all familiar with the subject, that waters differ very widely from each other in their value for steam purposes. Almost all waters contain more or less mineral matter dissolved in the water, which, when the water is boiled away, is left behind as a hard residue in the boiler, commonly known as boiler scale, and the waters that must be used vary from, perhaps, three grains to the gallon, up to as high as 40 or 50 grains per gallon of scale-making material. It has for quite a long time been the practice of the Pennsylvania Railroad to establish no new water stations until all the sources of water supply in that region have been examined as to the scale-making properties of the waters, and it is known that much good has resulted from this examination. Oft-times an expenditure of a number of thousand dollars, and the establishing of a poor water station, is avoided by so simple a thing as the determination of the total solid residue left on evaporating a sample of the water. The saving in boiler repairs and coal resulting from only using the best water accessible, is hardly capable of calculation, but those who are best informed on the subject will not hesitate to assent to the statement, that it amounts to thousands of dollars per year on any railroad having as many as 100 locomotives.

Another example in this line will make the matter still more clear. Some four or five years ago, investigations were made in the laboratory of the Pennsylvania Railroad, on the composition of the oil burned in the hand lanterns and elsewhere, and known in railroad language as signal oil. This oil, as is doubtless well known, is a mixed oil, the principal constituents being either lard, colza, or mustard-seed oil, together with varying proportions of petroleum distillate, known in the market as 300° fire-test oil, and as head-light oil. The question to be decided was, What mixtures of these various oils will give satisfactory results at the least possible cost? To solve this problem analyses of various mixtures of signal oil obtainable in the market were made, and then new mixtures were made in various proportions of the oils mentioned above, which were subjected to burning tests. As a result of the whole work, which extended over a period of a month or two, a formula was developed which gave an oil that was perfectly satisfactory by all tests, and at the same time produced a saving at the prices then prevalent of about 10 cents per gallon over the practice then in use. Oil was made according to this formula, and distributed to the men without their knowledge that any change had been made, and quite to the gratification of those authorizing the change, and somewhat to their astonishment, no increase of complaints in regard to oil could be observed. The economy in operating expenses produced by this change amounted to about $15,000 per year.

In addition to the examination of water for boiler use, a chemist on a railroad is not infrequently called upon to examine water for drinking purposes, both in a chemical and hygienic way. The money results of such an examination can hardly be stated, since to say nothing about the direct losses due to sickness and disease, it is, of course, impossible to calculate the detriment to the service due to inefficiency arising from a semi-invalid body.

Still another class of work where a railroad chemist has a chance to exert himself, is found in the testing of new devices offered as possible improvements in the present practices of railroads. A very good example of this are the experiments made on the ventilation of cars some eight or ten years ago, under the direction of the Chemist and the Engineer of Tests of the Pennsylvania Railroad. A new system of car ventilation having the name of the inventor had been developed and put on a single car. The money of a number of "promoters" was invested to the extent of fitting up this car, and the possibilities of a large company to push the matter, and bring the system into general use on railroads, was in prospect. This car was turned over to the two experts, with instructions to devise and make such experiments as would demonstrate whether the new system had any points of superiority over the one at that time in use. Without going minutely into detail, experiments were made on the relative capacity of the two systems to exclude objectionable matter, especially dust and cinders. Various experiments were also made on the capability of the two systems for removing objectionable matter formed within the car. These experiments embraced the relative length of time under normal conditions, that the two cars were freed from smoke and from odors generated in the car. Finally, the two cars were loaded in accordance with their capacity with men from the shops, and a run made, the ventilation being entirely a function of the characteristics of the two systems—that is, no doors or windows were left open. Samples of air were taken from the cars toward the end of the run, and also while standing on the tracks, without opening the doors or windows, to see what the ventilation was when standing still. These samples of air were duly analyzed for carbonic acid, that gas being, as is well known, thrown off by the lungs and body of every person. The results of the tests showed that while the two cars were running, the air in the new car contained from 0.50 to 0.60 per cent. of carbonic acid, while the car fitted with the old system contained from 0.20 to 0.30 per cent. While standing still the old car contained 0.55 per cent. of carbonic acid, and the new car ran up to something over 3 per cent. As the amount of carbonic acid allowable in the air for health, as stated by the best hygienic authorities, is not over 0.10 or 0.15 per cent., it was evident that not only the standard car in use needed attention as to ventilation, but also that the new car offered in competition had no points of superiority sufficient to recommend its adoption. It is, perhaps, needless to say that this investigation produced a complete collapse of the new car-ventilating company. It may be added for information, that analyses of air from cars made under the direction of the State Board of Health of Massachusetts, confirm the analyses of the Pennsylvania Railroad car, as given above; and that it seems probable the average of the air in cars throughout the country during the winter season, at least, is about one-half as good as it should be. In other words, since the ventilation of cars, as elsewhere, consists of taking fresh air into the car and foul air out, one-half as much air per hour is taken into cars in the United States in general, as should be for health, at least, during the winter season.

Perhaps the most important work of the Chemist on a railroad is the investigation in regard to the materials or supplies used, and the examination of shipments to see whether they are what they profess to be. The usual method pursued on the Pennsylvania Railroad is something as follows: Some difficulty arises in the service; the case is investigated, and the cause of the difficulty ascertained. If this difficulty is due to something characteristic of the practice of the road, usually a circular of instruction to the men is prepared, explaining the difficulty, and how to avoid it. A number of such circulars of instruction have already been prepared and issued to the men, with very gratifying results.

If, on the other hand, the difficulty is found to lie in the material or supplies furnished, a careful study of the special material at fault is made. This study may take a year or two before satisfactory conclusions are reached, but ultimately the results of the study are embodied in what are known as "specifications" in printed form, a copy of which specifications accompanies each order for that kind of material. The finding out what substances give the best results in service, or the making of specifications, is not at all an insignificant matter. It involves an intimate knowledge of all the requirements of the material from a railroad standpoint, and an intimate knowledge of all the processes leading up to the commercial product which is in question. Obviously, if the specifications do not give a material which proves satisfactory in service, or if the specifications demand more than the manufacturers can give, they are worthless. During the nearly 14 years' existence of the Pennsylvania Railroad Laboratory, chemical specifications for only about 25 different commercial products have been prepared. In later articles of this series an attempt will be made to give the reasons why, and a complete explanation of the specifications which have been prepared.

The preparation of the specifications, although a necessary preliminary, is only a small portion of the most important work of a railroad chemist. As long as competition in business is as severe as it is at present, there will be constant temptation on the part of the manufacturers to furnish inferior materials, even though the material is bought on specifications, and here comes the most voluminous work of the chemist—namely, the examination of samples taken from shipments, to see whether they fill requirements. In the Pennsylvania Railroad Laboratory, at the present time, four chemists are engaged on this work the largest portion of each working day. Samples from some 4,000 shipments per year are examined, the average number of determinations per sample being about five. This work, in addition to the examination of miscellaneous samples of material, either for investigation, or to settle some point connected with the service, makes the total number of determinations made in the Pennsylvania Railroad Laboratory somewhere between 25,000 and 30,000 per year.

It will, of course, be understood that the 25 specifications already issued cover only a small portion of the field. The number of kinds of material that do not yet have specifications is large, and the laboratory is constantly expanding in this direction, no less than three or four new specifications being under consideration at the present time.

It sometimes happens that after a subject has been investigated, and satisfactory conclusions reached in regard to the material desired, the obtaining of this material in the market is not easy, or, if it can be obtained, it is only at a high rate. So many difficulties of this kind have occurred, that, in connection with the laboratory, a manufacturing establishment has been started, which already makes a number of articles for the use of the road, notably disinfectant, polishing compound, blue-print solution, battery solutions, etc. It seems probable that this line will necessarily increase, for reasons that will be subsequently stated.

The query will naturally arise in the mind of every railroad man, whether specifying the quality of material does not necessarily increase the price, and, therefore, whether, after all, there is any real advantage in specifications. It is gratifying to be able to state that the experience of the Pennsylvania Railroad, for now nearly 14 years, is in general, that the price is not seriously affected either way by the preparation of specifications. Indeed, in many cases materials on specifications are obtained at lower rates than prevailed before the specifications were issued. The principal reasons for this seem to be, first, that manufacturers, knowing what is going to be used, can provide themselves with the raw materials in larger quantity, and thus get the benefit of reduced rates, and second, all manufacturers in the same line being required to bid on the same requirements, naturally bring their price just as low as it is possible to get it, in order to be sure of getting the business. Whatever the cause, the fact remains.

There is another gratifying result which follows the work of a good chemist on a railroad—and, indeed, the same may be said of any expert work—and that is, if the Chemist, Engineer of Tests, or other expert, is conscientious and competent, and carries his investigations on until he has obtained a complete explanation or solution of the problem in hand, based on some law of nature, the subsequent action taken by the railroad officers in accordance with the results of this investigation is so much more intelligently done, that it is quite apt to be permanent. Many questions have been put at rest, and many standard practices adopted on the Pennsylvania Railroad during the last 14 years, as the result of the studies and investigations of the various experts employed, and many of the problems studied during this time have been so well settled by the investigations made, that few questions in regard to them have subsequently arisen. There are few railroad operating officers, who will not appreciate the freedom from annoyance which results from the satisfactory solution of some knotty problem.

(TO BE CONTINUED.)

THE CAIRO BRIDGE.

THIS notable structure, one of the longest—if not the longest—truss bridges in the world, crosses the Ohio River just above its junction with the Mississippi, at a point where the crossing has heretofore been made by steam ferries, and where, until the recent great development of long-span construction, it was not deemed possible to build a bridge which would not be too serious an obstruction to navigation to be permitted. It connects permanently the Main Line and the Southern Division of the Illinois Central Railroad, the exchange of traffic between those sections of the Chicago-New Orleans Line having increased to a degree which warranted the Company in expending the large amount--some $2,500,000—required to build the bridge.

The bridge has no draw-span, being a high-level bridge placed at such an elevation as to permit the river steamers to pass under it without interference. There are 12 spans in the bridge proper, and 40 shorter spans in the approaches, making its total length a few feet over two miles.

As just stated, the bridge proper over the main river consists of 12 spans resting on masonry piers. Two of these on the northern end and one on the southern end are supported by pile foundations; the others are built upon caissons. These caissons were all sunk 75 ft. below the low-water level, and rest upon the bottom at that depth, which is very hard clay or compact sand. They were built of squared timber—Southern pine—bolted together, sheathed and caulked outside. They were filled with concrete after they were sunk to their places; three of them, carrying the piers for the long channel spans, are 30 ft. wide, 70 ft. long, and 16 ft. high, the crib on top being 34 ft. high; the others are 26 ft. wide, 60 ft. long, and 16 ft. high.

The level of the lower chord of the bridge is 102 ft. above low water, and the piers are consequently about 127 ft. in height from the top of the crib.

The arrangement of the spans of the main bridge is as follows, beginning on the northern or Illinois side of the river: Two spans of 257 ft. each; two spans of 523 ft. 6 in. each; one span of 406 ft.; six spans of 405 ft. each; one span of 255 ft. The lengths given for the spans are over all, the distance between the centers of the end pins being about 5 ft. less. They are all through spans and are double-intersection trusses, with the upper and lower chords parallel, except the 255-ft. and 257-ft. spans, which are deck-spans with single intersection. The trusses of the two longer spans are 60 ft. 9½ in. deep between centers of pins, and the 405-ft. and 406-ft. spans are 50 ft. in depth. The 255-ft. and 257-ft. spans are 26 ft. in depth. The entire superstructure is of steel.

The approaches are by themselves bridges of considerable size. That on the northern or Illinois end consists of 25 spans of 150 ft. each, and that on the southern or Kentucky end of 13 spans of 150 ft. each, and two of 105 ft. each. These approaches are all deck-spans, and rest on piers formed of steel cylinders placed in pairs. These cylinders were sunk to solid bottom, and filled with concrete.

Some very quick work was done in the building of this bridge. One of the 523-ft. spans was erected entirely in 45 working hours, and one of the 405-ft. spans in 31 hours, which is probably the best time ever made in erecting trusses of such great length.

The bridge was designed, and its construction superintended, by Messrs. George L. Morison and E. L. Corthell, Engineers, of Chicago and New York. Mr. Alfred Noble, of Memphis, Tenn., was Resident Engineer during the progress of the work.

The Union Bridge Company was contractor for the entire bridge, and the work on the superstructure was done in its shops at Athens, Pa., and at Buffalo. The foundations and masonry were built by Messrs. Anderson & Barr, as sub-contractors.

Considering the size and importance of the structure, and the great amount of work required on the foundations and piers, as well as on the superstructure, the time taken for its completion was comparatively short. The work was