Pharos, all the guns on shore were in open batteries, the parapets (sand) of which in most cases had been greatly strengthened. Thirty-five rifles and about 75 smooth-bores were actually manned and fired by the Egyptians. The rifles were all in embrasures, and so were much better protected than if mounted in barbette. Admiral Seymour brought against these batteries 8 armored vessels and 5 wooden gun-boats. Before the end of a 10 hours' bombardment, which took place at distances varying from 1,500 to 4,000 yards, the gunners were driven from their guns, the batteries silenced, and 10 of the rifles and 20 of the smooth-bore guns dismounted or disabled.

To fully understand the bearing of these examples upon the point at issue—the possibility, or rather the impossibility of efficiently serving open batteries under present conditions—it must be borne in mind (1) that in no case was the defensive power of the earth parapets injured to an extent that a few hours' work would not have restored them; (2) that the armament in each case was, in great measure, rendered unserviceable permanently or for a considerable length of time, the gunners being driven from their guns, and the batteries for the time being silenced; (3) that in each case the defense was stubborn and the gunnery by no means to be despised; and (4) that, except to a limited extent at Alexandria, this was accomplished with common-shell fire.

(TO BE CONCLUDED.)

## CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

### CHEMISTRY APPLIED TO RAILROADS.
### XXVI.—HOW TO MAKE SPECIFICATIONS.

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



(*Continued from page 89.*)

In the course of the articles of this series which have preceded the present one, frequent reference has been made to specifications, to limits of specifications, to revision of specifications, and indeed copies of the 26 or 28 specifications for materials now in force on the Pennsylvania Railroad have been published. It occurs to us that it might not be amiss to say something, growing out of the experience of now some sixteen years, as to the making of these specifications, and accordingly the present article will be devoted to answering the question, "How to Make Specifications."

If we may trust our experience, it is not at all an easy matter to make a specification which will work satisfactorily. Early in our work the making of specifications seemed to be the simplest of all things. All that it was necessary to do, we thought, was to sit down and write what would give a satisfactory material, saying largely what might be regarded as common knowledge; but a long experience has convinced us that such a specification is practically not worth the paper it is written on, and indeed is more of an annoyance than a benefit or help to both the manufacturer and consumer. As time has progressed more and more work and labor have been put on the making of specifications, until now it is not uncommon or rare for a specification to be under consideration six months, a year, or even longer before it is finally issued.

The reasons for the difficulty in making a satisfactory specification are not very hard to find. In the first place, common knowledge often does not cover sufficient ground for a specification based on it to give the material that is needed. Special investigations are needed many times, and indeed, we may say, are almost always required to decide actually what material is wanted in any particular branch of the service. This point will be taken up a little later, and indeed, as will appear further on, the finding out of what is wanted is not at all the simplest part of the work of making a specification. In the second place, specifications are difficult to make because the different parties who are to use the material in the service have quite varying ideas as to what materials should be used, and also have quite varying conditions to meet, so that a material that gives perfect satisfaction in the hands of certain parties and under certain conditions of the service may not give satisfaction at all in the hands of other parties and under different conditions of the service. It is not at all strange, in our experience, to have the same material praised and blamed from different parts of the service. A third reason why the making of a specification is difficult, is because those who are to furnish the materials have different ideas as to what is the most desirable material, and also have different facilities resulting in different costs of manufacture. There is, therefore, a state of affairs among the producers all tending to break down, to interfere with, or to complain of the requirements of the specifications. To meet these complaints, even when they are just, requires no small amount of work. Still another difficulty is that a successful specification must enable the material to be obtained in such a way that it can be tested, and if unsatisfactory returned to the makers, or otherwise disposed of without introducing too great delays in the service or too great expense. This point will hardly be appreciated by those who have not had practical experience in the working of specifications from day to day. Many times in the course of our work we have not put into our specifications desirable clauses or certain tests simply because the introduction of these clauses or tests, while they would secure a better material, would make the specifications unworkable on account of the difficulty of enforcing these clauses or tests without too great delay or expense to the service. Only those who have had experience can appreciate how powerful this influence is. The problem in making a specification is not simply to put in writing something which will give the best material, but to draw a specification that will give a satisfactory material, and at the same time will work smoothly.

In view of the difficulties above mentioned, it is perhaps not strange that we should claim that the making of specifications is not at all an easy matter, and we are confident the experience of all those who are actually engaged in their enforcement from day to day will confirm our view of the case.

It is well known by those who are informed, that there is considerable complaint among manufacturers of what they believe to be unnecessary annoyance and interference with their works and processes, due to specifications, and to such an extent has this matter developed, that at a recent meeting of the American Institute of Mining Engineers the manufacturers actually brought forward the question of trying to completely break down specifications. To our minds, while the remedy proposed by the manufacturers—namely, the abolishment of specifications, and trusting to the maker and his reputation for material, could hardly be approved, there is still much to be said in favor of their position. The real difficulty is that specifications are presented to the manufacturers which never ought to be presented. There is little doubt but that there are hosts of foolish specifications prepared without anything like proper consideration of the subject-matter, and also that specifications are very frequently badly drawn. We are confident that much of the friction between the manufacturers and the consumers would be relieved if specifications that are presented to the manufacturers were much more

* These articles contain information which cannot be found elsewhere. No. I, in the Journal for December, 1889, is on the Work of the Chemist on a Railroad; No. II, in the January, 1890, 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; No. X, in the August number, on Battery Materials; No. XI, in the September number, on Paints; No. XII, in the October number, on the Working Qualities of Paint; No. XIII, in the December, 1890, number, on the Drying of Paint; No. XIV, in the February number, on the Covering Power of Pigments; No. XV, in the April number, on How to Design a Paint; No. XVI, in the May number, on Paint Specifications; No. XVII, in the June number, on the same subject, and No. XVIII, also in June, on the Livering of Paint; No. XIX, in the July and August numbers, on How to Design a Paint; No. XX, in the September number, on Disinfectants; No. XXI, in the October number, on Mineral Wool, and No. XXII, in the same number, on Wood Preservative; No. XXIII, in the November and December numbers, on Soap; No. XXIV, in the January, 1892, number, on Steel for Springs; No. XXV, in the February number, on Bearing Metals.

carefully drawn. As already hinted at two or three times in what has preceded, as time progresses we are continually using more and more care, and putting more and more study on our specifications before they are issued.

Perhaps it will help us a little in the further consideration of this question to define what we understand by a specification. In its broadest sense, we cannot help thinking that a specification is an attempt on the part of the consumer to tell the manufacturer what he wants. This covers by far the largest portion of a specification. Also, in so far as specifications give limits and methods of testing, they are really in the nature of an agreement between the two parties, having a binding influence upon both. The above view is perhaps somewhat different from the ordinary one. A specification is usually regarded as a means of protecting the consumer, and as something which the producer takes, as he does a dose of medicine, not willingly, but because he must. Our experience and view in regard to specifications that are drawn in such a way as to have unnecessarily objectionable features is, that they are inefficient and, from the nature of the case, cannot be enforced satisfactorily. We accordingly prefer to take the higher ground—namely, that the producer wants to supply what the consumer needs, and that the specification is an effort on the part of the consumer to tell the manufacturer what he wants, and also a mutual agreement between them as to what the material shall be. Based on this conception, we will try to tell in what follows our ideas of how a specification shall be drawn.

First, then, the specifications being an attempt on the part of the consumer to tell the producer what he wants, it is obvious the consumer must know what he wants. How, then, shall the consumer get this information? As already stated, if we may trust our experience, this is no simple matter, and is sufficient reason for consuming considerable time and exercising great care in the preparation of specifications. In general, it may be stated, we think, the best source of information as to what a user wants is the service. That is to say, if you want to know what kind of material you should buy, ask the service. It is obvious this is the court of last resort, and it is consequently the best place to go for information. Our usual practice when we start in to make a specification is to ask, What does the service teach us as to what kind of materials give us the best results? Sometimes in getting this information we collect a large number of worn-out articles, which have given long life and good service, and an equal number, if possible, which have given short life and poor service. Careful examinations are then made of both these lots of samples. To give an illustration, in the case of fire-box steel, not less than 30 worn out fire-boxes were tested physically and analyzed carefully. The results of all these tests being gotten together, the question is, What do these tests teach us as to what gives the best results in service? It is obvious, if the number of samples is sufficiently great, and the teaching from them sufficiently free from contradictory results, that it is possible in this way to get very satisfactory indications, and indeed sometimes positive limitations to be used in making specifications. Such questioning of the service as is outlined above has been made use of in the preparation of quite a number of our specifications, which have already been published, and is constantly being made use of more and more. It will be readily understood that such investigations take time. A single example of good and bad will hardly satisfy, and it takes time to collect together a number of samples which have given good and bad service. Sometimes, likewise, it is difficult to get samples which will compare with each other. The long service of one sample may be due to certain favoring conditions, and the short service of another sample may be due to certain adverse conditions. Theoretically, it would seem as though an investigation carried through a sufficiently large number of samples of good and bad ought to be final authority on what the service teaches; but owing to the uncertainties just mentioned, we are hardly inclined to think that it is quite sufficient to follow blindly what seem to be the teachings of samples from service. We often get strong indications from such examinations; or, in other words, we frequently develop from such examinations a working hypothesis, but it is rare that we simply take alone the results of examinations of good and bad material from the service as final. We always like, however, to start a specification with the examination of materials from service.

It often happens, however, that we cannot get a sufficient number of samples of material that have given good and bad service as readily as we can make a positive experiment, and accordingly we frequently obtain material and put it into service, keeping watch of it to see how it behaves, or in other ways make a positive direct test. We have done a good deal of this work in regard to bearing metals, and also a great deal in regard to the various mixtures of oils to be used for burning and lubrication; also somewhat in regard to materials and proportions to be used in paints. Indications obtained from positive experiments, however, are sometimes misleading, unless great care is taken. Materials that will give perfectly satisfactory results at Altoona will not give perfectly satisfactory results at Wilmington. Moreover, there is always a personal element more or less strong in the use of materials, so that a material in certain hands may give satisfactory results, while in certain other hands it may not; so that we are actually inclined, strange as it may seem, to distrust the results of positive experiments, although the experiments are made by ourselves. On the other hand, the results of positive experiments do give strong indications, and sometimes enable us to set limits which can be wisely adhered to.

These two sources of information—namely, the teachings of good and poor materials taken from the service and actual experiments, as already stated, do not cover the ground completely. Of course, the material must work satisfactorily in the hands of those who are to use it before it goes into the service, and accordingly this source of information is made use of. Consultation with the foremen of the various shops who must use the materials sometimes direct experiments under their supervision, suggested either by themselves or ourselves, and the behavior of the different kinds of materials under these various tests throw much light on the subject. Upon this point of consultation with those who must use the material, we would like to say that, as a matter of policy in the preparation of specifications, it is extremely wise, and it is also wise to make the consultation as broad as possible—that is, do not try to get all your information as to the practical working of materials from one foreman. Comparison of views and comparison of experience from the different foremen throw much light on the subject. Moreover, if those who must use the material are consulted in the preparation of the specifications, they will, when the specifications are finally issued, be much more kindly received and more readily given a helping hand than if the specifications are prepared without their having any voice in the matter.

There is still another source of information which should not be disregarded in the making of specifications, and this is a careful examination and investigation of every piece of material that fails in the service. This is especially true of the breakage of parts made of iron or steel. We have gathered very much valuable information to be embodied in our specifications from this source, and indeed the examination of material that gives short life, or that fails, or that does not work satisfactorily is very often the starting point of the specifications. Something occurs in service that is a little abnormal; a study is made and information gathered. Possibly the same thing is repeated at another portion of the road within three months. Another investigation is made, and possibly the teaching may be the same, or it may throw additional light on the cause of the failure, and so on, until perhaps a dozen cases have occurred. If the teaching is plain enough on the first investigation to cause a change in practice, this is at once made use of, and the subject is held under advisement, for the accumulation of further information which shall lead to positive specifications.

Still another source of information which may be made use of in the preparation of many specifications is to examine the materials that the market affords. Manufacturers of the kind of material in question are asked by the Purchasing Agent to send to the Laboratory a sufficient sam-

ple of such material as they can furnish, and furnish regularly and satisfactorily. After these materials are received they are carefully subjected to analysis, or physical test, as the case may be, and the results tabulated and studied. This gives the man who is to write the specifications a knowledge of what actually is being done or can be done in the market. This source of information, however, is not wholly reliable, and if in making specifications one follows the teachings of such procedure as is outlined above, he will not infrequently run across difficulties later on. The reason for this is that manufacturers are inclined to put their best foot forward, and consequently send for examination a little better material than they can make regularly. It is not uncommon to find that we have placed limitations in specifications, which limitations were dictated by the analyses of the material that the parties have furnished themselves, and yet when we come to get shipments, the material will not pass the requirements. So much is this the case, that we have sometimes had to modify our specifications later on. This peculiarity, if we are rightly informed, agrees with the experience of other parties. Many of the Government specifications, based on correspondence with the steel manufacturers, have run across the same difficulty, because the manufacturers, in competition with each other, stated a little more than they could regularly and uniformly perform. Looked at in this light, of course it is the manufacturers themselves who are to blame for harassing specifications.

Another source of information, and one frequently made use of before the specification is put in writing, is to visit the various works where the materials in question are made. It is obvious that the man who draws the specification, in order to make it work successfully and smoothly, must be able to do justice both to the service, where the material is to be used, and also to those who are to make the material, and it not infrequently happens that by an inspection of the materials used in the manufacture and the processes used, and by consultation with those who make the materials, he gets such information as enables him to avoid putting into the specifications requirements which are unwise. We are very strongly of the opinion that the man who attempts to write a specification without any knowledge of the processes by which the material is made will make a serious blunder. The more intimate the knowledge of the process, the more wisely the specifications will be drawn.

We conclude, then, that for the purpose of getting the information necessary to make a specification, the following sources are all available—namely, *first*, study of good and bad materials which have given service; *second*, direct experiment on materials in service; *third*, consultation with those who must use the materials in service; *fourth*, examination of materials that fail in service; *fifth*, examination and test of materials from different manufacturers, and, *sixth*, visits to and study at the works where the materials are made.

It will be observed that we have given above practically six different sources of information, all of which should or may be studied before one sits down to write a specification. It is perhaps not too much to say that in most of the specifications in use on the Pennsylvania Railroad information has been accumulated from almost all of the above sources before the specifications were written out. Sometimes, according to the circumstances of the case, one source has thrown more light on the subject than another, and sometimes the necessity for action in the matter of securing better materials than we were actually receiving has been so great that we could only obtain information from one or two of the sources before putting out a preliminary specification. But we cannot but think that it is extremely desirable to have each of these sources of information probed as far as possible before the specifications are made. The more care and study there is expended in collecting information before the specification is written, the more likely the specification is to work smoothly after it is written.

Let us suppose now that sufficient information has been obtained from the different sources, so that it is deemed advisable to embody it in the form of specifications; the person who is to do the work gets the information together, sifts it, and gets the teaching from each point, and sits down and puts in writing the proposed specification, embodying all the information as best he can. It is our practice in doing this to give a pattern, or practically describe in brief the material desired. Following this are usually discussions of the methods of selecting the sample, methods of testing, under what regulations the material will be bought, and finally the limitations are given upon which the materials will not be accepted. This information having been drawn up, it is put in print in proof form, and copies are sent to the various officers of the road, who are most closely interested in the use of the material, and also to the Purchasing Agents, with the request to the latter that they distribute the proofs to those from whom they desire to purchase this material, and ask for their criticism. This method of consulting the manufacturers who are to furnish the material is entirely characteristic of all our later specifications, and we feel that it is essential.

This leads us to the second clause in our definition of specifications—namely, that, assuming that the manufacturers desire to furnish what the consumer wants, the specification is really in the nature of an agreement between them, and consequently the producer has a perfect right to be consulted in the making of the specification. Moreover, the knowledge which the producer has of the capabilities of his works, and of what the various processes will yield, is necessarily more intimate and valuable than can be obtained by the person who writes the specification, unless the latter happens to have especial experience in the manufacture of that kind of material, so that the consumer is really shutting out a valuable source of knowledge unless he consults the manufacturers. It is, of course, fair to say that many manufacturers are inclined to bend the specifications to suit their individual circumstances, and we have had very many amusing criticisms and suggested modifications of our specifications sent us in reply to our request for suggestions. On the other hand, we have no hesitancy and no embarrassment in saying that many of the limitations and conditions of our specifications have been suggested by the criticisms of the manufacturers. Some of the limits, and, indeed, the wording in some cases have been taken from the criticisms of the manufacturers on our first draft in proof form.

There is another phase of this case—namely, that if the manufacturers are consulted beforehand in the making of the specifications, they are well informed as to what the demands and growth of knowledge from the consumer's standpoint are going to require of them. Still further, they are conciliated, and they are much better prepared to give the specification a kindly welcome when it is issued than if a full-fledged specification is presented to them that emanates from the brain of some, perhaps, a little too overconfident person. If we may judge from our experience, it is a foolish man who attempts to issue a specification for any kind of material without consulting those who are to make that material for him.

The criticisms from the manufacturers and from the various officers above referred to having been received, these are all sifted, and such modifications in the original draft as seem wise are introduced. It is fair to say that it is not possible always to follow all the suggestions of the manufacturers, and we have found quite to our gratification that the criticisms of the manufacturers were a pretty good antidote to each other. Where they all agree upon a point, it is usually wise to follow their suggestion. Where some are on one side and some on another on a disputed point, you are fairly safe in following your judgment between the two.

While this criticism and discussion is going on, it is usually our custom to have sent to the Laboratory samples from the shipments of the material under discussion, and examine these in the light of the proposed specifications. In this way we accumulate a certain amount of information that we can get in no other way. In reality, we assume, for the purpose of the Laboratory work, that the specification is in force, and examine all the shipments of the material that are received, just the same as though they were in force, the only difference being that if we find the shipments do not conform to the specifications, we do not reject them, because they were not bought in accordance

with specifications. We were led to this method by finding that usually, after all our care in making specifications, something would occur, within the first six months of their actual working, which would demand a modification, and so we utilize all the time we can in getting experience with the specifications before they are issued. Moreover, the manufacturers of many commercial products are frequently not fully informed of their own product, and the information collected in this way from the examination of shipments of their material is often sent them for their guidance and knowledge.

The criticisms all being in, and experience being obtained, the specifications are finally issued. It is perhaps not too much to say that in important specifications, with all our care, we still have to revise from time to time. Progress in knowledge, changes in our practices, and many times changes in methods of manufacture lead to these modifications. It is no small work to keep up with the development and changes in the methods of manufacture for the various articles for which we now have specifications. Again, each manufacturer is constantly trying to make a material which will meet the limits of the specifications at less cost to himself, and it not infrequently happens that this leads to the production of a material which is inferior. The specifications must therefore be modified to meet this peculiarity.

We are quite well aware that it is probable the criticism will be made by many engineers, that if our method of making specifications were followed, there would be no specifications, as many times it would be impossible to have such facilities and access to sources of information as will enable study enough to be put upon the subject to make a specification wisely. It will undoubtedly be urged that many specifications must necessarily be made from common knowledge, and also that in many cases the consumer knows without special study what he wants, which is simply the best which can be made of the kind.

In reply to this we would say that we are quite familiar with the emergencies which are constantly occurring, and which lead to action on insufficient knowledge. No class of men in the community are meeting emergencies more constantly than railroad men, and it not infrequently happens in our experience that we are called upon to make specifications without having given the matter sufficient study. In such cases, recognizing that our knowledge is limited, we have thus far drawn specifications so as to overcome the difficulty which gave rise to the necessity for action, but at the same time in such a way as not to cause hardship to those who must furnish the material. In other words, we cannot but conceive it wise, if we do not have positive knowledge, which leads to a rigid demand on the manufacturers, it is much better to make the demand one that can be fairly easily filled. We are perfectly rigid and unyielding where the service furnishes the information leading us to take such a position, but where it is a question of judgment, where limitations must be placed on general information, we submit that it is wise simply to make the limits such that they will not cause unnecessary annoyance to those who are to fill the specifications. To put the whole matter in a single sentence, we cannot but feel that in many cases a specification is made a place to show how much the man who draws it knows. We also feel that this is certainly unwise, and that the interests of the service will be equally well protected without many of the narrow limitations and tortuous tests which are characteristic of some of the specifications which have come under our eyes. A mild specification rigidly enforced is infinitely better than a rigid specification, with constant jangling and constant yielding by the inspector to allow materials to pass.

In the next article we will try to say something about Sampling, and the Enforcement of Specifications.

(TO BE CONTINUED.)

## COLUMBIAN EXPOSITION NOTES.

IT is announced that the Pennsylvania Railroad Company will make a fine exhibit in the Transportation Department, and that the New York Central & Hudson River and its allied companies will also make a large exhibit. Both of these will be planned and arranged to illustrate American railroad practice on the most improved lines; they will also be historical in their nature, and will show the growth of the several systems. Mr. T. N. Ely has charge of the preparation of the Pennsylvania Railroad exhibit.

Seven of the World's Fair buildings are now so far advanced that they are fast assuming the appearance of finished structures. The rough carpentry work on them is practically done, and the ornamental and finishing work is in progress. These buildings are the Woman's, Horticulture, Transportation, Mines, Administration, Forestry and Fisheries. Five more—the Government, Fine Arts, Agriculture, Dairy and Illinois State—are erected to the roof lines. The Electricity, Manufactures and Machinery buildings are being advanced rapidly.

Plaster work on the Mines Building is finished; the gallery railings are nearly completed, and wire work is being set. Staff work on the south end of the building is nearly finished. All of the carpentry work and iron work on the Transportation Building is in place except the central elevator tower.

All of the trusses of the Electricity Building, with the exception of the central diagonal trusses, are in position.

On the Administration Building 160,000 ft. of lumber and 20,000 lbs. of iron have been added during the week. Roofers are working on the northeast and northwest pavilions.

On the big Manufactures Building the record shows a total of 9,797,152 ft. of lumber used, in addition to which has been received 444,000 ft. of lumber and 168,000 lbs. of carpenters' iron. The great traveler which is to be used for hoisting the immense girders spanning the central court is already 120 ft. high, and is yet less than half completed. When completed it will be used for putting in place the largest trusses ever made for architectural purposes, spanning 368 ft. and rising to a height of 211 ft.

The iron work for the dome of the Fisheries Building is complete, and staff work is nearly finished in both annexes.

Ornamental staff work is being rapidly placed on the west end of the Agricultural Building, and the roof trusses over the nave and transept are in position. The iron for the entire building is on the ground, and the walls for the south half are about ready for the roof iron.

Work on Machinery Hall has been retarded, owing to non-delivery of iron, but the total amount of lumber placed foots up 30,000 ft., and iron, 102,000 lbs. Most of the carpentry work has been to frame the annex superstructure. The second of the large arches is now in position.

Work on the Dairy Building is nearly finished, also on the Forestry Building. The latter is being temporarily used as a shop for the molders who are casting the big figures and groups for the Administration Building.

## SOME NEW COMPOUND LOCOMOTIVES.

A COMPOUND consolidation locomotive of the pattern devised by Mr. F. W. Johnstone, of the Mexican Central Railroad, was described in our columns some time ago. Mr. Johnstone has now completed plans for a double-bogie compound engine, and several locomotives of this pattern are to be built for his road. The engines have two boilers placed end to end, the fire-boxes adjoining each other and the fire-doors being at the side. The boiler and the cylinders will be carried on a rigid frame, but the running gear will be arranged in two groups, each group forming an independent truck. The plan is in outward appearance somewhat similar to the Fairlie double-bogie engine, which attracted considerable attention some years ago, but with the essential difference that in the Fairlie system the cylinders were carried on the truck frames, while in Mr. Johnstone's plan the cylinders are secured to the boilers and to the main engine frame. The piston-rods of the engine work on the upper ends of levers carried in bearings on the main frame, and the connecting-rods are attached to the lower end of these levers. Each of the truck frames carries three pairs of coupled driving-wheels and a two-wheeled truck, the radius-bar of this truck being pivoted to the front of the truck frame. The